

CURIOS



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REAL ASTRONOMICAL EVENT?

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THE TWILIGHT ZONE?

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NEWS BITES



Glitter Ban

You may notice less of the sparkly stuff this festive season as the European Union's ban on the sale of microplastics in consumer products has gone into effect. This means that glitter made from plastic that isn't biodegradable, natural, or water-soluble cannot be added to cosmetics, paint, or festive decorations such as cards or wrapping paper. However, the ban does not include environmentally friendly glitter, which has seen a huge rise in the last few years as the damage to the environment regular glitter does has been widely acknowledged. The US and the UK may follow suit, although neither has announced plans yet. If you can, this festive season find a different way to sparkle.



Visit Europa

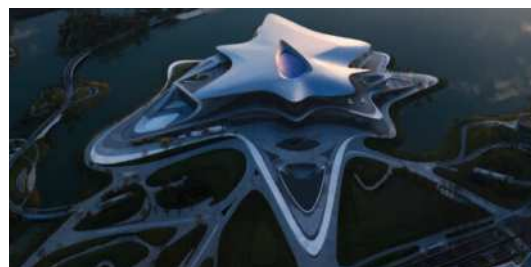
Looking for a festive gift that is out of this world?

Send your loved one's name to Jupiter's icy moon Europa. NASA's Europa Clipper mission to explore this "ocean world" launches next year, and your name will be **etched onto a microchip** and mounted on the spacecraft – the first to explore a world besides Earth with a global ocean, one which may support life. You can also download this and other space travel posters designed by NASA, which also make excellent gifts, for free [here](#).



Space Opera

Despite writer and actor strikes in Hollywood pushing back a glut of movies slated for a December release, there are still a few big sci-fi films hitting big and small screens this month, notably the Frankenstein-esque *Poor Things* and the long-awaited *Aquaman* sequel. Perhaps the most anticipated is Zach Snyder's epic space opera, *Rebel Moon Part 1: A Child Of Fire* for Netflix. Part 2 arrives in April 2024, with the hope of launching a franchise not that dissimilar to another space opera that played out in a galaxy far, far away. *Rebel Moon* tells the story of a mysterious female soldier as she recruits warriors from across the galaxy to fight back against a corrupt ruling force threatening galactic peace. Whether it comes with sassy robots and furry sidekicks is yet to be seen.



A Sci-Fi Museum Out Of This World

China's newest science fiction museum has got the world talking for myriad reasons, not least its out-of-this-world design. The Chengdu Science Fiction Museum in the capital of Sichuan province in Southwest China could pass for a spaceship floating on a lake. From above, it looks like a seven-point star or a liquid metal that is starting to spread. However, the design team from the world-famous Zaha Hadid Architects also designed the roof and canopy to mimic the distant mountains and clouds above. Incredibly, the whole thing went from concept to completion in just 12 months to host the 81st annual World Science Fiction Convention back in October. The inside is just as wild as the outside, which you can see [here](#).



The Moonwalkers Experience

Tom Hanks returns to the Moon in this new immersive virtual experience that hits London, UK, this month. The production team behind **Apollo Remastered**, the most comprehensive collection of digitally remastered Apollo photos, has teamed up with Hanks, famous for issuing the line “Houston, we have a problem,” as Apollo 13 astronaut Jim Lovell, to offer a unique new perspective on humanity’s journeys to the Moon. **The Moonwalkers: A Journey With Tom Hanks** will not only tell the history of the Apollo missions but also the plans for Artemis to return 50 years after humans last visited. The visuals that will be projected across the floor and walls of London’s Lightroom include some of the photos featured in *Apollo Remastered*, plus archival and newly shot film, and interviews with Hanks and the Artemis 2 crew as Hanks narrates the nearly hour-long journey. Moonwalkers is on until April 2024.



Purrfect Poker Face

Worried about your poker face should you receive some questionable gifts this holiday season? Perhaps look to your nearest feline for pointers on facial expressions. An adorable **new study** has revealed cats have nearly 300 different facial expressions they use to communicate with each other: 26 facial movements ranging from an ear flick or blink to a curl of their whiskers that combine to make 276 distinct expressions. Humans have only 44 facial expressions while dogs have a mere 27 – so if you’re unsure how to respond to your grandma’s questionable gift choices look to your cats, not your canines, they’re of no help here.

WHAT'S UP?



Santa Claus Is Coming To Town How To Spot His Sleigh This Holiday

Name: Santa Claus/Father Christmas/that old guy you saw your mom kissing

Appearance: Round belly, big beard, and a rather fetching red and white suit

Location: 408 kilometers (253 miles) above the Earth... and chimneys

Is it really Santa’s sleigh?

OK, you got us – it isn’t actually Saint Nick and his band of gravity-defying reindeer. It’s the International Space Station (ISS), which can be seen whizzing across the skies each year on Christmas Eve and Christmas Day.

Where and when can I see it?

The ISS will only be visible during the holidays at certain times and places. This is because a) it needs to be pretty dark in order to see it and b) each of its orbits covers a different part of the Earth.

NASA’s new **Spot The Station App** can tell you if you’re one of

the lucky ones; simply enter your location and it’ll show you all sighting opportunities. However, it only gives this information a couple of weeks in advance, so you’ll have to check the timings for your location closer to the day.

Fair warning though if you’re hoping for a lie-in – last year’s flypasts happened pretty early in the morning on both December 24 and 25. If you’re willing to make that sacrifice, look for a fast and constant bright light in the sky, traveling from east to west.

What if I miss it?

Hopefully, that means you were tucked up in bed fast asleep, as we all know that’s when Santa drops in. If you want to make the good list but still see the ISS, you’re in luck – it orbits the planet 16 times a day, every day, so there are plenty of opportunities outside of the festive season.

OUR COVER STORY



ARE NO TWO SNOWFLAKES ALIKE?

Snow crystal development is complex but deterministic, so can we really say that no two snowflakes are the same?

By Rachael Funnell

Image Credit: James Rodrigues. Modified from ChaoticMind75/Stock, themefire/Envato

They say no two snowflakes are alike, but, when you think about it, how could anyone possibly know that? The truth is that you can't, for reasons we'll dive into later, but what we can know is that your chances of getting two identical snowflakes out in the wild are pretty much zero. Why? Because the process through which they form is so environmentally specific.

Snowflakes can be any old fleck that falls from a winter cloud, but when we talk about the individual structure that gets slapped all over festive decorations, we're talking about snow crystals. These delicate crystals form in **specific patterns** depending on the temperature and are the result of water freezing from a gas (vapor) straight to a solid (ice) without first becoming liquid. When a waterdrop freezes, that makes what we call sleet.

The biggest snow crystals can take as long as 45 minutes to form, providing a big window for environmental conditions to change and shape their development. As it turns out, that classic Christmas "stellar" snowflake is just one of many forms these crystals can take, and within the minutiae exists near limitless variety.

The shape of snowflakes

A snowflake develops in stages, gradually increasing in diameter as it sprouts new branches, and the six-fold symmetry we see in snow crystals is due to the way water molecules are arranged within the lattice. The starting point is a three-dimensional hexagon, but this can be a long column or a flat plate. They typically develop slowly and symmetrically, but while maintaining a small size.

However, six-sided isn't the only shape on the cards.

"Most snowflakes are hexagonal, but sometimes they're more triangular in shape,

and on rare occasions, they're almost perfect equilateral triangles," Professor of Physics at Caltech **Dr Kenneth Libbrecht** told IFLScience. "They were first documented about 150 years ago and I've seen them outside many times. Why are they triangular? Part of the puzzle was that when you saw one, you were likely to see another, so they do cluster, and nobody had an explanation for that."

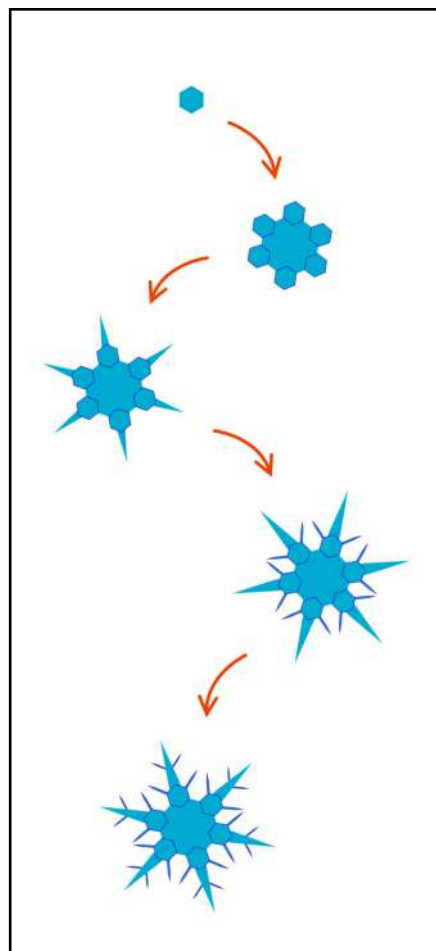


Image credit: © IFLScience

Fortunately, Libbrecht was able to come up with one. Over two decades, he has been chipping away at the many mysteries surrounding the science behind snow crystals. A leading achievement was the establishment of a model that could explain why different temperatures give rise to different crystal shapes, something that was a mystery when he first set out.

"That was a puzzle it just seemed like somebody should solve. That's an

embarrassment to the scientific community that we don't know how that works. I mean, this stuff falls out of the sky," he continued.

Triangular snowflakes cluster because they require a very narrow window of environmental conditions to occur, namely being at -14°C (7°F) with the right humidity, creating just the right amount of instability to give rise to an alternative crystal shape. Libbrecht's model pointed him towards these parameters, and when he tried them out in the lab – hey presto, triangular snowflakes.

That model hinged on the fact that the surface structure of ice depends on temperature, and it can undergo surface pre-melting where the top layer melts, changing the mobility of the molecules found here. While all falling snow crystals will experience surface pre-melting, they won't go through it at the same time as the microchanges in humidity and temperature they experience on the way down won't be identical, as they don't fall in an identical path at the same time.

A lot of variation, then. So, is it time for the big question?

Are no two snowflakes alike?

"I like to say it's a bit of a Zen koan," said Libbrecht – referring to the "paradoxical questions" Buddhist monks must address on their path to enlightenment. "Whether no two snowflakes are alike, it depends on exactly what you mean by alike. And what do you mean by a snowflake? In the lab, we make tiny, tiny little snowflakes the diameter of a human hair, and most of them are just simple hexagons, and they all look alike."

"Those tiny crystals are outside too, and if you see them, they'll look alike, but they're awfully small. If you look at these big stellar crystals, then no, they're very complex. And the complexity comes from the conditions during which they grow[...] You can estimate how many different ways there are to make a snowflake, and it's just an astronomically large number."

Libbrecht compares it to shuffling a **deck of cards** and calculating the chance you'd make the exact same 52-draw again. We

can't say for certain that it would never happen, but the chances are so incredibly slim as to almost be impossible.

The same is true of finding two wild "identical" snowflakes – which as Libbrecht points out in a moment, is probably the wrong word for it anyway. Besides the ridiculous odds of two crystals developing in the same way, your chances of catching them both outside? Now that's definitely zero.

Can two snowflakes ever be the same?

It's staggeringly unlikely that two snowflakes in the wild will fall in the exact same way, encountering the exact same conditions at the exact same time to wind up with the exact same structure. But what about in the lab? Well, Libbrecht did just that when he made what he calls "identical twins".

"I call them identical twin snowflakes because identical is a bit of a loaded word," he said. "Some people will interpret that as being

identical down to the last molecule, and that's never true. So, I like to say they're a little like identical twin people: they are **not exactly precisely alike**, but they look far more alike than you would think.

"The way it's done is I just drop a crystal onto a piece of glass and then blow warm air down on top of it and then I can change the growth conditions just by changing the temperature and the humidity[...] Because they're fixed, that's a little like having two crystals follow the exact same path through the atmosphere."

"I can make them change and they will both change in the same way at the same time. It tells you that the growth is what we would call deterministic. It's not extremely random. It's mostly determined by the external conditions and if you can provide the same external conditions, then you will get very, very similar-looking snow crystals."

And if you ever found that out in the wild? Well, it'd be a Christmas miracle. ●

How to ID snowflakes

Just like birdwatching, snow crystal enthusiasts observe snowflakes to see what crystalline structures they can ID. Want to try it? Here are some of Libbrecht's top tips:

Wear something warm with a dark sleeve – you need a backdrop for your snow crystal to land on.

Take a magnifier – 5X should do it and cost less than \$5.

Know your snowflakes – just like how you need to know the species to see the birds, you've got to know your snow crystal before you can spot them in the wild. Libbrecht wrote what he calls a "field guide to snowflakes", or you can find photographs and videos of different kinds on his [website](#).

Then, all you need is some cold weather and a bit of patience.



Image credit: MaYcaL/iStock

Image Credit Background: themefire/Envato



Image Credit: Searsie/iStock

MERRY CHRISTMAS (BEETLE)

What could be more festive than a glittering, golden, Christmas Beetle? These beetles from the *Anoplognathus* genus are a type of scarab – closely related to dung beetles – and they like to put on a show for the Australian midsummer by swarming around streetlights. There are around 36 species within the genus, with all but one being endemic to Australia. They can be tricky to tell apart, but as principal research scientist Chris Reid explained for the Australian Museum, looking at the hair on their butts can help.



Image Credit: Diego Grandi/Shutterstock

HOW DO YOU FIND A MATE IN THE TWILIGHT ZONE?

DATING IN THE DARK IS EASIER WITH AN EXTRA SENSE.

By Rachael Funnell

The twilight zone is filled with bizarre, alien-like species that look as if they splash-landed from outer space, and yet there is something that connects us: sexual reproduction. There's no Tinder in the twilight zone, so how are animals looking for love in a place with little-to-no light?

As NOAA Ocean Exploration biologist **Ashley Marranzino**, who has a background in deep-sea fish and sensory biology, told us, there are many unanswered questions, but what we do know is that many of the species' adaptations to life in the deep sea have enabled them to make the most of fleeting physical interactions. That is, unless you're a **male anglerfish**. Yeesh...

How do twilight zone species communicate with mates?

AM: We still don't know a lot about how most species are mating in the deep sea. It's likely that animals living in the twilight zone rely on a combination of different signals to find prospective mates. Many animals likely rely on chemical signals emitted by mates. Others, like

bioluminescent squids, shrimps, and fishes, also generate light that is likely used to signal to potential mates.

Some species (like myctophids, also called "lanternfishes") produce their own light in special **bioluminescent** organs called photophores. The arrangement of photophores is different in each species. In some lanternfish species, there is even a difference in the photophore placement between males and females.

You can imagine that in an environment devoid of sunlight, having a map of different lights on your body would be a great way to signal to another individual if you are of the same species and if you are of a different sex – basically like using flashlights in a dark room to signal if you're compatible or not.

Is finding a mate difficult?

AM: The twilight zone is the largest habitat on the planet and the animals living there aren't always clustered together. We tend to think that it is more difficult to find mates in the twilight zone than it is in shallow water environments, like coral reefs, but the animals are continuing to find mates and reproduce so they must have a strategy.

We're still trying to figure out exactly what triggers different species to mate, how often they reproduce, and how many offspring or gametes they produce. Many of the general strategies are similar to what we see in shallow water species. For instance, some species are broadcast spawners, meaning they release gametes (eggs/sperm) into the water and just hope that an egg will get fertilized by a sperm.

The odds aren't high, so species that use this strategy usually make a lot of really small eggs/sperm in the hopes that a few will survive. Other species, like some shrimps, have internal fertilization and will carry the fertilized eggs until they are ready to hatch. This increases the chances of survival a bit and species that use this strategy will tend to invest more energy into caring for fewer eggs.

Some species appear to have found ways to maximize their chances of finding mates by evolving forms of hermaphroditism. The lancetfish (*Alepisaurus ferox*) are simultaneous hermaphrodites, meaning a single individual has mature male and female reproductive organs at the same time. By enabling lancetfish to mate with any other individual in their population (no need

to find a male if you're a female!), this mating strategy may allow lancetfish to maximize their chances of finding a mate in a large, sparsely populated habitat.

Is mating brief or complex?

AM: Mating has very rarely been witnessed in the twilight zone, but like in shallow waters, it is probably a fairly brief affair: a burst of gametes released into the water, which are quickly swept up by currents or gobbled up by other animals. But there are some exceptions.

One of my favorite mating strategies (and arguably the most bizarre) can be found in anglerfishes. Anglerfish are sexually dimorphic, meaning the males and females have different appearances: Females are much larger and have the quintessential bioluminescent lure on their forehead we so often think of with these fish.

Males, on the other hand, are extremely tiny and lack any light-producing organs. But they do have large noses and relatively large eyes, which they use to help find a female mate. Once the male anglerfish has found his mate, he latches onto the side of her body, where he will stay for the rest of his life.

Image Credit: NOAA Ocean Exploration



In some species, the male angler fish will entirely fuse to the female mate – their circulatory systems will even join so the male receives nutrients directly from his mate. The parasitic males essentially provide a viable mate for the female whenever she is ready, allowing both to take advantage of their reproductive cycles without having to locate a new mate whenever they are ready to reproduce.

Are there any other reproductive obstacles?

AM: If species are broadcast spawning, there is a pretty high chance that the gametes will be eaten, possibly before eggs have been fertilized. From there, it is still a game of chance. Fertilized eggs are small and a great source of nutrients for other animals, so they have a very low chance of survival.

Even if a fertilized egg manages to beat the odds and survive to hatching, the risks are still omnipresent. Larvae are small and must avoid being eaten until they get larger. They also have to get enough food to grow properly. Many species will spend their larval and juvenile life stages in shallower waters where there are more food sources available. But there are also more predators to avoid in these waters. Even in the face of incredible odds, some individuals will survive to adulthood, allowing them to continue the cycle.

Along with these natural pressures, humans are adding additional obstacles for deep-sea species. Even if they seem alien and remote to us, the animals living in the twilight zone are deeply connected to life on the surface of the ocean. Climate change is altering the ocean even in the twilight zone, increasing temperature, lowering pH levels, and expanding oxygen minimum zones.

All of these changes will have implications for how animals in the twilight zone grow and find food in their most vulnerable larval and juvenile phases of life. Pollution (from land-based sources and drilling activities) also impacts the capacity for animals to reproduce in the twilight zone,

exposing these animals to toxins that can lower their reproductive output or increase mortality.

What senses do you need in the twilight zone?

AM: All fishes have six senses. In addition to touch, taste, hearing, vision, and smell, fishes have an added sensory system called the lateral line system that allows them to detect water moving around them – think of it like being able to sense touch at a distance.

While the fishes in the twilight zone share these six senses with their shallow-dwelling relatives, some species have evolved specializations to these sensory systems that allow them to live in a realm with little to no sunlight (only about 1 percent of visible sunlight makes it below 200 meters [656 feet] into the twilight zone and no sunlight reaches below depths of 1,000 meters [3,281 feet]).

What do we still not understand about how deep-sea fishes communicate?

AM: There are a lot of gaps in our understanding of how deep-sea fishes communicate. Unfortunately, research on communication and behavior requires observing live animals either in a laboratory or in the wild. It is not possible to keep these species alive in labs and it is very difficult to observe deep-sea fishes in the wild – the deep-sea is hard to reach, requires expensive technology, and uses tools that typically alter fish behaviors.

Most of what we do know about communication we infer from looking at preserved specimens to hypothesize how the fish could be behaving. For example, we can study the eye of a fish to see what types of rods and cones are present to understand the sensory system's capability even if we cannot experimentally confirm that by studying animal behavior in a lab.

New technology is being developed to help us gain a better understanding of the twilight zone and the animals that live there, which is really exciting because we still have so much to discover! ●



SCIENCE FACT OR FICTION:

WAS THE CHRISTMAS STAR A REAL ASTRONOMICAL EVENT?

The “Star of Bethlehem” is a surprisingly small element of the Christmas story, and yet possible real astronomical events have been put forward as an explanation. Was it a comet, planetary conjunction, or even a supernova? Dr Alfredo Carpineti investigates.



"There came wise men from the east to Jerusalem saying, Where is he that is born King of the Jews? for we have seen his star in the east, and are come to worship him." That's how Matthew describes the "Star of Bethlehem" in **the Bible**; the celestial portent



that announced the birth of Jesus Christ to the Magi and set those three wise men on their travels. But was it a real event?

For centuries, religious scholars and astronomers have wondered this – and if it was real, what was it? The Gospel of Matthew was written around the year 85 CE based on a variety of sources and is the only one of the four canonical Gospels to mention the star. Originally written in Greek, ἀστὲρα was translated as "astra" meaning star, but it could also refer to other celestial objects like a planet or comet. A transient event of some sort is the favored explanation: a comet, supernova, or even a planetary alignment.

"There has been a lot of debate over what the Star of Bethlehem could be," **Dr Greg Brown**, astronomer at the Royal Observatory Greenwich in London, told IFLScience.

"An unusual event like a supernova would certainly be a possible candidate with one having occurred in the year 4 BCE. Alternatively, an event with a strong astrological association, like a comet or conjunction of a planet or the Moon with

a star (especially Regulus, the little king) would also potentially have been noted as an event that may herald the birth of an important person."

That is assuming the event took place in the first place. Given that the star only appears in the Gospel of Matthew, the simplest explanation is that it is a fictional addition by the authors, possibly to link the birth of Jesus to the Star Prophecy from the Book of Numbers and strengthen his messianic claim.

"Despite a lot of effort to find out, the reality is that we can't be certain that the apparently astronomical event actually happened, or that any particular astronomical event was in fact recognized as a specific sign at the time," Dr Brown said. "There is always the chance that an event that occurred around the time may have been attributed as a sign after the fact and written in by later authors as though it were recognized at the time."

A supernova sign?

In the case that it is real, noting it suggests something had changed in the night sky. Stars do not move quickly enough for humans to appreciate them in a new location, so one interpretation is that if a star was involved, it became visible because it suddenly became much brighter, likely as a result of exploding as a **supernova**. It's rare to witness a supernova. The **earliest recorded** was by Chinese astronomers in 185 CE who described a mysterious "guest star" that stayed in the sky for eight months. Kepler's Supernova was visible in the sky for 18 months after appearing in 1604. That's enough time for the wise men to pack their camels and get to Bethlehem.

***PERHAPS THE THREE WISE
MEN DIDN'T SEE A SINGLE OBJECT.
THE INTERPRETATION OF THE MAGI WAS
THAT THE CONJUNCTION WAS A
"STAR", ALTHOUGH PERHAPS
NOT IN MODERN TERMS.***

There are few candidates for such an object. RCW103 is a supernova remnant that

appeared to have exploded about 2,000 years ago. It is in the southern constellation of Norma, which can only be seen completely by observers south of 29° parallel North. Bethlehem has a latitude of 31.7°. Another possibility is the Hulse–Taylor pulsar in the constellation of Aquila, the Eagle. Chinese and Korean astronomers recorded an event that could be linked to the progenitor of the pulsar going supernova sometime between **4 and 2 BCE**.

It might not have been a supernova at all but a nova, a temporary brightening of a white dwarf. These stars have companions from whom they steal material. As the material hits the surface of the white dwarf, the overall brightness increases massively. If the white dwarf steals enough mass, it might even collapse on itself and become a supernova.

Novae are a lot more common than supernovae, so could be a good explanation for the Christmas star. There is about one new nova every 12 to 18 months that becomes

bright enough to be visible to the naked eye. However, an alternative that does not involve sudden brightening but still involves a star (together with planets in this case) is the celestial configuration known as appulse.

Planetary conjunction, alignment, or appulse

Perhaps the three wise men didn't see a single object. The interpretation of the Magi was that the conjunction was a "star", although perhaps not in modern terms.

An appulse is the apparent closest approach of two objects in the sky, related to a similar event known as a conjunction, but technically a single instant, Dr Brown explained. This may appear to the observer as a single point of light.

"Depending on the objects, they can appear close together in the sky for a considerable period of time. Conjunctions involving the Moon will be close for several hours, while conjunctions involving a planet could last

several days or even weeks depending on the objects involved and how close together is deemed 'close' in the eye of the observer."

THERE IS ONE PROBLEM WHEN IT COMES TO FINDING A SUITABLE ASTRONOMICAL CANDIDATE FOR THE GUIDING STAR: ITS JOB IS TO GIVE DIRECTION – AND MOST CELESTIAL EVENTS ARE VERY BAD AT DOING THAT.

There were certainly interesting planetary conjunctions in the decade or so before the canonical birth of Jesus. Some were close but not visually impressive, such as the Jupiter and Saturn conjunction, others might have been a bit more peculiar, such as the meeting between Regulus, Jupiter, and Venus in 3 BCE or the Venus–Jupiter conjunction of 2 BCE.



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However, there is one problem when it comes to finding a suitable astronomical candidate for the guiding star: its job is to give direction – and most celestial events are very bad at doing that.

“THE CONSTANT SPIN OF THE EARTH MEANS THAT ANY OBJECT THAT STARTS IN ONE PART OF THE SKY WILL INEVITABLY MOVE ACROSS IT OVER THE COURSE OF A FEW HOURS.”

Comet: a celestial GPS?

The most common interpretation of the star is that it was a comet, because they move across the sky. Possibly, it is also the directional appearance of comets – the head and the tail are a bit like an arrow – that suggests something for the wise men to follow, to be guided to Bethlehem. However, there is also a major problem with that as a definitive explanation.

“A comet has certainly been used to represent the Star of Bethlehem before but as a deliberate marker of direction, it suffers

from the same problem as every other object in space does: The constant spin of the Earth means that any object that starts in one part of the sky will inevitably move across it over the course of a few hours,” Dr Brown told IFLScience.

“The result is that with the exception of the North and South celestial poles (directly above the North and South poles), if you try and walk towards an object in the night sky you will be constantly changing direction over the course of the day and it won’t point at any specific place.”

The Earth spins on its axis and moves around the Sun so the position of objects in the night sky shifts a little bit every day. In fact, although the planets are all moving in one direction around the Sun, when the Earth catches up to them (or them to Earth) in their orbital path, they can appear to stop still in the sky, or even move backward –

Mercury in retrograde, for example.

This apparent stationary period for planets is short and wouldn’t be much use as a signpost for a specific location on Earth.

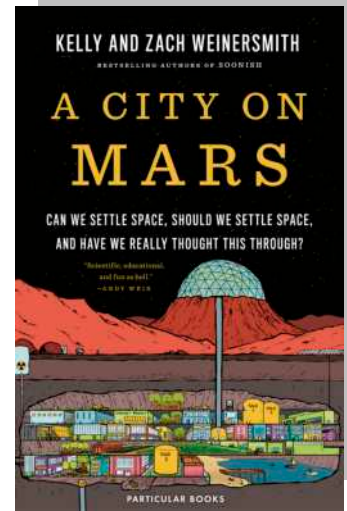
“A comet might seem more plausible given that it will move across the sky over time, possibly partly countering the spin of the Earth, but the reality is that it would still be unable to maintain a constant direction in the sky or reasonably guide someone towards a specific place,” Dr Brown explained.

“Instead, perhaps a more likely explanation is that they followed the sign of the ‘star’ existing, not literally followed it by walking towards it. This would be more consistent with astrological work of the time.”

Some scholars believe the wise men were astrologers who had been watching the skies for years for a sign portending the birth of the new king as told in the Old Testament, and when a suitable astronomical event occurred, they identified it as the time being right to set out and claim him. However, with the Catholic church later declaring **astrology** as heretical, this interpretation of the heavens might over time have fallen out of favor for a more tangible explanation – an event that just happened to coincide with the birth of Jesus. ●



A HOMESTEADER'S GUIDE TO THE RED PLANET



Best-selling authors Kelly and Zach Weinersmith consider the many complex questions of humanity's expansion into space in this excerpt from *A City on Mars*.

So. Space settlements. Have we really thought this through?

If humanity survives the next few centuries, it's probable we'll expand into space. People, nations, and the international community have options about how to proceed. The choices we make now – about the pace of expansion and the rules underpinning it – will shape that future in ways we can't yet imagine. The wrong choices wouldn't merely slow us down, they might create existential risk for humanity.

We can't make these choices properly unless people actually know what the truth is about space settlement. All of it. Not just the size of the rocket or the power needs of a settlement or the available minerals in asteroids, but the big, open questions about things like medicine, reproduction, law, ecology, economics, sociology, and warfare. Detailed treatments that are honest about the severe difficulty of these things are almost invariably left out of books and documentaries about space settlement.

Why is this discourse so often bad? We believe there are two major reasons. First, the general public knows very little about space. Most people can name exactly one astronaut, and

with an appropriate mnemonic can say the planets in order. Outside of a few weirdos, most of us don't know things like what lunar soil is made of, or what the Outer Space Treaty says, or the history of nuclear weapon detonation in space.

Given the limited public knowledge of space science in general, knowledge of its weird little cousin – space-settlement science – is almost nonexistent. And that's where we arrive at the second problem. If you are ignorant about space settlement and want to become educated, many of the articles you'll read, many of the documentaries you'll watch, and pretty much every single book on the topic have been created by an advocate for space settlement.

Now look, there's nothing wrong with advocacy. The space-settlement geeks we've met are smart, thoughtful people. Most of them, anyway. But reading about space settlement today is kind of like reading about what quantity of beer is safe to drink in a world where all the relevant books are written by breweries. Even when they're trying to be evenhanded, they leave things out. One of the most prominent books on space settlement, *The Case for Mars*, is over 400 pages long, including obscure historical information on Mars conferences of the 1980s as well as detailed chemical equations for plastic production at the Martian surface, but never once mentions the existence of international space law. Of the five decades of legal precedent that will dictate the political nature and geopolitical consequences of any Martian future, not a word.

The little book you're reading right now, which admittedly begins with a Uranus joke and contains an explainer on space cannibalism

(stay tuned), is nevertheless the only popular science book we're aware of that offers the whole picture without trying to sell you on the idea of near-term space expansion. Rather, we'll try to clear up a lot of misconceptions and then replace them with a much more realistic view of how feasible space settlements are and what they might mean for humanity.

But first, we should introduce ourselves. Hi. We're Kelly and Zach Weinersmith. Kelly is a biologist and Zach is a cartoonist. We're also a wife-and-husband research team who've spent the last four years trying to understand how humans will become space settlers. We've gone to conferences, conducted endless interviews, and collected, at last count, 27 shelves of books and papers on space settlement and related subjects. We are space geeks. We love rocket launches and zero-gravity antics. We love space history's strange corners like red cubes and tampon bandoliers.

After a few years of researching space settlements, we began in secret to refer to ourselves as the "space bastards" because we found we were more pessimistic than almost everyone in the space-settlement field, and especially skeptical about the most grand plans of space geeks. We weren't always this way. The data made us do it. Frankly, we are cowards and would very much like to agree with the consensus. We didn't like being this pessimistic, especially about an endeavor that so many people think embodies the best of human nature. It makes one feel like, well, a bastard. We think space settlement is possible, but the discourse needs more realism – not to ruin everyone's fun, but to provide guardrails against genuinely dangerous directions for planet Earth. ●

AUTHOR Q&A



KELLY & ZACH WEINERSMITH

AUTHORS OF *A CITY ON MARS*

In the hilarious *A City on Mars*, best-selling authors Kelly and Zach Weinersmith set out to write the seminal guide to future settlements on other worlds, specifically Mars – but having written the book, now they're not sure it's a great idea...

The book may burst some bubbles for those interested in settling the cosmos in the near future. What were your expectations about the reality of such a complex endeavor and did anything surprise you about it?

We thought space settlements were coming quite soon, and it was time to think more carefully about high-level human stuff, like international law and local governance structures. That stuff certainly matters a lot, but we were surprised by how much of the more basic stuff was simply not worked out – things like medicine and agriculture. We were also surprised by how, quite often, there are whole debates premised on things that aren't viable. For example, articles crop up about who might get rich using lunar water – in reality,

there's just not that much water and even the most gettable water is still very hard to use.

Perhaps most surprising is just how little science we have about human reproduction in space – we barely even know anything about rodent reproduction. It's a huge impediment to space settlement. Or, worse, if we proceed with space settlement without making sure reproduction is safe, a Mars settlement could rapidly become an ethical nightmare.

Is there a particular challenge that you feel is purposely overlooked among space enthusiasts?

Many. A very basic one is that the Moon is carbon-poor. Carbon! The basis of life. Good luck farming without it. You sometimes read articles claiming you can grow plants in lunar soil, but you literally cannot. You can grow plants in lunar soil if you add nutrients, water, and an atmosphere, but that's true of anything that isn't plant poison. Stuff we take for granted on Earth will have to be shipped at tremendous cost.

The book is full of not just interesting science but also hilarious facts, from milk commercials in space to Scott Kelly's suction pants. What was your favorite?

The taco sauce story. We love that story. As far as we know, the only time a currency was independently developed off-Earth was that shuttle flight where scarce taco sauce

packets became the medium of exchange. We tried very hard to find funny stories people hadn't heard, which also illustrated a principle. If people are wondering why taco sauce was so valuable, it's because the senses of taste and smell appear to dull in space.

If you were to give a realistic timeline for a moderate-sized settlement in space, how many decades away is it?

We have a strong bias against predicting since it's all quite path-dependent. For example, if during the next 10 years there were very rapid developments in autonomous robotics, fusion reactors, and ecosystem design, and if SpaceX's **giant new rocket system** works out as planned, plausibly you could imagine a Moon settlement with thousands of people in 20 or 30 years.

In reality, it'll likely be slower – and that's a good thing. Imagine a future where nations, corporations, and individual rich people control millions of tons of high-speed metal above Earth's gravity well. Throw in that some of those nations are geopolitical rivals. Throw in that some of those nations have nuclear weapons. Throw in that the best parts of the Moon for bases and settlements are quite limited in size. Throw in that the current legal regime could be very conflict-prone because it blocks nations from claiming territory, but (if you believe the US interpretation) allows basically anybody to use any space resources however they like. We need to get a proper international framework in place for this stuff, and frankly the state of the world right this second suggests this will not be easy. More time is both desirable and likely.

For you long-term optimists, we do provide a sort of roadmap of issues that need solutions in our conclusion, including everything from space babies to **space law**. It'll be painstaking work, but to be honest, it's – and we believe this word is allowed here – fucking awesome. Ecosystem construction, robotics, structuring property law for asteroids, and a lot more. •

***A City on Mars* by Kelly and Zach Weinersmith is published by Particular Books and is available now.**

An aerial photograph of a massive glacier calving into the sea. The glacier is a brilliant white, with deep blue veins of meltwater visible on its surface. It has broken into large, jagged icebergs that float in the turquoise water. In the lower right, several seals are swimming, their dark backs and heads visible above the water's surface. The water is a deep, vibrant blue, contrasting sharply with the white ice.

A calving glacier in Greenland makes the rest of the Northern Hemisphere's ice giants look lazy, being among the fastest and most active in the world. Found in the Ilulissat Icefjord, Sermeq Kujalleq is of great importance in research dedicated to monitoring the health of our planet.

THE FASTEST GLACIER IN THE NORTHERN HEMISPHERE

Ilulissat Icefjord – the sea mouth of the Sermeq Kujalleq glacier – is a UNESCO World Heritage Site that boasts some pretty impressive accolades. Located on the west coast of Greenland, it's one of only a handful of glaciers that connects the Greenland ice sheet – a staggering dome in east-central Greenland that sits at over 3,000 meters (9,842 feet) above sea level – with the ocean.

It might not look like a track star, but Sermeq Kujalleq is the fastest glacier in the Northern Hemisphere and one of the most active in the world. According to the **UNESCO World Heritage Convention**, it calves over 35 cubic kilometers (8.4 cubic miles) of ice each year, producing 10 percent of Greenland's total calf ice – contributing more than any other glacier outside of Antarctica.

Ice calving is when large chunks of ice are released from glaciers. When they calve into the sea, they eventually melt, contributing to sea level rise. This in turn releases fresh water into the ocean, altering its salinity, which can disrupt currents and influence global climate systems.

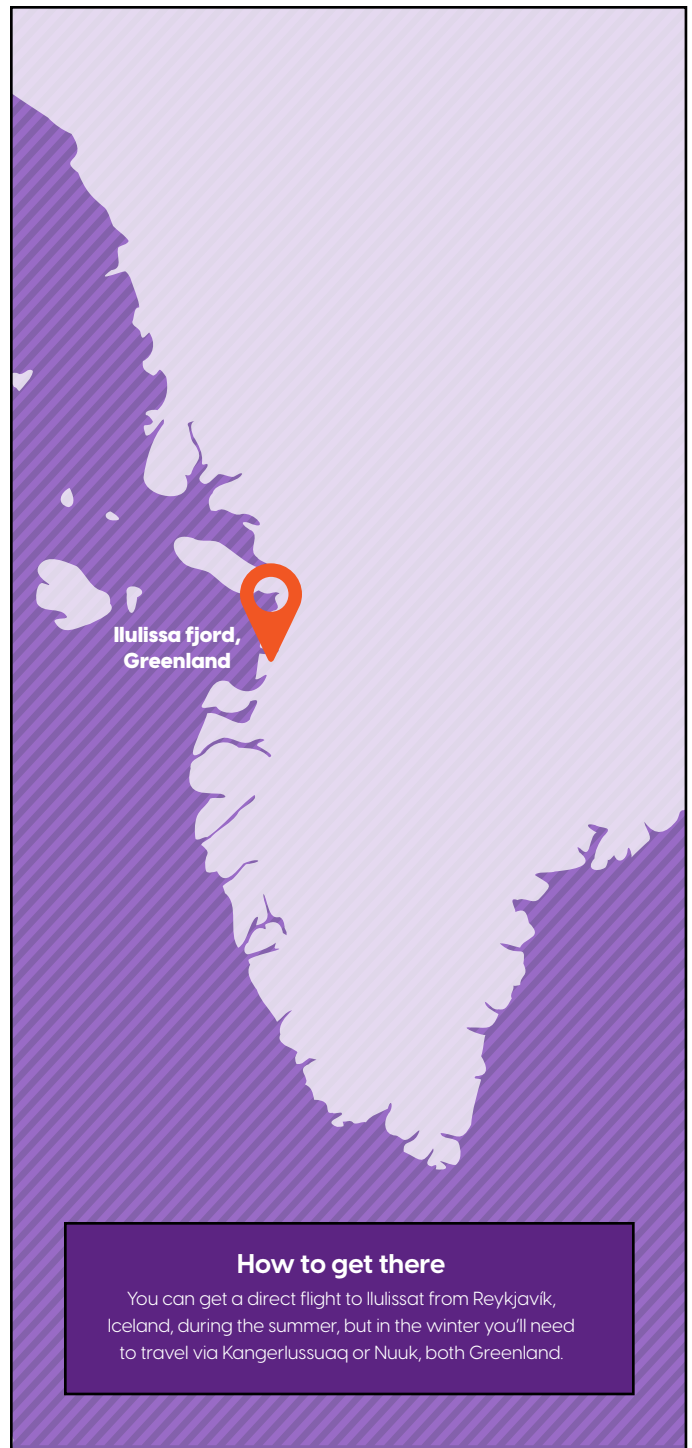
It's not all bad, however, as ice calving also creates new habitats in the form of floating islands. Everything from walruses and seals to seabirds need these shelters, but as wildlife presenter Bertie Gregory's **Wildlife Photographer Of The Year 2023** entry demonstrates, even sitting on a giant ice cube isn't enough to protect you from killer whales.

Scientists are keenly interested in ice calving due to the far-reaching consequences it can have for the health of wildlife and the planet, which makes calving glaciers like that found at Ilulissat Icefjord of great significance. And while they are complicated, they are also staggeringly beautiful.

The ever-changing nature of the fjord means you never quite know what you're going to witness in terms of icebergs, but the nearby town of Ilulissat (which actually means iceberg) is a great starting point for your adventures.

Ilulissat sits in the funky named Disko Bay – or Disko Bugt in Greenlandic – which is a hit with tourists and **migrating whales** alike. Humpback, minke, bowhead, pilot, and fin whales all regularly cruise through here, sometimes slipping through as dorsal fins just breaking the surface, or coming down with a slap as they breach.

Groovy, baby. ●



PLAY



Extremely Powerful Capybaras Game from Studio Bravard

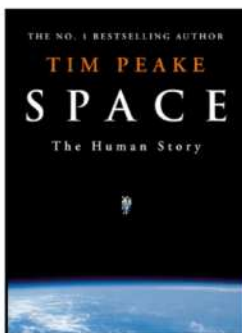
The chilliest animal on Earth gets a chaotic makeover in this PC game that can be played alone or with friends in four-player co-op mode. You'll face down foes from strange corners of the animal kingdom in pursuit of capy-powering weapons on your journey from the **yuzu bath** to victory.

Available from **December 5**.

READ

Space: The Human Story Book by Tim Peake

Journey into an exhaustive history of humans' explorations in space from an astronaut who has clocked over 180 days off-planet. In his latest book, Tim Peake shares exclusive interviews with the men and women who have forged the way for today's astronauts, revealing what it's like to leave Earth, and how it feels trying to readjust to terra firma.



Available to **buy now**.

SEE



Leave The World Behind Film from Netflix

When a cyberattack plunges the world into an apocalypse, two families on vacation must try to find their places in a collapsing world. Written and directed by Sam Esmail of *Mr Robot*, it's a timely reminder of the destructive power of cyberattacks (find out about some real-life hacks [here](#)).

In select cinemas from **Nov 22**, or available on Netflix from **Dec 8**.

LISTEN

Armchair Explorer Podcast with Aaron Millar

As we tilt towards the holiday season, parts of the globe are plunging into darkness – so why not escape the cold and gloomy evenings with the Armchair Explorer? This podcast will transport you to some of the most remarkable journeys humans have made as travel writer Aaron Millar interviews explorers who have tackled the Gobi Desert, the Amazon rainforest, and even plunged into the deep ocean.



Find it on all good **podcast platforms**.

WATCH

Wild Scandinavia TV series from the BBC

This three-part series captures the dramatic landscape and curious wildlife of the furthest northern reaches of Europe. Discover wolf spiders that overwinter in Icelandic springs, giant sea eagles that snatch fish from the ocean, and the mating behaviors of the elusive lynx. You can also ride along with base-jumper Hege Ringard as she plummets at 160 kilometers per hour (100 miles per hour) from clifftop to the shore in the Norwegian fjords.

Available first week of **January**.



SCIENCE IN MEDIA





DATES TO REMEMBER

'Tis the season for celebration – and we're not just talking about festive holidays. This December, we welcome the winter solstice, unite in the fight against HIV, witness the glorious Geminids peak, and much more. It really is the most wonderful time of the year.

DECEMBER



1 World AIDS Day

We kick off the month with World AIDS Day on December 1 – an annual opportunity for people around the world to show their support for people living with and affected by HIV and to remember those who have lost their lives to AIDS. To find out how you can get involved, be it by fundraising, donating, or donning the iconic red ribbon, check out the World AIDS Day [website](#).

International Day of Persons with Disabilities

The International Day of Persons with Disabilities is a United Nations (UN) day that aims to promote a better understanding of disability issues and support the dignity, rights, and well-being of persons with disabilities. "Disability inclusion is an essential condition to upholding human rights, sustainable development, and peace and security," the **UN** says. "The commitment to realizing the rights of persons with disabilities is not only a matter of justice; it is an investment in a common future."

3

Human Rights Day

This year, December 10 marks the 75th anniversary of the Universal Declaration of Human Rights – the landmark legislation that enshrines the rights of all human beings. In the three-quarters of a century since its adoption, human rights have become more recognized and more guaranteed across the globe, but there is still a long way to go to ensure the rights and freedoms of all the world's people are protected. As such, 2023's Human Rights Day theme is "Dignity, Freedom, and Justice for All". Find out more [here](#).

10



Geminids

The Geminids will be soaring through the sky from December 4–20, peaking on Dec 14–15. The meteors are unusual in that they are multicolored – mainly white, but also yellow, green, red, and blue – and originate from a stream of debris left behind by asteroid 3200 Phaethon, which means they're one of the only major showers not to originate from a comet.

14

21/22 Winter Solstice

In the Northern Hemisphere, winter is about to begin. On December 21/22, the Sun will travel its shortest path through the sky, resulting in the day of the year with the least sunlight (around 7 hours and 14 minutes) and therefore, the longest night. This year, the solstice will occur at 3:27 am UTC.



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 the radioactive reason behind Marie Curie's death. If you like your science lighter, find out how you can use a "DNA test" to see if Santa's real.

DEADLY DISCOVERY

If you're not in the mood to celebrate the festive season, then acknowledge the 125th anniversary of this deadly discovery. On December 26, 1898, Marie Curie and her husband Pierre announced the discovery of the radioactive element radium, mere months after identifying polonium. She would later go on to receive Nobel Prizes for her findings – becoming the first woman to do so, the first person to win twice, and the only person to win in two different sciences. Sadly, that world would eventually become fatal to her.

TO THIS DAY, SOME OF CURIE'S BOOKS AND PAPERS ARE STILL SO RADIOACTIVE THAT THEY HAVE TO BE STORED IN LEAD BOXES.

Curie would go on to spend much of her life exposed to radiation in one way or another, whether during her Nobel-winning research or whilst using the mobile X-ray units she developed and then used on the frontline during

World War I. To give you an idea of the level of exposure Curie would've experienced, to this day, some of her books and papers are still so radioactive that they have to be stored in **lead boxes**.

Of course, whilst scientists are now well aware of the dangers of radioactive materials – somewhat morbidly, thanks to people like Curie – little to nothing was known at the time, and so researchers in the field plowed ahead unprotected.

"I WAS TAUGHT THAT THE WAY OF PROGRESS WAS NEITHER SWIFT NOR EASY."

Curie and her husband spent many years working in a poorly ventilated shed and were constantly ill from radiation sickness. She eventually died from aplastic anemia, a condition in which bone marrow cannot produce enough new blood cells, due to stem cell damage. In Curie's case, this was likely caused by her exposure to radiation.

Though an unfortunate ending, Curie once quite fittingly said, "I was taught that the way of progress was neither swift nor easy," and boy, did she make science progress.

THE SANTA GENE

Forget "Elf on the Shelf", there's a new and scientific-ish way of keeping the Christmas spirit alive for kids this year – "testing" for Santa's DNA.

Last year, a young girl **asked police** in Providence, USA to run a DNA test on a cookie to see if Santa was, in fact, real. He was also under suspicion of "failure to finish snacks", which is, of course, a very serious crime – although he's yet to be convicted.

IF THE SAMPLE TAKEN TURNS GREEN, CONGRATULATIONS – YOU'VE GOT YOURSELF A BIT OF "SANTA DNA".

Christine Clow, a mom of four from Massachusetts, was then inspired to create an at-home "DNA test" kit so that children could find out for themselves if Ol' Saint Nick was alive and kicking.

"[I] remember in school the kids were learning about DNA and how it identified you as one person," said Clow,

speaking to **NBC 10 News**. "So we started looking into it [...] and we found out that Santa Claus actually has a special gene." Although we're not sure the research behind that statement is peer-reviewed (or even exists for that matter), you can't deny that it's a fun concept.

IT'S A CREATIVE MIX OF ENGAGING KIDS' SCIENTIFIC CURIOSITY AND FESTIVE SPIRIT.

On Christmas Eve, festive detectives can leave out a cup with a tasty beverage for Santa to drink, leaving DNA in the process. In the morning, they can use the swab in Clow's test kits to swipe the rim, which is then put in a test tube containing a red liquid. If the sample taken turns green, congratulations – you've got yourself a bit of "Santa DNA".

Whilst it might not be the most rigorous of scientific tests, that's easily forgotten when you consider its creative mix of engaging kids' scientific curiosity and festive spirit. "There's so many things kids question at those ages," said Clow. "I feel like if there were little things like this we could [...] make them believe a little longer."



**The Darker Side
of Science**



**THE LIGHTER SIDE
OF SCIENCE**