

CURIOS



CAN HUMANS LEARN
TO HIBERNATE?

WHY ARE THERE NO
GREEN MAMMALS?

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DARE WE BECOME
TRANSHUMAN?



7

WHAT ON EARTH

HAIR ICE GROWS ON ROTTING WOOD

This curious phenomenon only occurs under a specific set of circumstances.



10

DEEP DIVE

CAN HUMANS LEARN TO HIBERNATE?

Why are we still awake? More importantly, do we really have to be? Katie Spalding investigates.



4

OUR COVER STORY

DARE WE BECOME TRANSHUMAN?

Tom Hale explores the lofty goal with a murky past.

December 2022

CONTENTS

News Bites | page 2

What's new, what's weird, what's happening?

We Have Questions | page 8

Why are there no green mammals?

Book Bites | page 14

How do you define a number?

Meet The Author | page 15

Manil Suri on *The Big Bang Of Numbers*

Where On Earth | page 16

Red crab migration on Christmas Island

Science In Media | page 18

What to watch, read, and listen to this month

Dates To Remember | page 19

What to look out for this month

Dark Vs. Light | page 20

How will you end the issue?

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NEWS BITES



World's Largest Digital Camera

Behold, the world's largest digital camera has been unveiled, and with a lens that stretches 1.65 meters (5.5 feet) across, it's officially a Guinness World Record holder. Engineers at the SLAC National Accelerator Laboratory in California have spent the last seven years building the Legacy Survey of Space and Time (LSST) camera, which is set to be the star of the new Vera C. Rubin Observatory being built in the Chilean mountains. The size of a small car, it works like any other digital camera, just on a much bigger scale. With a 3,200-megapixel camera, it can take images high-res enough to spot a golf ball from 24 kilometers (15 miles) away. Scientists think the LSST will help discover 17 billion new stars. Once operating, the camera will take a wide-field picture of the sky seven times the width of the Moon every 15 seconds, capturing a panorama of the entire southern sky each night. One day, it may even help astronomers solve the mysteries of dark matter and dark energy.



A New Treasure Hunt

Looking to leave dark and dreary December behind? Luckily Disney's new *National Treasure: Edge Of History* starts airing this month. A continuation of the movie franchise (sans Nic Cage, sadly), the new 10-part TV series sees heroine Jess Valenzuela's life turned upside down when a stranger gives her an ancient relic that may be connected to her father and sets her on the hunt for possibly the world's greatest treasure. In the long tradition of these adventure stories, there are maps, a few liberties with historical events, puzzles to solve, bad guys to beat, and action, lots of action. The series airs on Disney+ from December 14.



What's The Time... On Mars?

Looking for a snazzy gift for the space nerd in your life? How about a watch that tells the time on Mars? Swiss watch brand Omega® has teamed up with the European Space Agency (ESA) to launch Marstimer, the first watch to tell the time on Earth and Mars. Developed with ESA's Mars exploration team, Omega has long been associated with space travel: NASA's Gemini and Apollo astronauts wore its Speedmaster watches during the Moon landing missions. Marstimer is the first watch to find true north on both Earth and Mars without a magnetic compass (helpful for the lack of a magnetic field on Mars). As Omega puts it, it's made for humankind's next giant leap.

A Buzz Like Thunder

Flying insects contribute to atmospheric electricity and swarming honeybees can produce as much electric charge as a thunderstorm, according to a **study** that has the world abuzz. The flapping of hundreds of tiny wings can electrify the air in a similar way to how clouds of water vapor charge the air inside a storm. Scientists say this means that we should consider biological phenomena when modeling patterns in atmospheric electric fields. So, the next time you hear that ominous roll and curse the fact you forgot your umbrella, check first you're not being followed by a swarm of bees.



Women Cryptologists of WWII

Eleven thousand American cryptologist women played a vital part in the Allied victory of World War II, but crucially their efforts and identities were kept secret. Now, you can honor them with the US Postal Service's latest collectible "Forever" stamps: **Women Cryptologists of WWII**. The stamps feature an image of a woman from a WWII-era Women Accepted for Volunteer Emergency Service (WAVES) recruitment poster overlaid with characters from the so-called "Purple" code. On September 20, 1940, mathematician Genevieve Grotjan cracked the code used by the Japanese Foreign Office and the cipher was codenamed Purple. If you look closely on the stamps, seemingly random letters can be deciphered to reveal real words. The stamps even come with the cipher needed to read the words.

Destination Moon

The Smithsonian's National Air and Space Museum in Washington DC has reopened with eight new and renovated galleries that explore humanity's exploration of the skies and beyond. The most hotly anticipated is the new "Destination Moon" exhibition. Alongside items like the silver pressure suit worn by Alan Shepard and the Mercury capsule that made him the first American in space, sit immersive galleries that let you see what it would be like to stand on another world, and even a full-sized *Star Wars* X-Wing Starfighter on loan from Lucasfilm Ltd. They've even renovated the restrooms near the exhibits with fun facts about bathrooms on aircraft and in space.

WHAT'S UP?



Space Balloons

What goes up must come down

Name: Halo Space.

Appearance: Like a cable car being held up by a balloon.

Location: The stratosphere.

Who? HALO Space is a space tourism company with big plans to kickstart its zero-emissions commercial space balloon flights in 2025.

Space balloon? Well, more of a capsule suspended by a balloon.

So, no basket? It looks more like traveling to the edge of space in a fancy cable car, or one of the London Eye's capsules. It seats eight plus a pilot and has huge windows that give a 360-degree view of Earth, which is similar to a hot air balloon basket.

How high up does it go? The plan is to reach 40 kilometers (25 miles) in altitude, smack in the middle of the stratosphere, which

stretches from 20-50 kilometers (12-30 miles) above Earth.

Is that space? Earth's atmosphere has five layers: the troposphere, stratosphere, mesosphere, thermosphere, and exosphere. The common agreement is that space starts at the Kármán line 100 kilometers (60 miles) above Earth, in the lower thermosphere.

How long will it stay up for?

That hasn't been confirmed but the test flight is set to stay in the stratosphere for six hours. Commercial flights may be less as current designs don't appear to include onboard restrooms.

Can I go now? Sadly, no. The plan is to start flights in 2025, with an ambitious goal of 400 flights and 3,000 passengers a year by 2029. But first, it needs to ace its test flight, set to be carried out in India later this month.



DARE WE BECOME TRANSHUMAN?

**Transhumanism has lofty goals but a murky past.
Dare we attempt it, or are we already there?**

By Tom Hale

Transhumanism offers humans one of the loftiest goals ever proposed: through science and technology, we hold the power to turbo-charge our senses, edit out our biological frailties, meld minds with computers, and perfect our fleshy bodies to the point where we become something that is beyond human – perhaps something almost God-like. Nietzsche would have a field day.

In decades gone by it was the stuff of science fiction, but we are fast approaching a point where many of these futurist dreams could become reality: **CRISPR** has made **gene editing easier** than ever; the gap between the human brain and computers is closing; robotics has never been better; our understanding of biological aging continues to grow.

The real question, however, is whether we should embark on such a daring plan?

Transhumanism presents an optimistic vision of the future where humans can improve themselves through the radical extension of the human lifespan, the eradication of disease, and the elimination of pain.

Do you want to run like Usain Bolt? That's nothing gene editing and robotics couldn't manage. Do you wish to possess one of the greatest minds in history? Perhaps a computer-brain interface would achieve that.

It's a nebulous term that often relies on the hypothetical, drawing on all kinds of scientific fields, from artificial intelligence (AI) and robotics to biotechnology and space exploration. However, one discipline that transhumanism frequently touches on – and was even arguably born out of – is genetics.

The murky beginnings of becoming beyond human

The term transhumanism ("trans" stemming from the Latin word for "across", "over", or "beyond") was first coined by evolutionary biologist Julian Huxley, the grandson of Thomas Henry Huxley, a giant of Victorian science who became known as "Darwin's Bulldog" for his ardent advocacy of the theory of evolution by natural selection.

Julian's brother and close confidant was Aldous Huxley, author of *Brave New World*, a novel that vividly illustrates a future society in which the totems of science, technology, and efficiency have forged a bleak dystopia.

Julian first wrote the term in the 1950s, but themes that would now be considered transhumanist had emerged in his thoughts well before World War II. He held the belief that humankind had seemingly unbounded potential, but were thwarted by intrinsic weaknesses that had become interwoven into our nature. Just like any other beast on this planet, we can be ignorant, weak, and get old.

He believed that it was the duty of scientific advancement to break from these chains and gain the "fullest realization of man's possibilities". In his mind, the scientific developments of modernity had made humans the "managing director of the biggest business of all, the business of evolution" – and it was an opportunity that held vast possibility.

"We have pretty well finished the geographical exploration of the earth; we have pushed the scientific exploration of nature, both lifeless and living, to a point at which its main outlines have become clear;

but the exploration of human nature and its possibilities has scarcely begun. A vast New World of uncharted possibilities awaits its Columbus," he wrote in 1957.

Huxley thought the initial stages of this could be achieved through education and social enrichment. However, like many "great minds" of the 19th and 20th centuries, he became increasingly interested in eugenics; the idea that the genetic quality of the human population could be improved by removing undesirable variants from the gene pool.

From 1959 to 1962, he stood as president of the British Eugenics Society. When comparing how farmers bred their animals to encourage certain characteristics like meaty thighs, Huxley would ask why the same couldn't be achieved in human stock. Although he strongly argued against the extermination of those considered unfit, he believed that one way to achieve a strong population was by encouraging people of the "professional middle classes" to have children.

In his mind, it would be possible to raise the caliber of the human population to higher levels through social engineering. Just



like breeding chickens for bigger breasts, society could create a stock of people to the point they become beyond human.

Huxley's imagination was somewhat limited by the scientific understanding of his time. When Huxley was writing about transhumanism in the 1950s, the three-dimensional structure of DNA had only just been identified and it would be two more decades until scientists started seriously toying with the idea of genetic engineering.

BEYOND THE SCIENTIFIC AND MEDICAL ISSUES, IT OPENED A PANDORA'S BOX OF ETHICAL AND MORAL QUESTIONS.

With today's technology, however, it could be possible to go even further down the path Huxley started to carve out.

Is the dream of transhumanism already a reality?

Through human germline engineering, it's possible to tweak the DNA of people in such a way that the change is a fundamental part of their genome and is even passed onto their children.

The legality of human germline engineering differs around the world. While it's outright banned in the European Union, it's only prohibited with the use of federal funding in the United States. This is even before you consider the minefield of ethical and moral dilemmas that surround this feat.

Nevertheless, there are claims that this has already become a reality. In November 2018, Chinese biophysicist He Jiankui claimed that he had created the **first human genetically edited babies**, Lulu and Nana.

Using CRISPR, he edited the genomes of the twins when they were embryos, endowing them with genetic protection against HIV by targeting a gene, CCR5, which codes for a protein that the virus uses to hijack cells. The babies effectively had superhuman protection against a disease that killed tens of millions of people.

The incident sparked outrage and shock across the world. He was painted as a mad scientist gone rogue in the media and countless streams of scientists claimed this behavior was wreckless, deeply unethical, and even criminal.

Much of this was founded on the unanswered scientific questions that surrounded the affair. This is uncharted territory and there's really no telling how the germline engineering of embryos could impact their wider health and well-being, let alone generations down the line. Beyond the scientific and medical issues, it opened a Pandora's box of ethical and moral questions.

Brave new world

While few would argue genetic protection against HIV is a bad thing, how do we draw up these distinctions between "good" and "bad" when it comes to the uses of this technology? Which human traits are

"normal" and which can be considered a disability or disorder? Even if the world does agree on these distinctions, what's to stop us from meddling with other traits such as intelligence, good looks, or athletic ability?

EVEN IN A WORLD WHERE GENETIC EDITING IS PROLIFIC, COULD IT MAKE THE WORLD LESS ACCEPTING OF PEOPLE WHO ARE DIFFERENT?

Then comes the issue of how this technology is distributed. At least in the short run, it's likely only the privileged, rich, and those born on the right patches of Earth will be able to enjoy the fruits of this development. Even in a world where genetic editing is prolific, could it make the world less accepting of people who are different?

All of these questions are fundamentally why eugenics is so frowned upon today. By the latter half of the 20th century, eugenics became widely regarded as immoral and unethical, let alone scientifically erroneous. So much so, anyone who flirts with transhumanist ideas would no doubt vehemently argue that the movement is wildly different from eugenics. After all, transhumanism doesn't just involve genetics, but also AI, computer science, robotics, neuroscience, biomedicine, and all kinds of future-pushing scientific fields.

It's certainly possible for the future to utilize any scientific advancement to maximize public health and happiness while minimizing inequalities and suffering. If this goes far enough, perhaps we could eventually consider our species to be distinct from the *Homo sapiens* that created cave paintings and hunted mammoths.

However, these technologies don't exist in a vacuum and, whenever they are used, they will remain closely intertwined with the social norms of the day. If this is a journey we are willing to take, we need to tip-toe carefully. ●





Image Credit: TT, © iStock

HAIR ICE GROWS ON ROTTING WOOD

Delicate whorls of ice are blossoming on rotten wood in parts of the planet experiencing freezing temperatures this month. The unusual structures, known as **hair ice**, form only on moist rotting wood from a broadleaf tree in the presence of *Exidiopsis effusa*, a type of fungus. As the wood freezes, ice segregation forces water out through its pores, which then freezes in the cold air. This creates hair-thin strands of ice around 0.01 millimeters (0.0004 inches) in diameter and 10 centimeters (4 inches) long that can hold their shape for hours.



Image Credit: Angyalosi Beata / IFLScience / © Shutterstock.com

WHY ARE THERE NO GREEN MAMMALS?

IS THERE REALLY NOT A SINGLE MAMMAL ON EARTH WITH GREEN COLORATION, AND IF NOT, WHY NOT?

By Rachael Funnell

Has anyone ever tried to milk the Grinch? We know it's a weird point to start on, but as a fluffy, bipedal animal you'd be tempted to qualify it as a mammal. And that got us to thinking: why aren't there any green mammals?

They say absence of evidence isn't evidence of absence. By that thinking, it could be argued that just because we haven't found any mammals covered in voluminous green fur yet doesn't necessarily mean they don't exist (has anyone checked Mount Crumpit?). Stranger things have certainly been found across the animal kingdom, and when it comes to green, nobody's doing it better than the sacoglossans. As a group of "solar-powered sea slugs", they're able to energize themselves through photosynthesis by taking chloroplasts from their diet and building them into their own cells.

However, when it comes to evolution, we can expect to see certain limitations present across groups of animals.

While the sacoglossans can be as green and **self-decapitatingly strange** as they like, mammals' coloration is more restricted, being largely decided by fur or hair which has specific properties, including pigments. While vivid shades of orange can be achieved through ginger hair, turning into the Grinch may be just out of our fuzzy-fingered reach.

Fun as it might be to imagine a grass-green pygmy possum hiding from human eyes in the Australian bush, zookeeper at ZSL London Zoo, UK, Shannon Farrington, explains to IFLScience why what we know about wider mammals tells us that we won't find any green ones.

What are the key evolutionary drivers that influence an animal's appearance?

SF: There will be a few factors at play here, one of which is female sexual selection. Whichever male impresses the female most will get to breed, and whether that's the strongest, loudest, or most colourful will all depend on the species.



Another driver will be the animals' adaptations. For example, a longer neck can make it easier to access food. If an animal doesn't possess the adaptations needed to thrive in its habitat, then there's less of a chance it'll make it to adulthood, never mind being able to reproduce!

What are some of the weirdest colorations among mammals?

SF: I think it depends on what you mean by weird, but in terms of the brightest I'd probably have to say some of the members of the primate family, such as mandrills. Both the face and the posterior of the males are an incredibly striking

combination of blue and red to help them attract females and show their dominance.

What are the constraints on how colorful mammals can be?

SF: Just like humans, other mammals are constrained by evolutionary history. Would it be useful to have blue or green skin or pink eyes? Would it help us to survive any better than we already do? Many animals have undergone thousands of years of development to become exactly what they need to be to survive.

So... are there any green mammals?

SF: No, there aren't any mammals born with green colouration. The closest animal I can think of to the colour green is a sloth. Sloths have special hairs and each one is full of grooves; these grooves collect debris from the external environment, which in the case of the South American rainforest is warm and very humid.

This means you'll find sloths carrying around lots of algae and fungi making them look green. It works great

for an animal that's trying to camouflage in its surroundings to avoid predators.

Not only do they end up looking like trees, but they smell like them too! The sloth's fur becomes its own little micro-environment.

Why aren't there any green mammals?

SF: The reason you won't find any green mammals is because hair doesn't produce green or blue pigments. It's the same as in humans – there are lighter pigments, such as blonde and oranges, and then darker pigments, like browns and blacks. No combination of those could create a shade of green. •



SCIENCE FACT OR FICTION:

CAN HUMANS LEARN TO HIBERNATE?

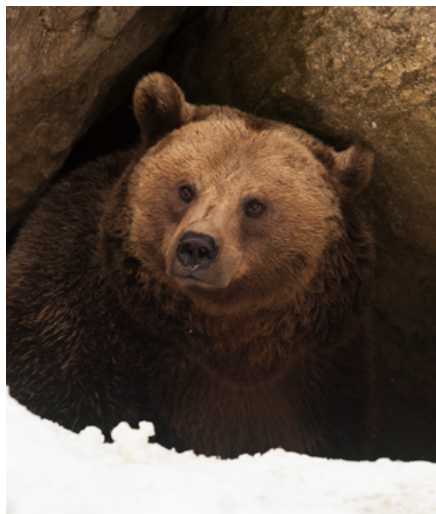
Hunkering down until spring is tempting, so why, exactly, are we all still awake? And – more importantly – do we really have to be? Katie Spalding investigates.





There's no mistaking that nip in the air, or the longer, colder nights. We can't be the only ones thinking about crawling into bed until the Sun comes back, right?

Of course we aren't – after all, the **bears of Katmai National Park** finished preparing for hibernation more than a month ago now. The tiny hedgehogs in England are turning in for the winter; any box turtles nearby have likely retreated into their shell; even fat-tailed dwarf lemurs, the only primate known to hibernate, is now spending most of its time snoozing away the days until spring comes back.



So why, exactly, are we all still awake? And – more importantly – do we really have to be?

What is hibernation?

We all know what hibernation is, don't we? It's probably one of the earliest "science" facts we learn in life: every winter, instead of facing the cold and dreary weather ahead of them, certain animals opt to bulk up, hunker down, and nestle in for a nice, deep sleep until the Sun comes out again.

But like seemingly every piece of science we learned in elementary school, "hibernation" is more complicated than that. For one thing, it's not one thing at all: there are varying levels of dormancy in the animal kingdom, ranging from the one-day bouts of torpor experienced by animals like mice or bats to transformations so extreme as to be almost unbelievable.

"For instance, when Arctic ground squirrels hibernate, they get too cold to perform an EEG [electroencephalogram]," explains Kelly Drew, a researcher in hibernation biology at the University of Alaska, Fairbanks, and director of the NIH Center for Transformative Research in Metabolism. With a core body temperature lower than the freezing point of water, "it looks like they're in a coma," she told IFLScience.

Not every winter napper is so dramatic about it. Brown bears, one of the most famous hibernators thanks to the annual pageantry of Fat Bear Week, experience a drop in body temperature of less than about 5°C (9°F) – and contrary to how we imagine hibernation, they wake up quite often during those months inside.

This might leave you wondering: if both these extremes count as hibernation, then what exactly is the unifying feature here?

"Technically, [torpor] refers to a regulated state of reduced metabolism, meaning the chemical reactions in an organism's body that keep it alive slow down," explained Vladyslav Vyazovskiy, an associate professor of neuroscience at the University of Oxford, in an article for **The Conversation**.

"Heart rate, breathing, and energy consumption all dramatically decrease, body temperature can also fall."

It's these technicalities that separate hibernation, which is the extended period of torpor found in some warm-blooded animals, from brumation, the dormant state experienced by certain reptiles like turtles or leopard geckos during colder weather. It is, on its surface, virtually indistinguishable from hibernation – but metabolically it's very different, being induced by external rather than internal processes.

"Obligate hibernators, like ground squirrels, are driven to hibernate by an endogenous circannual rhythm," Drew told IFLScience. "Facultative hibernators, like hamsters, respond to shortening day length. In both cases, hibernation is linked to reproduction and resource availability."

Tucking in for the night

If we want to extend hibernation to humanity, we should probably know what we're signing up for. What, precisely, is going on as an animal settles in for the winter – and could a human body really cope with such a long period of, to put it bluntly, nothing at all?

"Controlled hypothermia and metabolism are already widely used in clinical practice," explained Vyazovskiy. "[It's used] during

cardiac surgery and to protect tissues from damage when blood flow is reduced, such as after a stroke.”

There are clear benefits to the technique: a reduced metabolism and body temperature means the cells in the body require less oxygen to survive, for example. “But the key difference is that animals [seem] to ‘know’ the way to safely and spontaneously enter torpor,” he continued. “Lowering a human’s body temperature by blocking their natural thermoregulation requires the aggressive use of drugs.”

As it stands, replicating true hibernation or torpor in humans is a little out of reach – and that’s for quite a few reasons.

We know what happens to an animal’s body as it retreats for the winter: it’s essentially a two-step process, Drew explained, with defined periods of pre-hibernation and torpor.

“[In] the pre-hibernation season, gonads regress, the drive to sleep increases, the thermostat is turned down, metabolic rate

decreases,” she told IFLScience. “The second switch drives the animal into prolonged torpor, [in which] thermogenesis (heat production) is turned down significantly... [which] then contributes to further energy savings.”

But what we don’t know exactly is how this all occurs. Is it a “bottom up” process, where the main biological changes begin at a cellular level? Or is it more “top down” – starting with a hormonal response or a signal from the nervous system, and rippling down to the smaller metabolic processes?

Evidence has been found for both these possibilities, with little in the way of any conclusive answers. And the mysteries don’t stop there – there are some things about hibernation that, frankly, don’t make sense at all.

Hibernation on Mars?

By the time a bear emerges from hibernation, it will be significantly smaller and lighter than when it started. That’s not surprising, it has spent up to seven months near immobilized, without eating, drinking,

peeing, or pooping. But the loss isn’t quite as catastrophic as you might think – and that offers some intriguing possibilities for the future.

“Bears exit their den healthily in spring with only marginal loss of muscle mass,” said Professor Alexander Choukér, co-author of a **paper** on the European Space Agency’s (ESA) hibernation strategy for deep space missions. “It only takes them about 20 days to be back to normal. This teaches us that hibernation prevents disuse atrophy of muscle and bone, and protects against tissue damage.”

Hibernation is quite the hot topic in the astronautics industry right now. As humanity looks hungrily towards our red neighbor, many experts have hit upon induced hibernation – or, more likely, torpor – as the solution for myriad problems that would beset any future missions to Mars.

A round trip to the Red Planet would likely take around 18 months, during which time any human passengers will probably want to eat, or move around. Spending so long in space could also have serious implications for any astronauts’ physical health. Even outside of practical concerns, human hibernation might be worth it for the psychological protection it could provide.

“If humans could [hibernate]... it could increase our chances of making humans a spacefaring species,” Gary Hardiman, senior author of a study inducing torpor in zebrafish, said in a **statement**. “It would... cut down on psychological stress. The change to [astronaut] metabolism would stop them requiring food, oxygen or water, and there is a possibility it would protect their muscles from wasting due to the effects caused by radiation and microgravity.”

The hazards of hibernation

By now, we’re sure there are some of you out there wondering where you can sign up for a human hibernation study. But don’t be too hasty.

Like ESA, NASA has dedicated research regarding human hibernation protocols – but even it warns that hibernation would



have drawbacks: it would require our bodies to be fed via a tube inserted through the abdomen, and, as it stands, would likely require heavy sedatives to squash our natural shivering reaction.

And you can forget about feeling well-rested afterwards. Hibernation is not the same thing as sleep – it “can be thought of as an extension of sleep,” Drew told IFLScience; “in fact, animals have to be asleep to enter hibernation – they go from slow wave sleep, into hibernation, and then back through slow wave sleep again to wake up.”

Perhaps most concerning – especially if you happen to be 94 million kilometers (58 million miles) away from home – is the effect such an extended period of unconsciousness would have on your brain. That’s particularly difficult to quantify because we don’t actually know what it would be.

“Torpor affects the brain... by reducing and reorganizing the synaptic connections that are the basis of our memories,” explained Vyazovskiy. “If we wanted to induce human hibernation it would be vitally important to investigate further how memories are retained over a long period of torpor.”

Human hibernation: could it be possible?

Regardless of any benefits or drawbacks, there’s one question at the heart of this we have yet to answer: could humans actually learn to hibernate?

“We think humans can hibernate,” Drew told IFLScience. “Experienced yogis can suppress [their] metabolism to induce hibernation-like states.”

If that surprises you, consider this: According to Dr Sandy Martin, author of **a study** last year investigating the particular gene expressions involved in mammal hibernation, it is simply so ubiquitous across the evolutionary tree of mammals that it’s probably just hard-wired into our genetic code. “The common ancestor of all mammals was [probably] a hibernator,” she recently told **New Scientist**. “It’s possible we all have the genetic hardware.”

In other words, hibernation in humans may not be a case of “learning”, but “remembering” how to do it. Indeed, we may not even need to stretch that far back, evolutionarily speaking. There’s “even some evidence,” albeit divisive, Drew told IFLScience, “suggest[ing] that prehistoric humans may have hibernated.”

To infinity and Zzzzzzzzzzz

So, could humanity’s future among the stars rest in a biological process we left behind in fossils? Perhaps. The truth is, Drew told IFLScience, we’re “still far from understanding” the nuances of hibernation, both past and future.

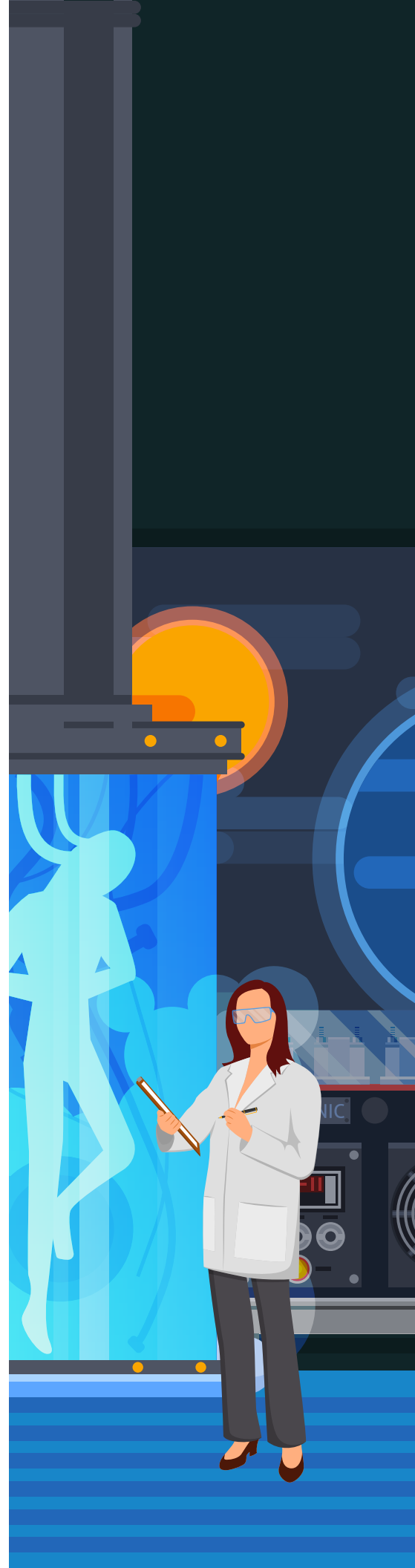
“Hibernation occurs across a wide and diverse spectrum of animals with no clear evolutionary lineage,” she pointed out. As to exactly why some animals go in for a winter-long naptime while others don’t, “we do not know,” she admitted.

Which sort of brings us to the crux of the matter: even if humans could learn to hibernate – would we want to? After all, it developed as a way for animals to survive the cruel and unforgiving winter; humans, with our unprecedentedly cushy lives, and our year-round access to things like hot food and central heating, may find ourselves having to give up our creature comforts if we want to justify hibernation to our genome. Would that really be worth it?

Perhaps, if the hopes of NASA and ESA are realized, hibernation does have a place in the future of humanity. But it will take a lot of hard work and research to get there.

As for the snoring astronauts of years to come, we can only imagine how different their lives will look from our own – and how similar they may look to those of certain other, more gloriously rotund members of the animal kingdom.

“Oh, bears, definitely,” Drew tells IFLScience. “Bears are the perfect model for human hibernation – they’re a similar size to us, they don’t get too cold like ground squirrels... bears are absolutely what we’d want to mimic.” ●



HOW DO YOU DEFINE A NUMBER?

In this excerpt from *The Big Bang Of Numbers*, author and mathematician Manil Suri asks if we really know how to define math and its constituent parts.

What is a number? That's easy. "One, two, three...", you start, but these are just examples. "A value used to count" or "A symbol used to quantify" are only descriptions – not particularly satisfying ones at that, since they use other undefined terms like "count" and "quantify". Notice how hard it is to actually pin down the definition of a number. It's my second-favorite question to quell an uppity maths class. (My favorite is "Define maths.")

The problem is we conflate the identity of numbers too much with their function, associating them only with counting and measurement. Perhaps this is a legacy from our early ancestors, who, after all, were motivated by purely practical needs when they embarked on their arduous quest for numbers. Asking them to characterize their invention might have elicited different replies through the ages: notches on a wolf bone, knots on a cord, hieroglyphics and pictographs, all the way to the Indo-Arabic symbols used now. They'd have dismissed us as precious (or worse, demented) had we persisted in asking them to define the essence of a number.

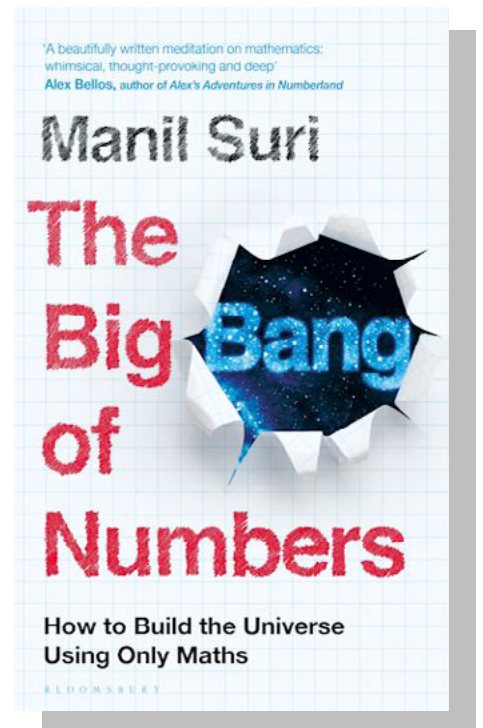
Plato would be an exception. He believed numbers to be abstract entities, living in

their own idealized universe – a universe containing galaxies of perfect concepts that exist independently of the material realm. The most humans could hope for was to get occasional glimpses of this cosmos, coming away with discoveries they could use in their own world.

Like Plato, we need to understand the nitty-gritty of numbers. We need to understand the material we're building our universe from. Unlike him, we won't take the easy way out by assuming numbers are givens, in existence since time immemorial. Rather, we'll construct them ourselves, much like an artisanal builder who personally bakes every brick for a house. That's the scout's motto for mathematicians: be prepared to build everything from scratch. As promised, there *will* be a blast!

So, imagine you're at a starting point that predates the universe – *all* universes, even Plato's. God has not yet commenced building and neither has physics – in fact, both are waiting somewhat testily for you to give them the numbers first. Given their penchant for sudden eruptions, you'd better get to work.

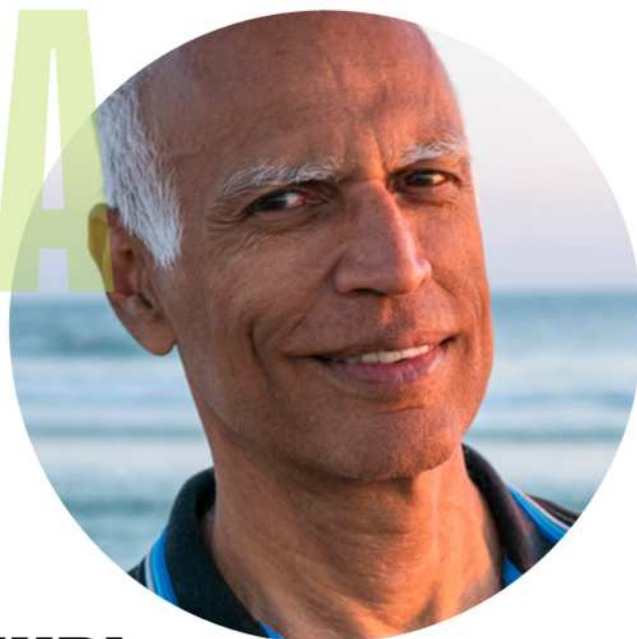
Except you literally have *nothing* to work with. No energy, no matter, no symbols, no objects to count. You can't even imagine yourself suspended alone in empty space because space hasn't been invented yet. Even the concept of space, along with that of length or area or dimension, has yet to be formulated. Time is hazy as well – perhaps it's waiting to be initiated. You've never felt so isolated, never seen a "nothing" so absolute, so stark. A "nothing"



you realize is your only resource – the commodity you'll have to construct your numbers from.

Now, King Lear may have warned that nothing can beget only nothing, but both religion and physics have been enchanted by the opposite, utopian notion. *Creatio ex nihilo* is the ultimate magic trick, whereby oceans, skies, planets, the universe, life itself, are all created out of nothing (*nihilo*). Either with the help of a divine entity, or unaided, through a spacetime "singularity" (as physicists might put it). Every religion has its own variant – if the universe isn't being blown out by Brahma in a single breath, then it's rising from the infinite sea of chaos posited by the ancient Egyptians.

The reason I call *creatio ex nihilo* a magic trick is that the "nothing" you start with always needs an asterisk (a singularity for the Big Bang, a Supreme Creator for Genesis). Some of these asterisks can be quite pronounced – making the *nihilo* part essentially a con. What's remarkable about the version you're about to use for the numbers is that the asterisk needed is so trifling, so close to nothing itself. It's called the empty set. •

Q&A
AUTHORWITH
MANIL SURI**MATHEMATICIAN AND AUTHOR OF *THE BIG BANG OF NUMBERS:
HOW TO BUILD THE UNIVERSE USING ONLY MATHS***

In his new mathematical origin story, mathematician and novelist Manil Suri demonstrates the ideas needed to design our world, starting with numbers and continuing through geometry, algebra, and beyond. Touching on multidimensional crochet and the Mona Lisa's asymmetrical smile, Suri wields inventive storytelling to outline complex concepts like infinity and relativity. We caught up with him to find out more about this playful exploration of numbers and the creation of a universe.

How can math help us understand the universe?

From the ellipses that explain planetary motion to the self-similar boundaries called fractals that shape clouds and cauliflowers, maths gives us ways to describe natural

phenomena. It allows us to characterize fundamental attributes like order, symmetry, and randomness that play crucial roles in shaping reality. Every pattern you see, whether in microscopic lifeforms or giant galaxies, is attributable to maths; it is the true intelligence behind the universe.

What key concepts does *The Big Bang Of Numbers* touch on?

The book shows how starting with nothing, you can build the numbers, and how, from these numbers, you can then build geometry and patterns and physics and more. It's an origin story for the universe based not on religion or physics, but mathematics. One of the surprising things is how much of a role infinity plays in our lives, even though we can never experience it.

Can you give us a taster of some of the more obscure ideas explored?

We've heard that our spacetime is "curved," but what does that mean? The answer,

surprisingly, can be approached through crocheting. Suppose you start crocheting a circular pattern, then extending it outward indefinitely will give you a flat plane.

Crocheting websites tell you two common mistakes to look out for. First, if you don't put enough stitches in (i.e. too little material), the edges of the circle will start curling upwards, or cupping as if trying to form a sphere. On the other hand, put too many stitches in, and the extra material will need to go somewhere, causing the edges to ruffle into increasingly extravagant shapes (called "hyperbolic").

Both these are examples of 2-D plane geometry being replaced by a "curved" version. This trick carries over to imagining 3-D space being crocheted – put too little material in and it will cup or close in; put too much and you will get ruffles to hold the extra material. The problem is the material now cups or ruffles into a fourth dimension, which we can't see.

Who is this book for?

It's for people who have an interest in mathematics and science. This includes those in the arts and humanities who may have always wanted to know more about maths, but never got the chance. I show that maths is more about ideas than calculation, so no special knowledge or expertise is needed to read the book.

What do you enjoy most about being a mathematician?

Being able to work anywhere, anytime on a problem – in the shower, on the underground, while attending a boring lecture. The only equipment you need is your mind. What I don't like about it is being asked to tell everyone what they owe when the restaurant bill comes. I'm a mathematician, not a calculator, I remind them. •

The Big Bang Of Numbers
by Manil Suri is published
by Bloomsbury and is
available to buy now.



Millions of red crabs will be making their perilous annual migration from their forest homes to the ocean in search of a mate right now. When they arrive, a baby boom will kick off in the safety of sandy burrows, but then the real danger begins.

RED CRAB MIGRATION ON CHRISTMAS ISLAND

From October through to January, red crabs (*Gecarcoidea natalis*) on Christmas Island, Australia, up sticks from their forest home and head for the ocean. Millions of crabs will scuttle across the island, which has had to build special **crab highways** and bridges to keep them clear of cars. They must reach their destination before dawn on a receding high tide during the last quarter of the moon, but can only get going after it rains. The window between the two decides if their migration will be a sprint or a marathon.

Males lead the charge and arrive at the sea first, where they are later joined by females who outnumber them. The males dig burrows, often fighting for territory, and with good reason. Females peruse the properties for one in which they'd like to mate, so the males need to impress if they're going to pass on their DNA.

Once mating is complete, the females hang out in the burrow for a few days to a few weeks to cook up some eggs. Each female will carry around 100,000 in a brood pouch, and she has to lay them in the sea. She's a land crab who can't swim, so waves are tricky.

There can be as many as 100 crabs per square meter when spawning night comes as the females congregate on the shore, getting ready to ditch their eggs. If she's going to launch the next generation, she'll have to brave the water, and the ideal time is when the high tide is turning just before dawn. They give a little shake at high tide, arms in the air like they just don't care, and the water turns black as billions of eggs are released.

These eggs hatch when they make contact with the water and get swept out with the tide to develop in deeper waters. They move through several larval stages, gradually moving back towards the shoreline as they do until they gather as prawn-like megalopae and finally turn into mini crabs.

Though billions of eggs go in, some years none make it out of the water. The swarms of defenseless larvae make for a convenient snack for manta rays and whale sharks. Other years, they experience a baby boom that can see millions scuttle out of the water, keeping the population topped up. ●



READ

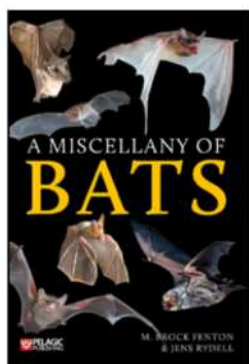
A Miscellany of Bats

Book by Brock Fenton and Jens Rydell

Two of the world's leading authorities on bat science come together in this ode to our non-feathered flying friends, drawing on decades of research and experience. Bats account for 20 percent of all mammal species worldwide, and here you can get to know 150 of them as knowledge gained from 25 years of collaboration is spun into engaging and informative stories

and anecdotes. Between pandemics and Halloween, bats get a bad rap, but these fuzzy pilots really do sit at the middle of it all.

Available to buy now.



PLAY

Lord Winklebottom Investigates

Game by Cave Monsters

Forget dusty old boardgames and Cluedo this holiday season, the real mystery to be solved is Lord Winklebottom

Investigates. As the world's foremost giraffe detective in 1920s Britain, Lord Winklebottom joins his steadfast companion, Dr Frumple (a hippo, obviously), to investigate the murder of an axolotl. As a game that's being described as "Monkey Island-level funny", it's as British as it is zoological. Showcasing point-and-click games in all their problem-solving wonder, you'll uncover clues, interrogate suspects, and drink tea until you capture the killer.

Available on Steam, Xbox, and Nintendo Switch



SEE

Violent Night

Film from Universal Pictures

What is Santa? A saint of old? A human? Or something else? This Christmas, see old Saint Nicholas in a rather more supernatural light as things get hectic in *Violent Night*. Fatigued and doing the usual festive rounds, Santa Claus slides down a chimney to find himself in a hostage situation. As ho ho ho turns to oh no no, ambulances will be called, but not for him. It's about time someone did a PR number on our "holly jolly" hero.

Watch in theaters from December 2.



EXPLORE

Beyond the Trees

Game by Broken Rules

Holiday family gatherings getting a bit stressful? Escape to the canopy with Gibbon: Beyond the Trees. Playing as – you guessed it – a gibbon, you'll experience ecological adventures as you soar through the treetops to unknown territories. There's game play with a narrative that explores the real-world struggles of wild animals, including deforestation, poaching, and climate change. Alternatively, you can simply enjoy going ape in liberation mode as you race to freedom. Master dynamic movements as you swing, slide, and somersault in search of a home in an ever-changing world.

Play on Nintendo Switch, PC, Mac, and more.



SCIENCE IN MEDIA



WATCH

The Witcher: Blood Origin

Series on Netflix

Hear that? Wind's howling, bringing news of *Witcher: Blood Origin*. Set 1,200 years before Geralt of Rivia, at a time when Witchers didn't even exist, the mini-series explores how and why they were created. It will also trace the events that led to the "Conjunction of the Spheres" as the worlds of monsters, men, and elves became one. Arriving as something of a Christmas present for Witcher fans, it's set to land on Netflix on December 25 after a delay from COVID. Michelle Yeoh headlines as elf Scian, joined by Sophia Brown as musician Éile.

Available to watch from December 25.





DATES TO REMEMBER

It's the most wonderful time of the year in some parts of the globe, but there's a lot more to be getting on with than festive fun this December. As we welcome the winter solstice, we unite in the fight against HIV on World Aids Day and later celebrate the greatest minds in scientific achievement as the Nobel Prize award ceremonies kick off.

DECEMBER



World Aids Day

This December we remember those who have died from AIDS-related illness, and work together to build a better future for people living with HIV. Globally, there are an estimated 38 million people with the virus, which, having only been identified in 1984, has claimed the lives of over 35 million people, making it one of the most devastating pandemics in human history. Rock the ribbon this **World Aids Day** as you fundraise for this worthy cause and support life-saving research.

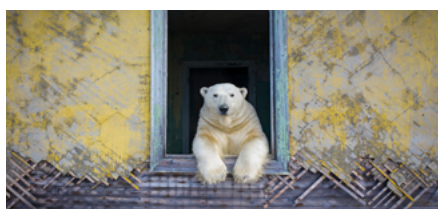


Geminid Meteor Shower

2022 will be seen out by one of the latest showers in the astronomer's year as the Geminid meteor shower puts on a reliable display each December. Peaking around December 14 to 15, you'll see space debris zooming into Earth's atmosphere at speeds of around 70 kilometers per second (43 miles per second). As they vaporize, you'll enjoy a technicolor display of white, yellow, green, red, and blue meteors caused by the trace metals they contain.

Wildlife Photographer Of The Year Entry Deadline

Were you wowed by this year's Wildlife Photographer of the Year competition and want to give it a go? The deadline to get your photos in and be considered for the WPY 59 competition is Dec 8. Considered one of the world's most prestigious awards in wildlife photography since 1965, there are a few rules to review, but entries are **open now** so check it out and don't miss your chance to tell your stories of the natural world.



2022 Nobel Prize Ceremonies

Looking to the greatest minds in physics, chemistry, medicine, and more, the Nobel Prize is showcasing a rich and diverse roster of laureates for the 2022 competition. Find out why the awards take place and what goes into the making of a **Nobel Prize laureate** in the lead-up to the award ceremonies on Dec 10.

21

Winter Solstice

The solstices are the two days each year when the Earth's poles reach their maximum tilt away from the Sun. At the winter solstice, the Sun travels the shortest path through the sky, meaning in the Northern Hemisphere it's the shortest day and the longest night. The actual solstice will happen at 9:48 pm UTC as the Sun's arc reaches its minimum point for the Northern Hemisphere, marking the beginning of brighter days ahead.



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

Choose how you end each issue. For those who prefer the darker side, Francesca Benson reveals how your books may be trying to poison you. If you like your science lighter, Maddy Chapman finds out what really gets the party started for us humans, music-wise.

YOUR TOUCH IS POISON

Watch out, old book enthusiasts – your collection might be poisoned. Starting with just one suspicious green tome that turned out to contain arsenic, the **Winterthur Poison Book Project** has so far identified a further 101 arsenic-tainted books out in the world, with more probably lurking undetected.

The culprit is a pigment called emerald green, aka copper acetoarsenite, used to color cloth book bindings. Discovered in 1808 and first manufactured as a pigment in 1814, the toxic compound has also been historically used as an insecticide.

ARSENIC POISONING IS SERIOUS, AND IN SOME CASES LETHAL.

Emerald green boomed in popularity in Britain and America in the 1850s. Indeed, many of the books in the database are from libraries across the US, with one found in a library in Leeds, England. The team even bought one in a local used bookshop for \$15.

"These bindings are very common in libraries and private collections," said Dr

Melissa Tedone, Conservator and Lab Head for Library Materials Conservation at Winterthur Museum, Garden, & Library, in a **statement**.

Tedone's interest was first piqued by *Rustic Adornments for Homes and Taste*, a green book published in 1857 with a "black, waxy excretion on the surface" and colorant that was "flaking off really easily," she told **National Geographic**. Further analysis of the pigment by Dr Rosie Grayburn, using X-ray fluorescence and Raman spectroscopy, revealed that it did indeed contain arsenic.

Those most at risk from these books are people that work with them, such as librarians and researchers, so the project advises wearing nitrile gloves to handle books with emerald green pigment and wiping down any surfaces they are on with a disposable cloth, as they can shed tiny amounts of arsenic. Arsenic poisoning is serious, and in some cases lethal. Short-term symptoms include nausea, diarrhea, and numb and tingling extremities. Long-term symptoms include skin lesions and an increased risk of various cancers.

So, anyone with a known interest in old books, if you find a dusty emerald green tome tucked in your stocking or under your tree, consider the real intentions of your Secret Santa...



The Darker Side of Science

FEEL (DON'T HEAR) THE BEAT

As we head full throttle into the holiday party season, you may find yourself wondering: How do I host the perfect festive fiesta? Don't worry, we've got you covered. Time to unearth last year's tinsel, crack out your Gran's eggnog recipe, and, er, stick some very low-frequency bass on the stereo.

Don't bother with a buffet, and don't even think about a Secret Santa, the secret to a good yuletide time lies in music you can't even hear. If you want to get people grooving, bass so low it's undetectable to the human ear may be the way to do it.

In a study in **Current Biology**, which unexpectedly meets all your festive party planning needs, scientists discovered that playing bass at extremely low frequencies could be the key to driving merrymakers to the dancefloor. In a live concert-cum-scientific experiment, researchers introduced inaudible levels of bass over the speakers and found that people threw more shapes when they did so.

Unbeknownst to the concertgoers, who were wearing motion-sensing headbands to measure their movements, the researchers were playing very low frequency bass on and off every two minutes and recording the effect this had on their dancing. When the bass was playing, they found, revelers danced almost 12 percent more than when it wasn't.

IF MARIAH ISN'T GETTING TOES TAPPING AS SHE RIGHTFULLY SHOULD, IT COULD BE TIME TO PLAY THAT ACE UP YOUR SLEEVE AND PRESS PLAY ON SOME LOW FREQUENCY SOUND.

So, if the dancefloor isn't popping at your holiday soiree and Mariah isn't getting toes tapping as she rightfully should, it could be time to play that ace up your sleeve and press play on some low frequency sound.

While we at IFLScience remain dubious that *All I Want For Christmas Is You* could bop any harder – if it ain't broke don't fix it, right? – we're always happy to be proved wrong, especially when good times are at stake.

Happy holidays! May your days be merry and bright, your dancefloor packed, and your bass low!



THE LIGHTER SIDE OF SCIENCE