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Q&A

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6TH
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ISSUE

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OUR **ACTIVE**
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MARTIAN WATER
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WE GET TO
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WHY DO
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LOVE **PRAWN**
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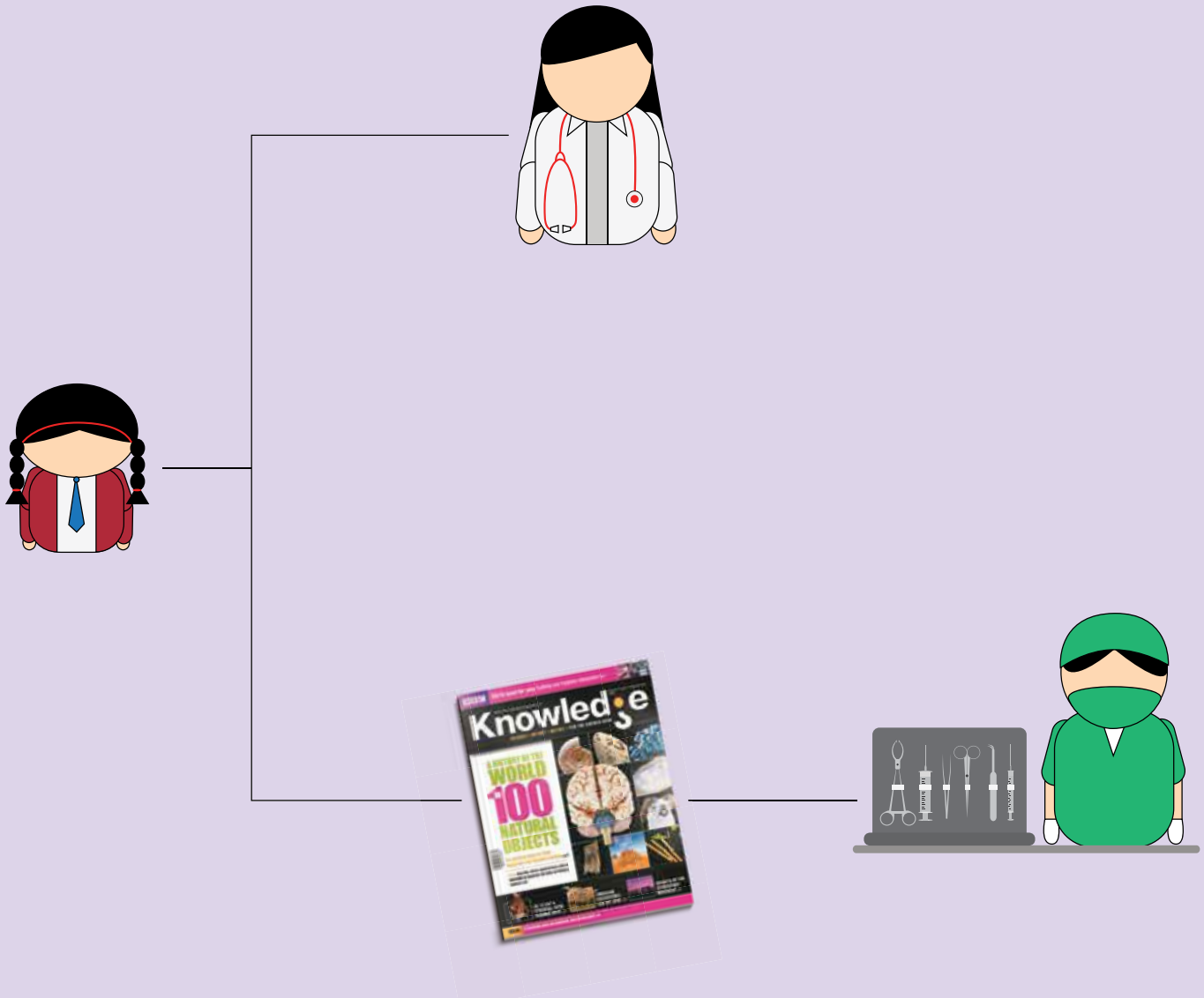
Only space is the limit for these Indian astronauts



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There's no telling what knowledge can do.

If anything can give your kids an edge over their peers, or propel them to do more than you thought possible, it's knowledge. So, give them a head start with BBC Knowledge's endless supply of riveting features, captivating photographs and awe-inspiring facts. One thing's for certain, the sooner you start, the further they'll go.

SCIENCE. HISTORY. NATURE. FOR THE CURIOUS MIND.

FROM THE EDITOR



Captain's log:

Earth Date: November 1, 2016

We're at the cusp of great discovery. Our spacecraft Juno has entered Jupiter's orbit and I know what we find will be rad...

Welcome to our sixth anniversary issue – a Space Special. We have a 26-page Q&A section totally devoted to the world out there, a set of extremely cool, retro-style posters from NASA, and a celebration of India's three space heroes in *In Focus*. Also, from this issue, we're thrilled to initiate a page featuring responses from BBC Knowledgers from our social media platforms. This month, you tell us, appropriately, why you deserve an introduction to Elon Musk.

Not a space cadet? We've got our usual menu of other great stories. Poo scientist, lava lover... there's a bizarre option to inspire you in **The Most Extreme Jobs in Science**. If you've ever felt a twinge of anxiety about putting your trust in a metal bird, there's reassurance in **How Safe is Your Plane?** You'll meet the intriguing geladas of the Ethiopian Highlands on our pages, and discover why some historians consider the **Gupta Period** the Golden Age of India. And, from this issue on, we're excited to foray into the world of travel and food with nuggets and tidbits from across the globe, and we will soon be adding more in literature, art and creativity to the magazine.

My name is Primrose, I bring on board years of experience in writing about women and travel, and I've signed on to be the new captain at the helm of *BBC Knowledge*. And, as you may have worked out by now, I'm more into *Star Trek* than *Star Wars*.

I'd love to hear from you – tell me what you'd like us to feature and email us at edit.bbcknowledge@wvm.co.in I'd love to have you join me on my grand new adventure: discovering new worlds and thoroughly exploring our own.

Primrose Monteiro-D'Souza

EXPERTS THIS ISSUE



Katherine Nightingale(l) and **Jo Carlowe(r)** are science writers, who contribute regularly to *BBC Focus* magazine.

In this issue, they join forces to inform us about some of the most extraordinary and bizarre jobs in science.

See page 58



Jerry Brotton is the associate director of the Queen Mary/Warwick University project *Global Shakespeare*, on which he is developing a series of initiatives in four countries, including India. In this issue, he reveals how some of Shakespeare's works reflected the political crises of the day – much to the ire of Queen Elizabeth's censors. **See page 64**



Neil Ashton is an aerospace engineer and a senior researcher at the University of Oxford's e-Research Centre. In this issue, he explores the rigorous tests that planes undergo to ensure flying remains one of the safest modes of transport. **See page 76**



Himanshu Prabha Ray is a Professor in the Centre for Historical Studies, Jawaharlal Nehru University, New Delhi. In this issue, she digs into the enduring legacy of the Gupta period. **See page 82**



SEND US YOUR LETTERS

Has something you've read in *BBC Knowledge Magazine* intrigued or excited you? Write in and share it with us. We'd love to hear from you and we'll publish a selection of your comments in the forthcoming issues.

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HERE'S HOW TO GET IN TOUCH

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QA

SPACE

SPECIAL

EXPERT PANEL

Dr Christian Jarrett

Christian is a psychology and neuroscience writer. His latest book is *Great Myths Of The Brain*.

Dr Alastair Gunn

Alastair is an astronomer at the Jodrell Bank Centre for Astrophysics at the University of Manchester.

Prof Robert Matthews

Robert is a physicist and science writer. He's visiting professor in science at Aston University.

Dr Peter J Bentley

Peter is a computer scientist and author who is based at University College London. His latest book is *Digitized*.

Luis Villazon

Luis is a freelance science and tech writer with a BSc in computing and an MSc in zoology from Oxford University.

Dr Mark Lorch

Mark is a senior lecturer at the University of Hull, where he teaches chemistry and science.

Dr Elizabeth Pearson

Elizabeth is Sky At Night Magazine's news editor and has a PhD in extragalactic astrophysics.

Colin Stuart

Colin is a science writer and astrophysicist. His most recent book is *Physics In 100 Numbers*.

Dr Stuart Clark

Stuart is an astronomy writer with a PhD in astrophysics. His latest book is *The Unknown Universe*.

Shannon Walker

Shannon is a scientist and NASA astronaut who went to the International Space Station in 2010.

HOW DO ASTRONAUTS GO TO THE LOO?
WHO WILL REACH THE MOON NEXT?
WHAT DOES MARTIAN WATER TASTE LIKE?
WHAT WILL WE LEARN FROM THE JUNO MISSION?
**HOW HIGH COULD YOU JUMP ON OTHER
SOLAR SYSTEM BODIES?**
WHERE ARE ALL THE ACTIVE SPACECRAFT?
WHY DO ASTRONAUTS LOVE PRAWN COCKTAIL?
WHICH ANIMALS HAVE VISITED SPACE?
COULD PLUTO BECOME A PLANET AGAIN?



How 'intelligent' could we make space probes?

One of our biggest problems with space probes and explorer robots is that it takes time to talk to them. Depending on the position of Earth and Mars, it can take anything from four to 24 minutes for a signal to cross the void between them. It currently takes more than 17 hours for a signal to reach Voyager 1, which is our most distant probe. That may be much too slow to warn it about an impending threat. Adding some intelligence to make them more autonomous would enable them to handle such situations by themselves. An explorer robot could avoid driving into a hole, or a probe could reconfigure its electronics and recover from damage. If we make them clever enough, maybe one day a probe might be the first Earth entity to hold a conversation with alien life. PB



Probes like Rosetta still need to receive their instructions from controllers on Earth

VITAL STATS

2,100

The speed, in km/h, of recorded winds on Neptune.

How do astronauts go to the loo?

For 'number ones', they use a funnel attached to a hose that is connected to a fan that generates suction. For solids, they 'dock' themselves carefully over a hole about the size of a drain pipe and clamp their feet into the foot restraints. Waste is caught in an individual bag liner, which they seal after use and the package is sucked into a collection drum. LV



GETTY, NASA



Does zero-g affect sleep and dreaming?

Astronauts in microgravity environments such as the International Space Station (ISS) have to strap themselves into a secured sleeping bag, otherwise they'd just float about. Sleep tends to be more disturbed on space missions than on Earth – this could be due to microgravity or to other factors such as noise, excitement, stress and jet lag type problems (there are 15 dawn and dusk cycles a day on the ISS). Astronauts report having dreams but seem to need less sleep in space – around six hours rather than seven or eight. One theory is that this may be due to the physical ease of moving in microgravity. CJ



Astronauts strap into sleep restraints when it's time to get some well-earned rest

Why don't more planets have rings?

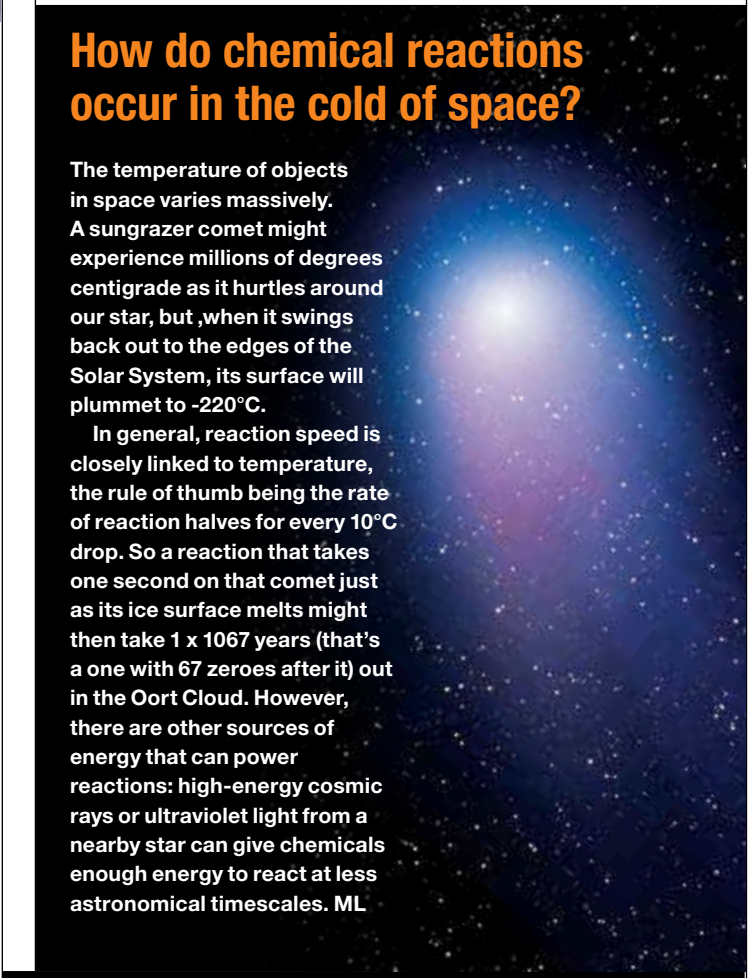
The gaseous outer planets all have rings, whereas the small, rocky inner planets do not. Scientists aren't sure how these rings came about. They may have assembled from leftover material from the planet's creation, or could be the remains of a moon that was destroyed by an impact or broken apart by the gravitational force of the parent planet.

As only the gas giants have rings, scientists think the ring-forming process may be related to the same mechanism that resulted in gas giants forming in the outer Solar System, and rocky planets in the inner Solar System. The energy given off by the infant Sun expelled most of the light gases and other volatile molecules into the outer regions of the Solar System, leaving the heavier elements to form rocky inner planets. This process also seems to have made it easier for the outer planets to form moons. So, the combination of large gravitational forces, the existence of volatile materials such as ices, and the shepherding of material by numerous moons probably means the outer planets were more likely to form and keep planetary rings. AG

How do chemical reactions occur in the cold of space?

The temperature of objects in space varies massively. A sungrazer comet might experience millions of degrees centigrade as it hurtles around our star, but, when it swings back out to the edges of the Solar System, its surface will plummet to -220°C .

In general, reaction speed is closely linked to temperature, the rule of thumb being the rate of reaction halves for every 10°C drop. So a reaction that takes one second on that comet just as its ice surface melts might then take 1×1067 years (that's a one with 67 zeroes after it) out in the Oort Cloud. However, there are other sources of energy that can power reactions: high-energy cosmic rays or ultraviolet light from a nearby star can give chemicals enough energy to react at less astronomical timescales. ML



EUROPE

Ever since Johann-Dietrich Woerner became director general in 2015, the European Space Agency (ESA) has been one of the most vocal bodies calling for us to return to the Moon. Woerner himself put forward the idea of building a permanent base on the Moon (*concept pictured*). He suggested it could be located in the Aitken Basin on the far side of the Moon.

Astronauts from various countries and agencies would be able to use the base to work together towards mutual goals, he says. So far, however, little money has been committed to the idea, but things could change later in the year when the agency decides its priorities and allocates its budget in its Ministerial Council meeting.

CHINA

On 14 December 2013, China became a true contender in the race to put humans back on the Moon when the country successfully landed its Jade Rabbit rover on the lunar surface. The rover operated for 42 days, and although well short of the planned three months, it was still a major boost for the Chinese exploration programme.

The Chinese National Space Administration (CNSA) is now working on its next exploration mission. Dubbed Chang'e 4, the mission will feature a lander and rover, and is scheduled to touch down in the Aitken Basin near the end of 2018. If successful, it will be the first landing on the Moon's far side. CNSA is also developing a powerful new rocket, the Long March-9 (*pictured*), that it says could potentially take humans to the Moon sometime in the 2030s.

RUSSIA

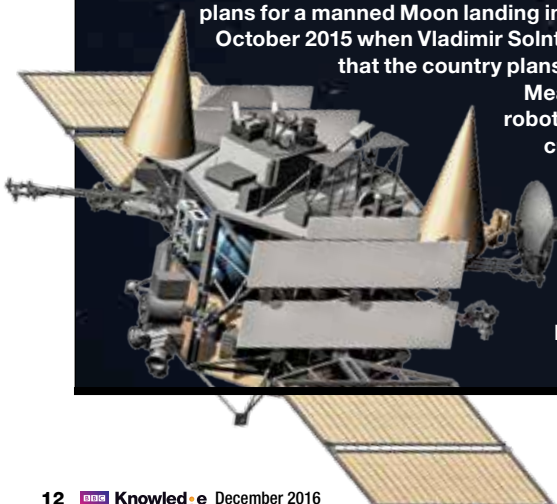
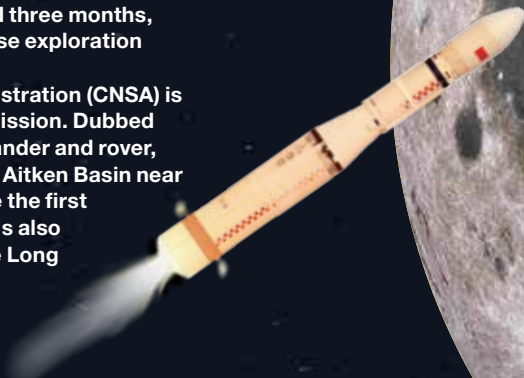
In May 2014, Russian newspaper *Izvestia* published a government document purported to show that the Russian space agency, Roscosmos, was drawing up plans for a manned Moon landing in 2030. Its ambitions were confirmed in October 2015 when Vladimir Solntsev, head of Roscosmos, told reporters that the country plans to send a crew to the Moon in 2029.

Meanwhile, the Russians are ramping up their robotic exploration programme. Roscosmos is currently working on a range of orbiters and landers called Luna-25, Luna-26 (*concept pictured*) and Luna-27. The idea is that the landers will explore the lunar south pole, prospecting for resources such as minerals and water ice that could be used to sustain a human outpost.

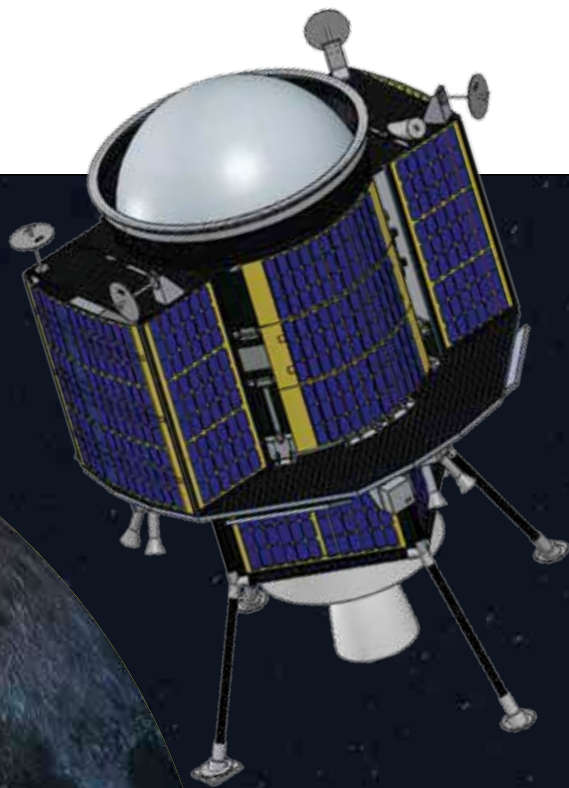


WHO REACH MOON

No human has set foot on the lunar surface since NASA astronaut Eugene Cernan re-entered the Challenger module as part of the Apollo 17 mission in 1972. Now, after more than four decades of inactivity, interest in putting humans back on the Moon is finally heating up again. But who will get there first?



WILL THE NEXT?

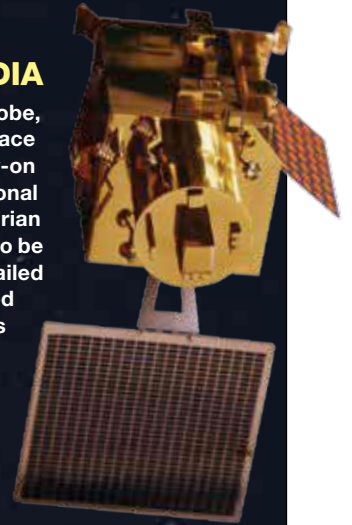


JAPAN

The Japanese Aerospace Exploration Agency (JAXA) has sent two missions into lunar orbit – 1990's Hiten and 2007's SELENE. It's currently working towards making its first lunar landing attempt. JAXA's original plans were for SELENE-2, a large 1,000kg lunar lander and 200kg rover. But JAXA has now scaled down its plans. The new mission, dubbed Smart Lander for Investigating the Moon (SLIM), is a smaller, 120kg craft (*pictured*) that will aim to demonstrate high-precision landing on the Moon's surface in 2018.

INDIA

Following the success of its first lunar probe, Chandrayaan-1 (*pictured*) in 2008, the Indian Space Research Organisation (ISRO) announced a follow-on mission. Whereas Chandrayaan-1 carried additional instruments provided by NASA, ESA and the Bulgarian Aerospace Agency, Chandrayaan-2 was meant to be a collaboration with Russia. When the Russians failed to deliver the promised lander in 2013, India decided to go it alone. The mission's current launch date is set for 2018, this time carrying an all-Indian payload of orbiter, lander and rover.

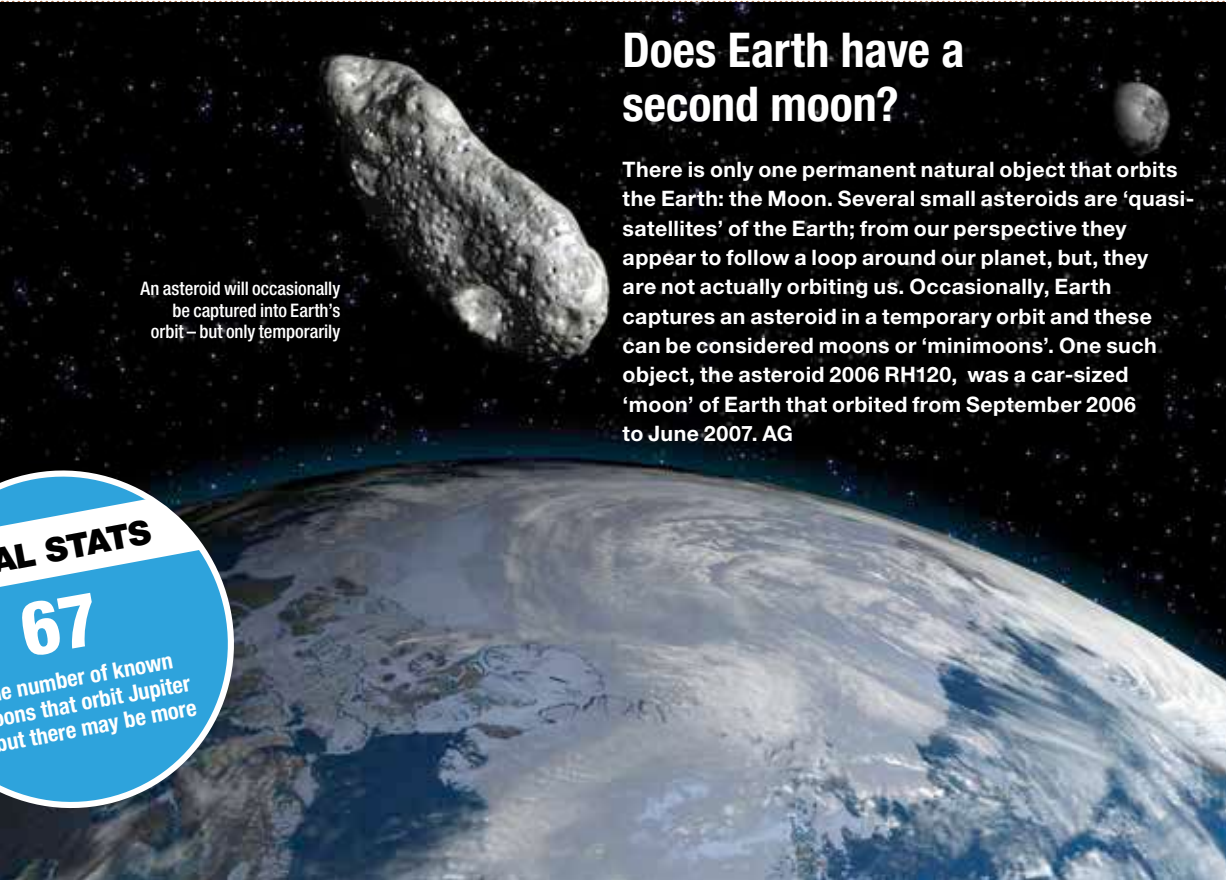


USA

NASA has earmarked Mars as its next big target for manned missions. But, without the rest of the world to help, it's going to be almost impossible to send anyone there. This fact has not been missed by veteran astronaut Buzz Aldrin, who has urged the space agency to refocus on returning to the Moon.

In December 2018, NASA plans to launch the Exploration Mission 1, an uncrewed test of their Orion astronaut capsule (*pictured*) in which the craft will loop around the Moon before returning to Earth. All being well, a crewed capsule will follow in 2023. Should the mission prove a success, the astronauts will be the first humans to see the far side of the Moon with their own eyes since Apollo 17 in 1972.





Does Earth have a second moon?

There is only one permanent natural object that orbits the Earth: the Moon. Several small asteroids are 'quasi-satellites' of the Earth; from our perspective they appear to follow a loop around our planet, but they are not actually orbiting us. Occasionally, Earth captures an asteroid in a temporary orbit and these can be considered moons or 'minimoons'. One such object, the asteroid 2006 RH120, was a car-sized 'moon' of Earth that orbited from September 2006 to June 2007. AG

An asteroid will occasionally be captured into Earth's orbit – but only temporarily

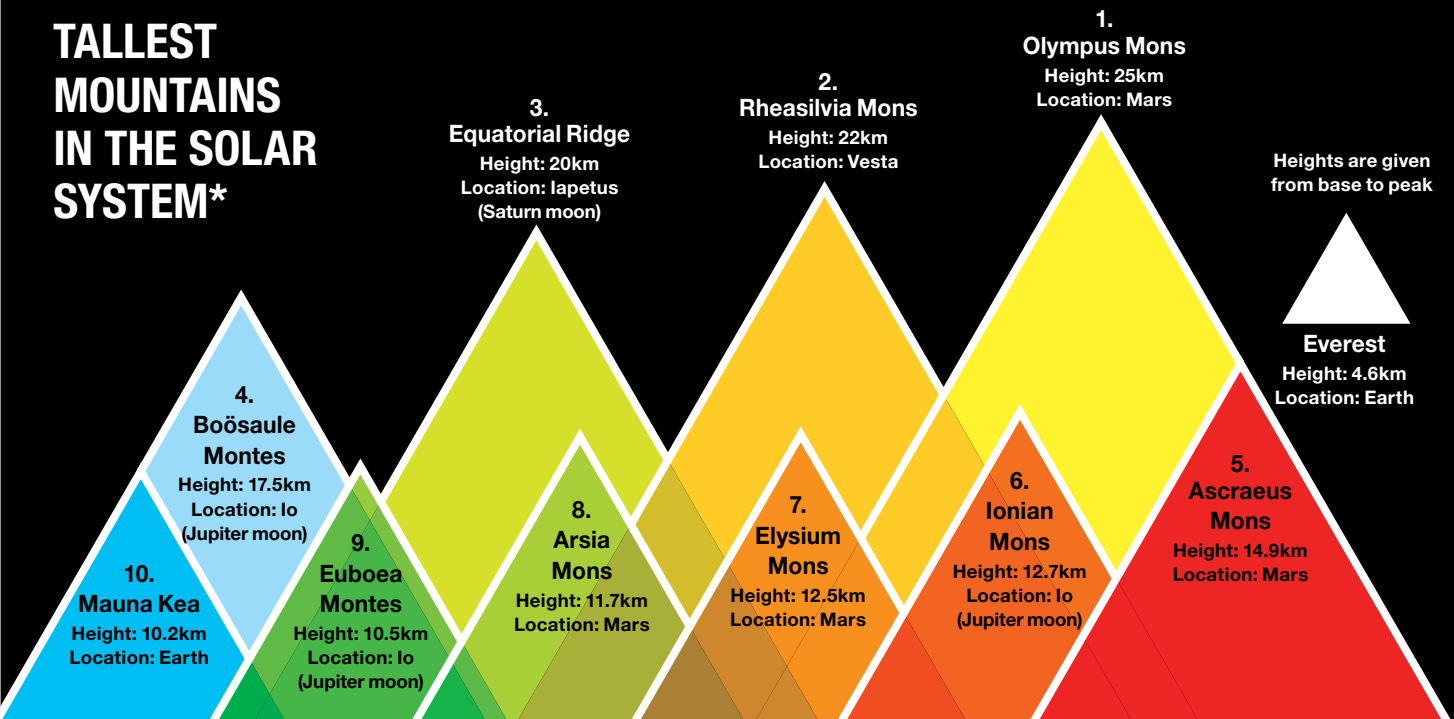
VITAL STATS

67

The number of known moons that orbit Jupiter – but there may be more



TOP 10 TALLEST MOUNTAINS IN THE SOLAR SYSTEM*



NASA, CALTECH/R.HURT(IPAC), GETTY ILLUSTRATION: CHRIS PHILPOT



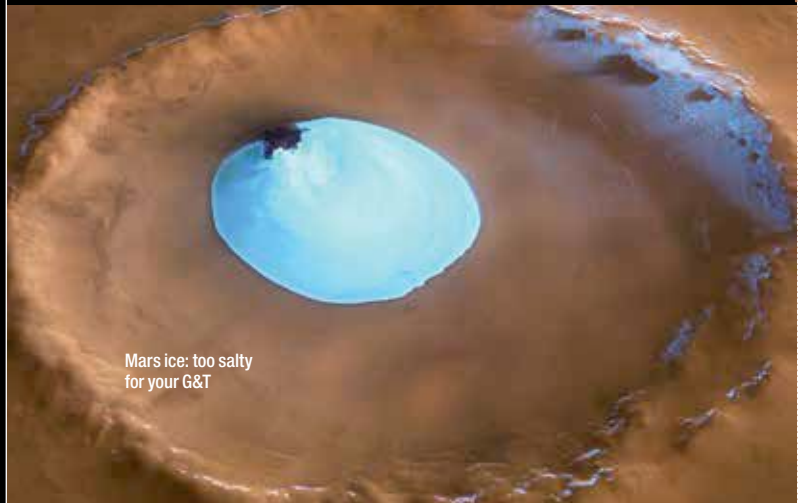
Artistic rendering of the theoretical planet nine

Could there be a planet nine?

It is certainly a possibility. Since we haven't discovered a ninth planet yet, we can be reasonably sure that if it exists it is quite distant from the Sun. Recently, astronomers analysed the motions of objects at the furthest edge of the Solar System and noticed something peculiar. The elliptical orbits of many of these objects all seem to line up in the same direction. This could be explained if a sizeable ninth planet exists. This as-yet-unproven planet must orbit at least 20 times further away than Neptune and could be 10 times the mass of the Earth. AG

What does Martian water taste like?

Most of Mars's water isn't present as liquid: it's ice, mixed in with the soil. Mars has such low atmospheric pressure that pure water ice sublimates directly from solid to gas without ever melting into liquid. There is evidence that the Red Planet may occasionally have some liquid water, but it would be undrinkably salty. If you distilled the water inside your pressurised habitat though, it would be quite safe to drink. LV



Mars ice: too salty for your G&T

BIGGEST CRATERS IN THE SOLAR SYSTEM



What will we learn from the Juno mission?

On 4 July 2016, NASA's Juno spacecraft completed its 2.8 billion kilometre journey to the king of the Solar System: Jupiter. For centuries, the gas giant has remained a mystery, shrouded in a thick atmosphere of hydrogen and helium. But now, Juno will look beyond the upper layers, right into the planet's heart.

Juno will map the gravitational and magnetic structure of the planet, allowing researchers to test theories about how its atmospheric gases behave under the extreme pressure of Jupiter's interior. Once Jupiter's current construction is known, it will then be possible to work out how, when and potentially where in the Solar System the planet first formed.

The NASA mission launched into space from Cape Canaveral on 5 August 2011 aboard an Atlas V rocket, but this alone could not deliver enough thrust to reach Jupiter. On 9 October 2013 the spacecraft performed a slingshot around the Earth, using our planet's gravity to accelerate to a final speed of 11km/s.

Once the craft arrives, Juno will perform 37 highly elliptical orbits over the planet's poles. Its path will pass less than 5,000km above the upper clouds before swinging out to a distance of millions of kilometres and back over the course of 14 days.

Once its mission is done, the probe will be deorbited in 2018, burning up in Jupiter's atmosphere to avoid any contamination of its moons – there are over 60 of them – which are thought to be our best chance of finding life outside our planet. ▶

SOLAR PANELS

Juno will be the most distant spacecraft to be powered by solar energy. As Jupiter receives 25 times less sunlight than the Earth, it requires three 2.65 x 8.9m solar panels to generate the 450W needed to power Juno.

JUNOCAM (hidden in this image)

The only camera on the craft, JunoCam, will take colour images of the planet. However, the task of choosing what targets to photograph and processing the final images will be done by the public. Go to missionjuno.swri.edu/junocam to get involved.



GRAVITY SCIENCE

Massive structures within Jupiter create fluctuations in the planet's gravitational field that will pull on Juno as it orbits, altering its speed. Gravity science will measure these velocity changes, creating a gravity map from the readings.

JOVIAN ENERGETIC PARTICLE DETECTOR INSTRUMENT (JEDI)

One of many particle detectors, JEDI will detect the highest energy particles around Jupiter. It will also investigate X-rays emitted from the planet's poles that do not appear to be related to the aurora.

JOVIAN AURORAL DISTRIBUTION EXPERIMENT (JADE)

The three JADE detectors will detect the particles and ions caught in Jupiter's magnetic field that cause the aurora.

MICROWAVE RADIOMETER (MWR)

By measuring the microwave emissions from Jupiter, the MWR will discern the thermal profile of Jupiter's atmosphere, helping to interpret how gas circulates on the planet.



**JOVIAN INFRARED AURORAL
MAPPER (JIRAM)**

(located on underside of the craft)

As well as imaging the aurora in the infrared, JIRAM will be able to measure the thermal output of Jupiter's upper layers and detect how much methane, water, ammonia and phosphine are present.

RADIATION VAULT

The high levels of radiation around Jupiter would rapidly destroy most electronics. The craft's sensitive systems have been encased in a 1cm-thick titanium radiation vault to protect them.

MAGNETOMETER

Juno's Magnetometer will create a map of the planet's magnetosphere by measuring the magnetic field's strength and direction all around Jupiter. The sensors are placed on a 3.6m boom to avoid interference from the craft's own electronics.

WAVES

The WAVES instrument will measure radio waves in the magnetosphere to investigate the interactions between Jupiter's magnetic field and its atmosphere.

VITAL STATS

716

The number of rotations made each second by the fastest-spinning neutron star.

VITAL STATS

-31°C

The maximum temperature of the coolest known star.

With a diameter of 140,000km and the mass of 318 Earths, Jupiter dominates our Solar System. In fact, its gravitational influence is so enormous that it affects the orbits of all the planets. It is thought that the planets of the Solar System originally formed in a slightly different configuration, but Jupiter's huge mass upset the gravitational balance, causing it and Saturn to migrate inwards, while Neptune was flung further out in the Solar System. And that's why Juno's mission is so important – it is impossible to understand how our planetary system formed without knowing more about this colossus.

But our current understanding of Jupiter is limited. So far, all we have been able to see is the top few hundred kilometres of the atmosphere. Here, the planet has remained remarkably stable; the striped cream and brown bands that ring Jupiter have barely shifted in latitude during the centuries we have been observing the planet.

No one knows what keeps these bands in motion, how deep they go, what causes their colouring or what's behind the great vortices that periodically appear within them. However, by peering through the clouds, Juno will finally allow us to answer at least some of these questions. By measuring the gravitational field of Jupiter, researchers will be able to find areas of high density deep within the planet, and discovering the subtleties of the magnetic field will give an insight into the workings of the inner core. Together with other measurements of the surface layers, Juno will unveil the structures hidden beneath the clouds of the Solar System's biggest enigma. EP

COMPOSITION

Though much of Jupiter is hydrogen (90 per cent) and helium (10 per cent), Juno will determine the levels of trace gases such as ammonia and water. Jupiter's atmosphere has remained mostly unchanged since its formation, so learning its composition will tell us much about the primordial Solar System that created it.

ATMOSPHERE

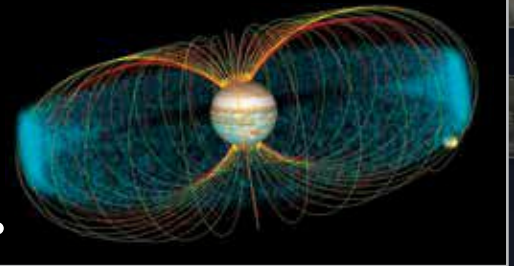
There is disagreement as to whether Jupiter's upper layers sit over a stable core, or whether there is no clear boundary and the two mix together freely. Juno's gravity maps will help detect which structure exists.

RINGS

Jupiter is surrounded by faint dusty rings, believed to be material ejected from some of its moons.

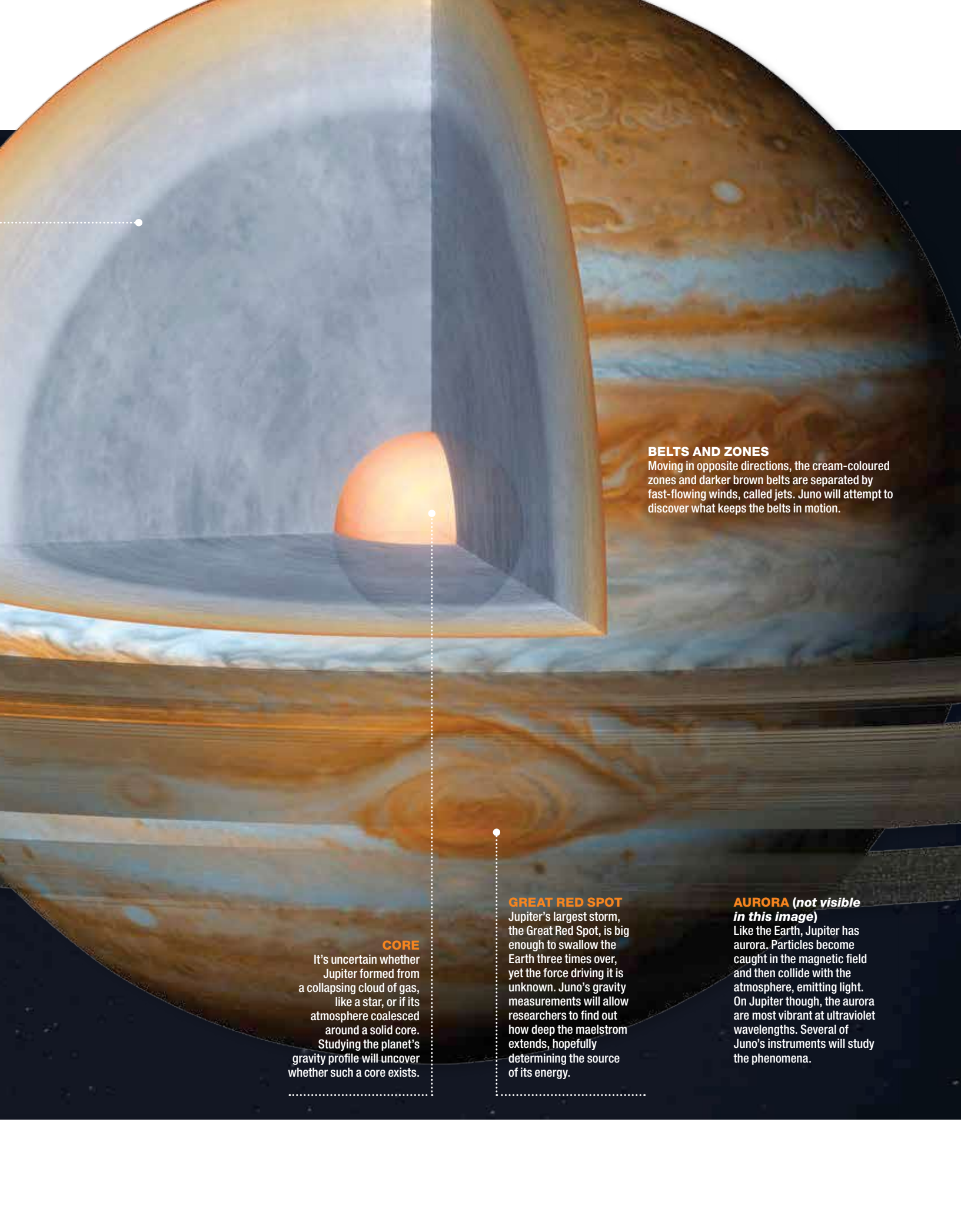
VORTICES

Caught in Jupiter's light-coloured zones are rotating vortices measuring thousands of kilometres across. These storms can last from as little as a few days to years or even centuries. Juno will look deep into their depths by imaging them in the infrared.



MAGNETOSPHERE

Jupiter's magnetic field, or magnetosphere, is one of the largest structures in the Solar System, extending three million kilometres around the gas giant. It's powered by electric currents deep in the interior, but Juno's magnetic map will determine if it is a solid core or the motion of highly pressurised 'metallic' hydrogen that generates these currents.



CORE

It's uncertain whether Jupiter formed from a collapsing cloud of gas, like a star, or if its atmosphere coalesced around a solid core. Studying the planet's gravity profile will uncover whether such a core exists.

BELTS AND ZONES

Moving in opposite directions, the cream-coloured zones and darker brown belts are separated by fast-flowing winds, called jets. Juno will attempt to discover what keeps the belts in motion.

GREAT RED SPOT

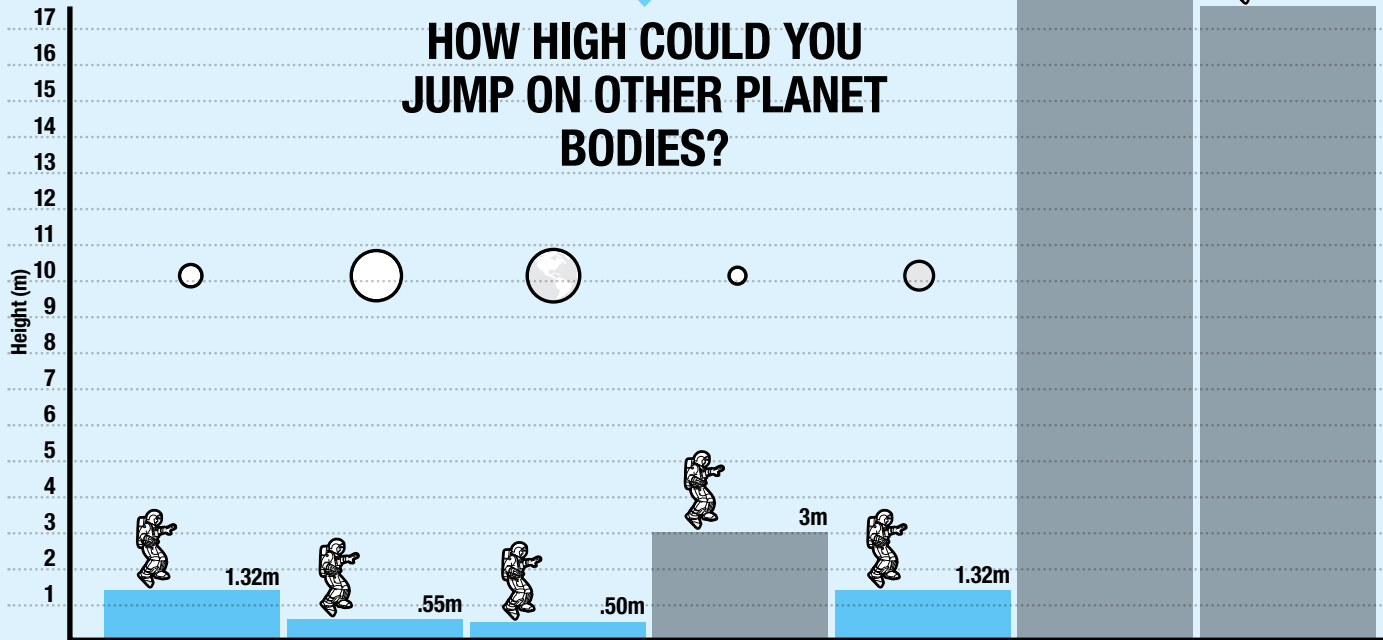
Jupiter's largest storm, the Great Red Spot, is big enough to swallow the Earth three times over, yet the force driving it is unknown. Juno's gravity measurements will allow researchers to find out how deep the maelstrom extends, hopefully determining the source of its energy.

AURORA (not visible in this image)

Like the Earth, Jupiter has aurora. Particles become caught in the magnetic field and then collide with the atmosphere, emitting light. On Jupiter though, the aurora are most vibrant at ultraviolet wavelengths. Several of Juno's instruments will study the phenomena.

THE THOUGHT EXPERIMENT

HOW HIGH COULD YOU JUMP ON OTHER PLANET BODIES?



	Mercury	Venus	Earth	Moon	Mars	Phobos	Ceres
Surface gravity	0.378G	0.91G	1.0G	0.166G	0.379G	0.00059G	0.0284G
Average person	30.2kg	72.8kg	80kg	13.3kg	30.3kg	0.0472kg	2.272kg

Could we ever detect other universes?

The idea that the Universe is just one of many, making up one, truly infinite 'multiverse', is among the most intriguing – and controversial – theories in modern physics. It's based on attempts to find the one true 'Theory of Everything' (ToE) that describes all the particles and forces making up reality in a single set of equations. Some attempts to create the ToE suggest that there are myriad different universes beyond our own, each with different laws of physics. According to some theorists, these differences may reveal the existence of universes neighbouring our own. Exactly how they'll be revealed is unclear, but one possibility is via distortions in the heat left from the Big Bang. This has been mapped with exquisite precision, and may contain telltale patterns consistent with the lurking presence of another universe. RM

VITAL STATS

90 percent

The amount of sunlight reflected by Enceladus. It is the most reflective object in the Solar System

Some physicists think the Universe is just one of many

WHERE ARE ALL THE ACTIVE SPACECRAFT IN OUR SOLAR SYSTEM?

Since Sputnik 1 was launched in 1957, humans have sent thousands of spacecraft into the cosmos. There are currently around 50 active* craft in our Solar System. Here's where they are and what research they are doing

*not including miniaturised, amateur or commercial craft.

AKATSUKI

Many mysteries abound around Venus, and Akatsuki is the latest probe to take a closer look. It will search for lightning in the Venusian atmosphere, study the abundance and distribution of key gases and look at how the planet's heat is distributed in the lower atmosphere. And that heat is significant – Venus is the hottest planet, even though it isn't closest to the Sun. Names and letters from a public competition went along for the ride on engraved aluminium plates.

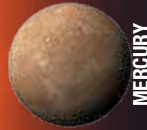


STEREO A/B (SOLAR TERRESTRIAL RELATIONS OBSERVATORY)

Building a 3D picture of storms erupting from the Sun. STEREO A is active, but STEREO B in 2014 contact was lost with

58 million km from Sun

108 million km from Sun



MERCURY



VENUS



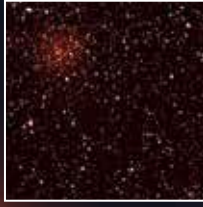
SPITZER SPACE TELESCOPE

Taking infrared images of galaxies and nebulae. Most instruments have stopped working



KEPLER

Detecting planets outside our Solar System, particularly those like the Earth



KEPLER

Kepler is the king of exoplanet hunters. Since its launch in 2009, this space observatory has uncovered 2,300 alien worlds by looking for small drops in the brightness of stars as planets ghost in front of them. From these 'transits', astronomers can work out the size of the planet and how far it orbits from its star – crucial in working out its temperature. Kepler's haul includes Earth-sized planets with temperatures friendly to liquid water, a world with two Suns, and a solar system with multiple planets squeezed closer to their sun than Mercury is to ours.



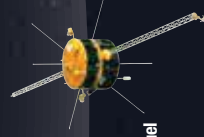
SOHO (SOLAR AND HELIOSPHERIC OBSERVATORY)

Studying the Sun's outer layers as well as the solar wind



LISA PATHFINDER

Testing out technology for a gravitational wave observatory



LAGRANGIAN POINT L1

WIND

Studying the solar wind. Has enough fuel to last another 53 years



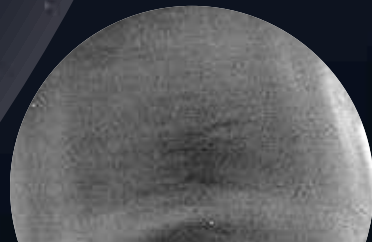
DSCOVR (DEEP SPACE CLIMATE OBSERVATORY)

Studying the Sun and climatic changes on Earth



ACE (ADVANCED COMPOSITION EXPLORER)

Studying the Sun. Has enough fuel to last until 2024





LISA PATHFINDER
Gravitational waves are the buzzwords in astronomy and physics right now. They are tiny ripples in the fabric of space itself. Predicted by Einstein in 1915, they come from violent events such as the collision of black holes. A proposed space-based mission called LISA would be a significant boost to our ability to detect these tiny disruptions, and LISA Pathfinder has shown that such a mission is feasible.

SOLAR AND HELIOSPHERIC OBSERVATORY
The SOHO mission revolutionised our understanding of the Sun. It was the first time we'd had our closest star under near-constant surveillance. As well as providing valuable data on the Sun's magnetic activity, it also inadvertently discovered 3,000 comets as they buzzed past.



HUBBLE SPACE TELESCOPE

When the Hubble Space Telescope entered service in 1990, its images were found to be slightly blurry – traced back to a flaw in its primary mirror. A complex service mission in 1993 fixed the issue and, since then, the telescope has been beaming back spectacular images of the cosmos. Perhaps its most iconic snapshot is the Hubble Deep Field, in which it focused on a tiny, nearly empty patch of space for 10 days. The resulting image showed that this apparent void was actually chock-full of distant and diverse galaxies, providing a new glimpse into the early Universe. The telescope's contribution to astronomy has been far-reaching, enabling scientists to pin down the age of the Universe, discover dark energy, and witness the birth of planets and stars.



150 million km from Sun

EARTH

HAYABUSA 2
 Its predecessor was the first time we'd returned a sample of an asteroid to Earth. However, that mission was plagued with problems, so hopefully, this time, things will run more smoothly and return more material for scientists to study.



DAWN

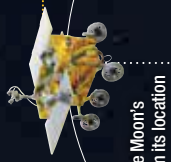
Dawn has gone down in history as the first probe to enter into orbit around two completely separate bodies in the same mission. Its innovative ion propulsion technology was key to getting in and out of the gravitational field of these two protoplanets. The white spots it has detected on Ceres continue to enthrall astronomers, dangling the possibility that they might be areas of water ice. Such missions are crucial precursors to any future attempts to mine asteroids for their wealth of resources.



150 million km from Sun

228 million km from Sun

CHANG'E 3
 Exploring the Moon's geology from its location on Mare Imbrium



MOON

LRO (LUNAR RECONNAISSANCE ORBITER)
 Making detailed lunar maps for future manned and robotic exploration



ARTEMIS P1/P2

Studying the interaction of the solar wind with the Moon



LAGRANGIAN POINT L2



GAIA
 Accurately cataloguing the positions of a billion stars



HAYABUSA 2
 Will survey an asteroid and return a sample to Earth. Due to arrive at asteroid 162173 Ryugu in July 2018



MOON

MARS ORBITER MISSION
 Demonstrating technology for future Indian Martian mission



MARS

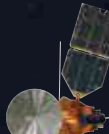
OPPORTUNITY
 Searching Mars for signs of past water and amenable conditions for life



2001 MARS ODYSSEY
 Detecting evidence of past or present water on Mars



MARS RECONNAISSANCE ORBITER (MRO)
 Monitoring Martian climate and mapping future landing sites



MARS

MARS ATMOSPHERE AND VOLATILE EVOLUTION MISSION (MAVEN)
 To discover how Mars lost its atmosphere and liquid water



CURIOSITY
 Assessing suitability of Martian environment for microbial life



MARS

EXOMARS TRACE GAS ORBITER
 Will investigate methane in the Martian atmosphere. Due to arrive in October 2016



CERES

DAWN
 Exploring the asteroid Vesta and dwarf planet Ceres



VESTA

VESTA

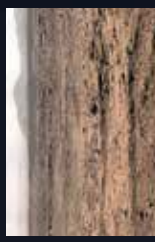
CHANG'E 3

This rover, nicknamed Jade Rabbit, touched down on the Moon in December 2013, making China only the third country to land on the lunar surface. It was the first soft landing on the Moon since 1976. Three years later, it was announced that the rover had found a new type of lunar rock. High-quality images – including of the Earth and the Pinwheel Galaxy – were taken.



CURIOSITY

As planetary missions go, few are as daring as Curiosity. Previous Martian rovers had been lowered onto the Martian surface inside inflatable balls, which slowly deflated to leave the machine to roll out onto Mars. But Curiosity was gently lowered onto the surface via an intricate 'sky crane'. Curiosity has now experienced two full cycles of the Martian seasons and is on its way to Mount Sharp.



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NEW HORIZONS

When the mission set off in early 2006, the world it was heading to was still a planet. Later that year, however, Pluto was downgraded to dwarf planet status by the International Astronomical Union. Yet that couldn't stop the worldwide excitement as New Horizons finally ended its nine-year journey to the Kuiper Belt last year. For the first time, we had crisp, close-up images of this world, and they didn't disappoint. Mission scientists were left baffled by how smooth and crater-free Pluto's surface is. That suggests this little world must have some kind of geological activity that constantly re-sculpts its surface. We also got closer views of Pluto's five moons: Charon, Nix, Hydra, Kerberos and Styx.

779 million km from Sun



ROSETTA

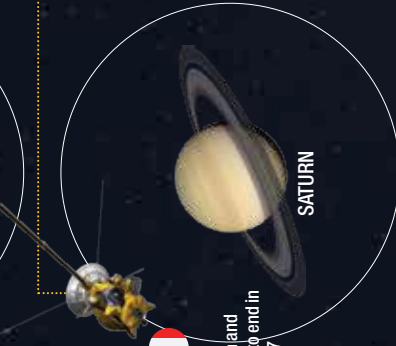
Mapping the comet 67P/Churyumov-Gerasimenko

COMET 67P-CHURYUMOV-GERASIMENKO

PHILAE

Made the first ever landing on a comet

1.43 billion km from Sun



CASSINI

Studying Saturn and its moons. Due to end in September 2017



JUNO (JUPITER NEAR-POLAR ORBITER)

Will explore Jupiter's composition, magnetism and gravity. Due to arrive on 4 July 2016



CHANG'E 2

Exploring the Moon and asteroids. Currently 100 million kilometres from Earth

CASSINI

Cassini ranks as one of the most successful interplanetary missions in history. It arrived at Saturn in 2004 after a seven-year voyage and has been beaming back gorgeous images and valuable data ever since. Its most famous image is probably the one showing a solar eclipse, with Earth appearing as a tiny dot. The Huygens lander piggybacked along, before touching down on the surface of Saturn's largest moon, Titan, in 2005. It's the only occasion we've landed in the outer Solar System.

2.87 billion km from Sun



URANUS

4.50 billion km from Sun



NEPTUNE

5.91 billion km from Sun



NEW HORIZONS

Explored Pluto and its moons. Now studying the Kuiper Belt



VOYAGER 1

Explored Jupiter, Saturn and its largest moon Titan. Has now left the Solar System and is over 20 billion kilometres from Earth



VOYAGER 2

Explored Jupiter, Saturn, Uranus and Neptune. Now close to the edge of the Solar System, 16.5 billion kilometres from Earth

VOYAGER 1

In August 2012, it was confirmed that Voyager 1 had departed the Solar System. But it still has a long way to go before it reaches the Oort Cloud – technically still part of the Solar System. Instead, it has left the magnetic influence of the Sun, as the solar wind is lost in the winds of other nearby stars



VITAL STATS

110

The speed, in km/s, at which the Andromeda Galaxy is approaching the Milky Way.

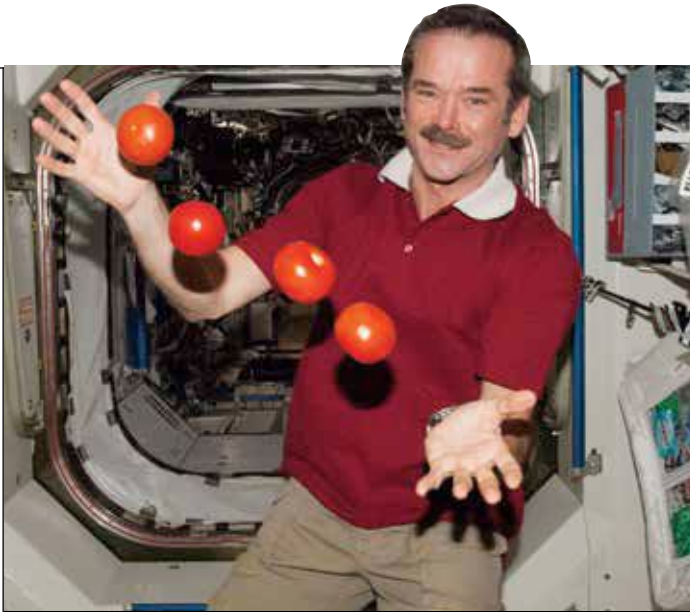
Why haven't spacesuits changed much?

Spacesuits have actually changed enormously. The earliest spacesuits were essentially just airtight versions of the flight suits that pilots wore. In 1965, cosmonaut Alexei Leonov almost became stranded in space during the first spacewalk, when his spacesuit ballooned out so much from its internal pressure that he couldn't move or operate the airlock door. The A7L suits developed for the Apollo missions used constant-volume joints to avoid this problem and added a self-contained air recycling unit and 100m of piping to pump cooling water

around the suit. The suits were custom tailored and each astronaut needed three suits (for training, flight and a spare) costing around \$500,000 each. The EMU and Russian Orlan suits, currently used on the International Space Station, are modular to keep costs down. Plus, because they are only used in microgravity, they can be much heavier. These suits have a rigid upper torso, which offers better protection and comfort. For future missions to Mars, NASA is developing the Z-series suits that have rigid joints with titanium bearings to allow the greatest flexibility. These are the first spacesuits that allow the wearer to touch their toes, and they also have a built-in airlock. LV

Aerospace engineer Dava Newman developed this BioSuit for Mars missions; it has a tight, elastic structure that counteracts lower pressures





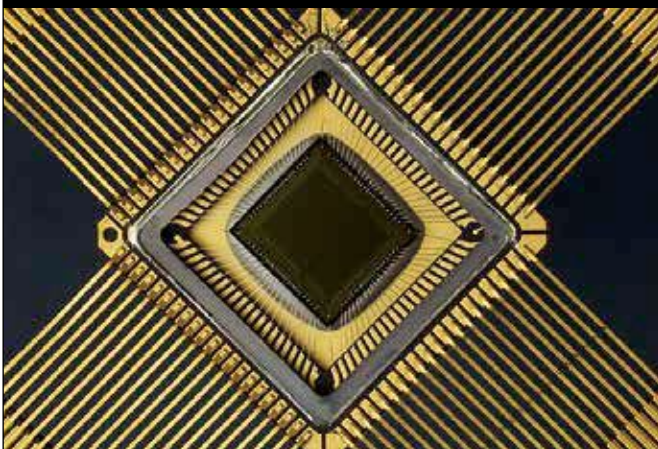
Is it harder to think straight in space?

Space travel is definitely disorienting. Without the effects of Earth-like gravity on the sensory system in the inner ear, your brain no longer has any clear idea about what is up and what is down. This can affect astronauts' ability to sense distances and rotate objects in their mind's eye and it can provoke some weird perceptual experiences such as the sudden sense that everything around them has been turned upside-down, or the converse, that they themselves have been flipped. Add to that the fatigue, the constant hum of equipment, the loneliness and claustrophobia, and perhaps it's no wonder that experts talk about astronauts suffering from 'space stupids' or 'space fog'. CJ

How are computers protected from radiation in space?

Space can be a dangerous place for electronics because solar flares or galactic cosmic rays can cause power resets or system failures. Electronics are protected from these dangers using several clever methods. Shielding helps stop the harmful rays reaching the delicate chips. Plus, redundant components are used, so that if, one is damaged, another can take over. Special radiation-hardened (RadHard) electronics are made from Silicon-on-Insulator or Silicon-on-Sapphire instead of the normal semiconductor wafers to make them thousands of times stronger against radiation. Reconfigurable electronics are utilised, which allow circuits to be adjusted remotely in order to make them work again. PB

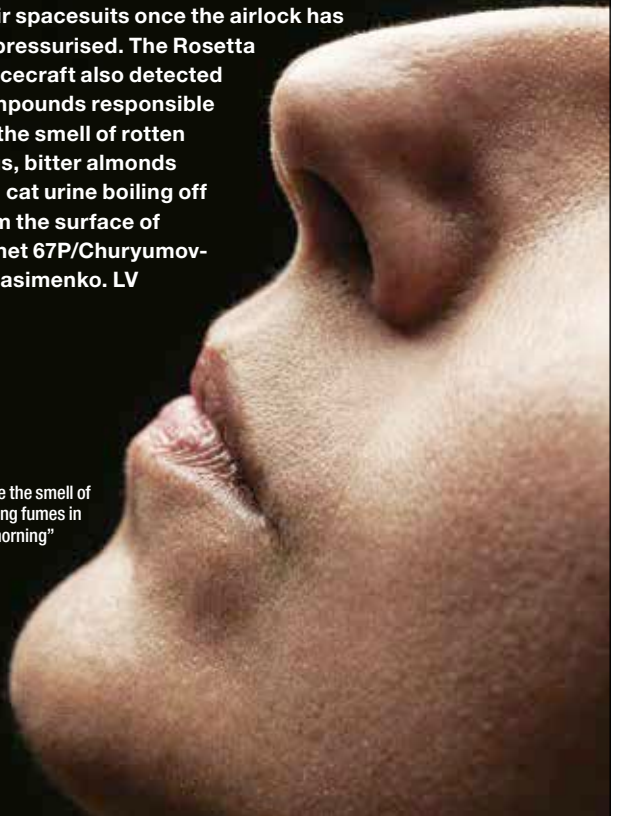
One of BAE's radiation-hardened chips



What does space smell like?

We can't smell space directly, because our noses don't work in a vacuum. But astronauts aboard the ISS have reported that they notice a metallic aroma – like the smell of welding fumes – on the surface of their spacesuits once the airlock has re-pressurised. The Rosetta spacecraft also detected compounds responsible for the smell of rotten eggs, bitter almonds and cat urine boiling off from the surface of comet 67P/Churyumov-Gerasimenko. LV

"I love the smell of welding fumes in the morning"





ASK AN

Shannon Walker is an American scientist and NASA astronaut who blasted off from the Baikonur Cosmodrome in June 2010 to spend five months aboard the International Space Station

How do you decide which way is up on the ISS?

Directions tend to lose their meaning in space, so we don't really need a formal up and down. But we orient ourselves according to the way the modules are presented to us in training. On the ground, we have simulators of all the International Space Station modules, and these have a definite orientation. One plane of the modules has lights attached, so you want the lights on the ceiling, just like they are at home. And then everything else on the ISS is designed around that, so that when you're having meals or floating around, your heads are all pointing towards the lights.

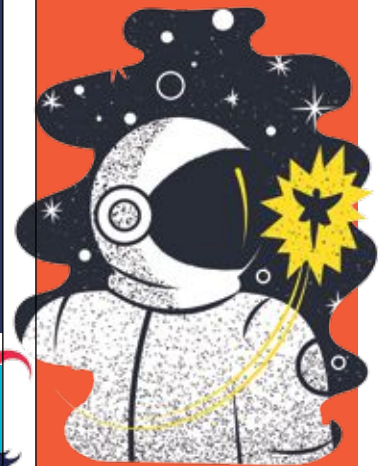


How quickly do you get used to microgravity?

It's strange to feel weightless, but it's interesting how quickly it becomes a natural state – it only takes a few days to get used to floating. What takes longer is figuring out that you have to push off to get anywhere, and knowing how hard you need to push. Some people feel motion sick when they first arrive, but that tends to go after a day or two.

What is a 'cosmic fairy', and have you seen one?

Yes, almost everyone on the ISS experiences these little flashes of light when they close their eyes. It's kind of like when you see a shooting star streaking across the sky, but inside your eye. It's pretty neat. The lights are caused by cosmic rays interacting with your retinas. On Earth,



Do astronauts really love prawn cocktail?

We definitely eat a lot of prawn cocktail in space, and it's pretty tasty. I'm not sure why this particular food gets so much attention, though – the prawns are a little rubbery! I think astronauts are mostly looking for foods with a strong flavour, as the meals in space don't have as much variety as on the ground. When I was there I really liked the Japanese and

Indian curries. And I also had a great barbecue beef. Some people say that they lose their sense of taste in space. You don't have gravity pulling all the fluids down in your body, so they travel towards your head and can cause congestion, affecting your sense of smell and taste. But it depends on the person – my taste buds seemed pretty much the same.



we're protected from this radiation by the planet's magnetic field. We don't have a lot of data on what effect these rays are having on astronauts in the long term, but that's something we're currently studying.

ASTRONAUT

“We definitely eat a lot of prawn cocktail in space, and it’s pretty tasty. I’m not sure why this particular food gets so much attention, though – the prawns are a little rubbery!”



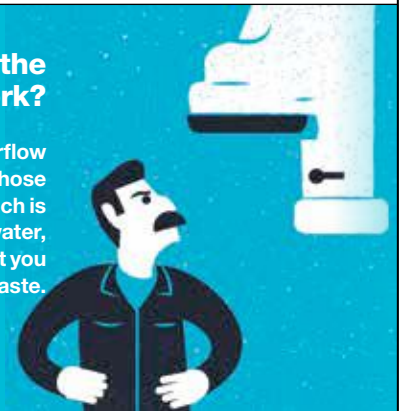
What advice would you give to Tim Peake about adjusting back to life on Earth?

Take it slowly. You’ll have aches and pains, and your inner ear will be trying to readjust, so you might feel dizzy and unable to walk in a straight line. But you’ll soon feel like your old self again.

Spend time with your family – they’ve been on this adventure with you, but they haven’t been in your presence for a long time. Savour the moments you had in space.

How does the ISS loo work?

Fans provide a gentle airflow and suction. There’s a hose with a funnel for urine, which is recycled into drinking water, and a separate tank that you sit over for your solid waste.



What happens if there’s a fire?

This is something we train for a lot. First, the Space Station tries to take care of the problem itself. We’ve got smoke detectors all over the place, so, if an experiment goes haywire and starts creating smoke, the ISS will automatically know where the issue is and start turning off electricity in that area. You may have lights and fans shutting down – you don’t want to keep blowing oxygen across the fire.

The crew is trained to gather in a central location and make sure everybody’s safe. If we can see the fire, and it’s simple and well-contained, we can use the onboard fire extinguishers. Otherwise, we shut down or depressurise the module where the fire is, and it’ll eventually go out. There’s never been a fire on the ISS, but they did have a couple of incidents on the Mir space station.



What’s the least glamorous task on the ISS?

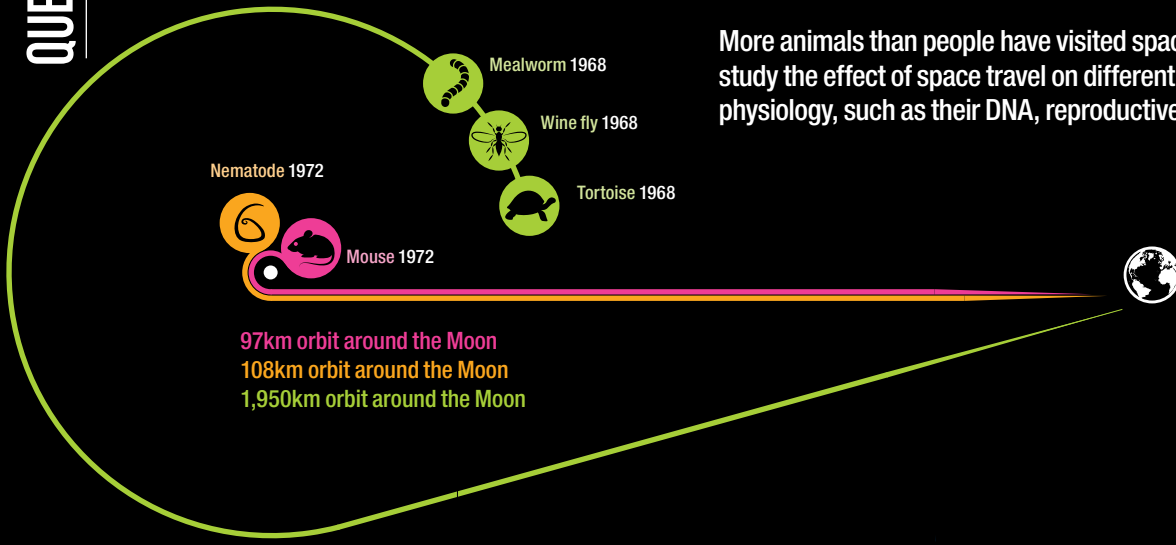
Most of our job isn’t glamorous at all! We still have to clean – we do housework and vacuuming, and somebody’s got to pack up the solid waste from the toilet and get it ready for the cargo ships to take away. Being an astronaut definitely has its perks, but it’s not all Hollywood.

How do astronauts keep clean?

There’s no shower on board, so we use wipes or a soapy towel. Washing your hair is a little trickier. We use no-rinse shampoo, but it still needs to be used with water from a drink bag. You have to be careful not to leave water floating around – you don’t want to be shorting out electrical systems.



QUESTIONS AND ANSWERS



More animals than people have visited space. Usually, they are sent to study the effect of space travel on different elements of their physiology, such as their DNA, reproductive systems or inner ears.

Dog 1966 887



600km

Which animals have visited space?

First animal in space – fruit fly

Fruit flies were the first animals ever sent to space. In 1947, they were launched to an altitude of 109km in the nose cone of a V2 rocket captured from the Nazis. The capsule ejected and returned the insects safely back to Earth by parachute.

First animal in Earth orbit – dog

Laika was the Russian dog that was the first animal sent to Earth orbit – and the first to die there in 1957. But the altitude record for dogs belongs to Veterok and Ugolyok who flew in Kosmos 110 in 1966.

First monkey in space – rhesus macaque

The first monkey in space was Albert II, a rhesus macaque. He was killed on impact when his V2 rocket's parachute failed. The altitude record for (non-human) primates was set in 1959

by rhesus and squirrel monkeys, called Able and Baker.

First animal to orbit the Moon – tortoise

In 1968, three months before Apollo 8, two Russian tortoises won the race to be the first animals to travel around the Moon, along with some flies, worms and bacteria. They flew aboard the Zond 5 spacecraft and returned safely to Earth after a seven-day voyage.

First animal to give birth in space – cockroach

In 2007, a cockroach called Nadezhda ('Hope', in Russian) became the first Earth creature to give birth in space. Nadezhda conceived and bore 33 young in microgravity, while travelling 258km above Earth in the FOTON-M3 spacecraft. The space cockroaches matured slightly faster but otherwise seemed normal.

Bullfrog 1970 590



Gecko 2014 575



Moth larva 2006 565



Hissing cockroach 2006 565

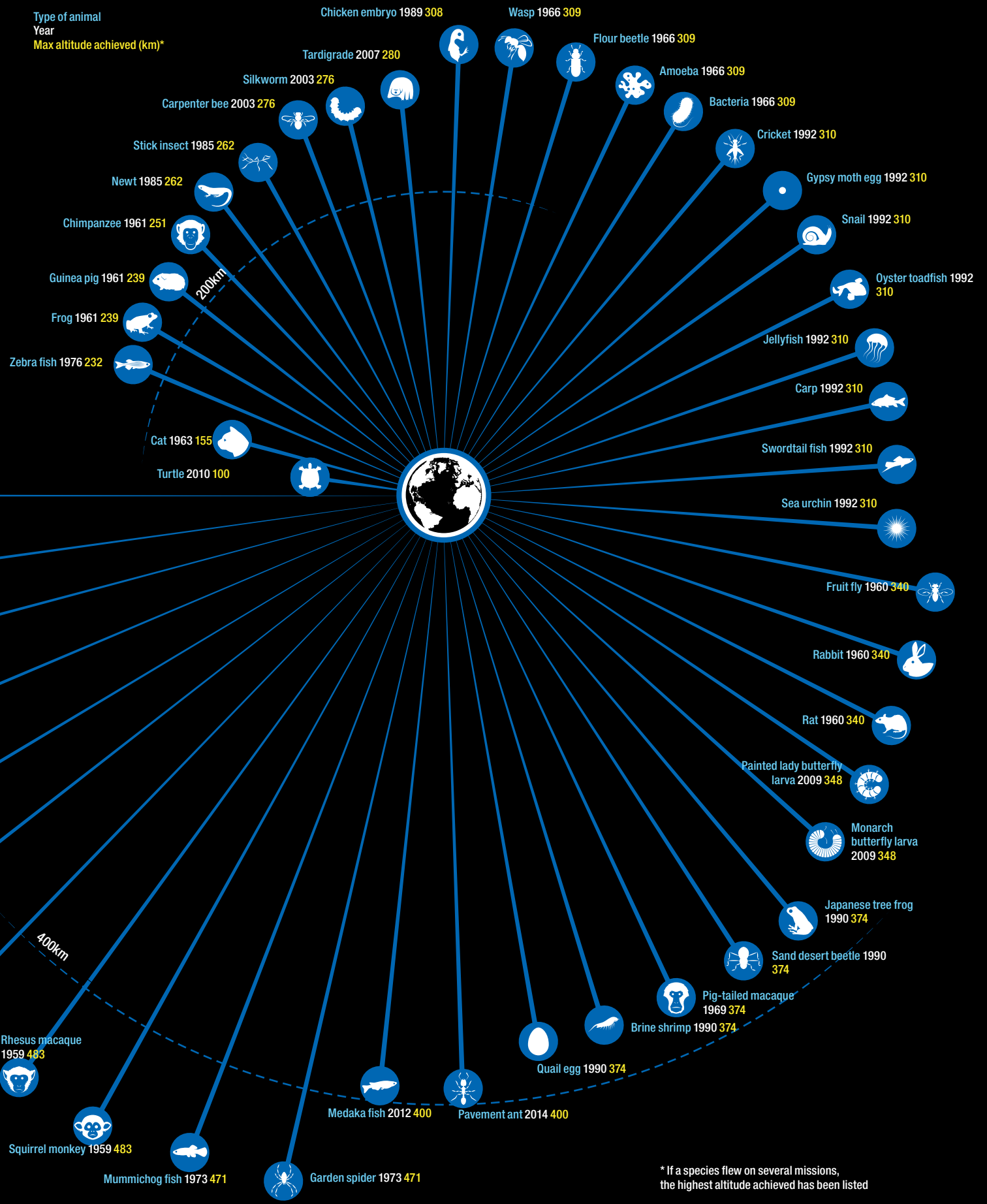


Flat rock scorpion 2007 561



Seed harvester ant 2007 561





* If a species flew on several missions, the highest altitude achieved has been listed

QUESTIONS AND ANSWERS

Can we reproduce in space?

We don't know yet. Rats that flew in space for part of their gestation were later born on Earth without the ability to right themselves, and other studies have shown that gravity is important for proper foetal development. Future colony ships may need to include centrifuge cabins to provide artificial gravity for any pregnant crew. LV

No babies have been conceived in space... yet



My Very Easy Method Just Speeds Up Naming... oh...

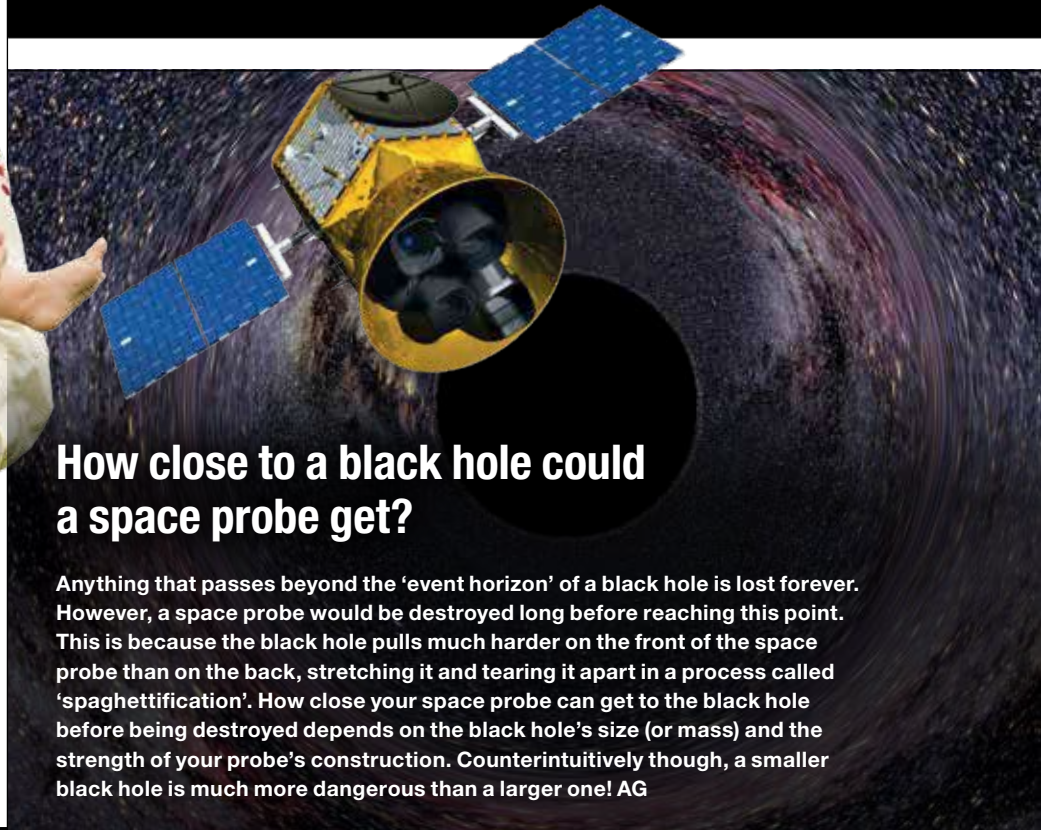
Could Pluto become a planet again?

When it was discovered in 1930, Pluto was hailed as the ninth planet in the Solar System. But in 2006, it was controversially downgraded to mere 'dwarf planet' status by the International Astronomical Union, on

the grounds that it's too small to clear its own path around the Sun. Despite repeated calls, Pluto has no chance of becoming a planet again without the IAU dropping its orbit-clearing criterion. RM

How close to a black hole could a space probe get?

Anything that passes beyond the 'event horizon' of a black hole is lost forever. However, a space probe would be destroyed long before reaching this point. This is because the black hole pulls much harder on the front of the space probe than on the back, stretching it and tearing it apart in a process called 'spaghettification'. How close your space probe can get to the black hole before being destroyed depends on the black hole's size (or mass) and the strength of your probe's construction. Counterintuitively though, a smaller black hole is much more dangerous than a larger one! AG



Why is there poo on the Moon?

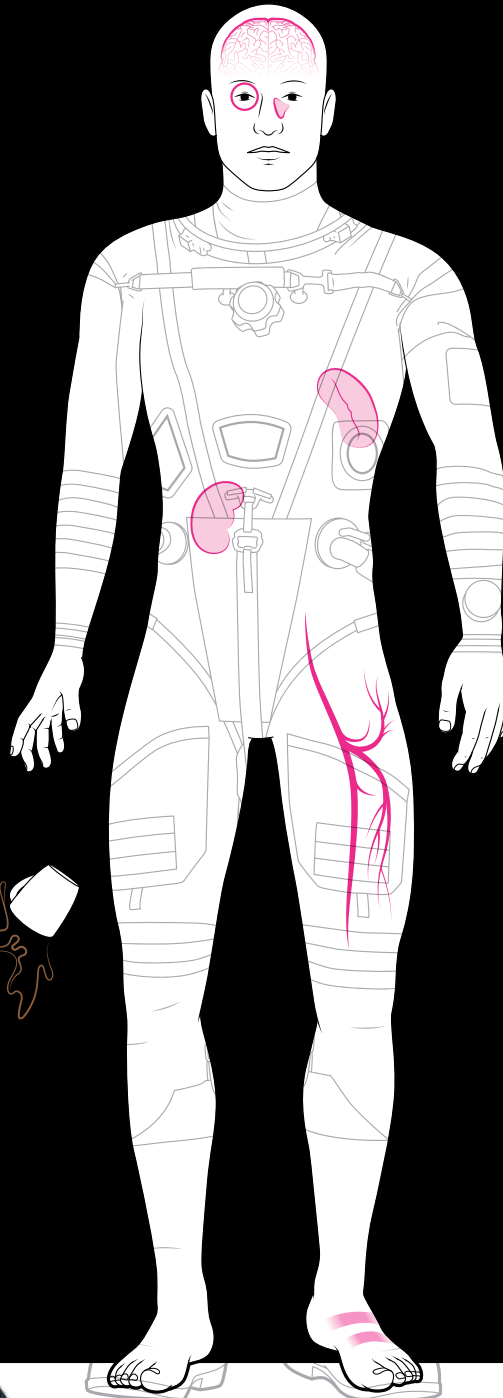
The Apollo landers were designed to lift off from the lunar surface at a particular weight. Since the Apollo astronauts were charged with bringing large amounts of Moon rock back home, the weight of those samples was offset by leaving behind unwanted items. This discarded junk included, among other things, two golf balls, 12 cameras, 12 pairs of boots, a gold-plated telescope, and a total of 96 bags of 'human waste' – urine, faeces and vomit! Although not the best example of green thinking, this detritus will have had no permanent effect on the lunar environment. Any microorganisms present in the human waste could not have grown under the harsh conditions of the lunar surface. It is possible, however, that some could have survived for a time as dormant, inactive spores. So, after 50 years on the lunar surface, the human waste, which is now probably just bags of dust, may contain important information on the survival of microorganisms in space. Astrobiologists would like to see if any of those microorganisms have undergone any genetic mutations due to the harsh lunar environment, or have indeed survived in a dormant state. They hope one day that private companies may eventually return this human waste for study! AG

Who knows what could have become of the poo left on the Moon?



What happens to the body in space?

On a five-month trip to the ISS, you can expect to lose 12 per cent of your bone density and 40 per cent of your muscle mass – even with daily sessions on the treadmill. This is the equivalent of ageing from 20 to 60 in a few months. Without gravity pulling it down, the fluid in your body redistributes, and your heart grows weaker. But there are some more subtle and unexpected changes too. LV



Brain

Mice exposed to the radiation levels typical of a journey to Mars showed more beta-amyloid proteins in their brains. This means that long space journeys could increase the chance of developing Alzheimer's disease.

Eyes

Fluid redistribution increases the pressure on the eyeball, slightly crushing the optic nerve, which can lead to visual problems later on. Increased radiation levels also raise the chance of developing cataracts.

Sinuses

Increased fluid in the head causes nasal congestion, bulging neck veins and a puffy face, which combine to feel like a constant head cold.

Mouth

Astronauts report that food tastes more bland in space, so many prefer to eat spicy food. In microgravity, gases in the stomach do not separate from liquids, so astronauts tend to have unpleasant 'wet burps'.

Coordination

Astronauts get used to things floating and their reflexes recalibrate to allow them to catch moving objects in microgravity. When they return to Earth, they are initially more clumsy and drop things.

Kidneys

Lost bone mass ends up as calcium in the bloodstream and this can precipitate into painful kidney stones.

Immune system

The T-cells in your immune system don't reproduce as well in space, making astronauts more prone to bacterial infections.

Blood

For the first few days in space, your body destroys any newly-produced red blood cells. This stops eventually, but your red blood cell count remains lower until you return to Earth.

Feet

The hard skin on the soles of your feet moults off because it's not in constant contact with the ground any more. But the tops of your feet become raw and sensitive from rubbing against the foot straps astronauts use to secure themselves in space.

A high-angle, wide shot of a massive crowd of people floating in a pool. The water is filled with hundreds of colorful inflatable rings in various shapes and colors, including rainbow patterns, solid colors like blue, yellow, and pink, and some with stars or other designs. The people are mostly young adults, many wearing swimsuits, and they appear to be enjoying the water. The overall scene is one of a large-scale recreational event.

SNAPSHOTS

Horde of the rings

**DAYING COUNTY,
SICHUAN PROVINCE,
CHINA**

And you thought your local swimming pool was crowded. Thousands of rubber-ringed revellers descended upon the Dead Sea of China water park this summer when temperatures in the Sichuan province soared to nearly 40°C.

This pool, which can fit up to 10,000 people, was inspired by the Dead Sea in the Middle East. Visitors are encouraged to float in the naturally buoyant saltwater, although we admire anyone who can relax when multiple limbs are jabbing into their inflatable.

Globally, this July was the warmest month on record. Incredibly, each consecutive month this year has broken its own temperature record, a fact which experts are attributing to rising greenhouse gas emissions.

“While the El Niño event in the tropical Pacific this winter gave a boost to global temperatures from October 2015 onwards, it is the underlying (long-term warming) trend which is producing these record numbers,” says Gavin Schmidt at NASA’s Goddard Institute for Space Studies.



The very hungry caterpillars

HUANJIANG MAONAN, GUANGXI, CHINA

These silkworms are chowing down on their favourite food – mulberry leaves. After about a month of voracious feeding, the fast-maturing caterpillars begin to spin a silken cocoon made from proteins found in their saliva in preparation for their metamorphosis into silk moths.

“A molecular marvel, the protein fibroin has a high tensile strength and a toughness that makes commercially-produced silk an incredibly useful and valuable material,” explains entomologist and BBC presenter Adam Hart. “Another protein, sericin, coats the fibroin and allows it to stick together, forming thicker and stronger fibres.”

To loosen the silk to prepare it for being fed onto a spinning wheel and woven into fabric, the cocoons are thrown into boiling water or pierced with a needle. In China, sericulture, the rearing of silkworms for the production of silk, is big business. In 2015, the industry produced 170,000 tonnes of fabric, which is nearly six times the output of India, its closest competitor.



Nothing to sniff at

MALANJE,
ANGOLA

A rat works hard in Angola, sniffing out landmines hidden beneath the soil. It is one of a team of 27 rats that have been trained by the company APOPO to help clear the land left riddled with mines by the recent civil war.

Weighing in at 1.5kg, the African giant pouched rat is too light to trigger a landmine, but can sniff them out with ease. They can detect tiny amounts of TNT, even when it's buried up to 20cm under the ground. It takes nine months and \$8,000 to train a rat, but it's worth it. Each can cover 400 square metres a day, 15 times what an engineer equipped with a detector can manage.

"When the rat detects the smell of TNT, he or she will put their nose in the air or scratch at the ground, and that indicates they've found something in that particular area," says biologist and BBC presenter Patrick Aryee, who witnessed the rats at work as part of the recent series *Super Senses: The Secret Power Of Animals*. "The rat has a banana or a nut as a reward, then carries on going up and down."

The rats are a squeaking success, having detected thousands of mines from Angola to Mozambique and Cambodia.



DISCOVERIES

DISPATCHES FROM THE CUTTING EDGE

PHYSICS

IS THERE A FIFTH FORCE FROM THE DARK SIDE?

Pretty much every physics textbook could imminently go out of date. Theorists at the University of California, Irvine, the USA, may have tantalising evidence of a fifth fundamental force of nature

The team discovered the potential fifth force while hunting for the force carrier of dark matter, visualised

ACCORDING to particle physics, there are four fundamental forces: gravity, electromagnetism, the weak force and the strong force. Electromagnetism, the weak and the strong forces have particles associated with them called bosons, which are the force-carriers. Gravity is yet to be integrated into the Standard Model, but is thought to have a force-carrying particle known as the graviton.

Last year, a group of Hungarian researchers spotted an unusual radioactive decay signal while searching for evidence of 'dark photons' – a hypothetical particle proposed to be the electromagnetic force carrier for dark matter. Though details were unclear, the signal appeared to have come from an unknown particle just 30 times the mass of an electron.

"If true, it's revolutionary," said researcher Jonathan Feng. "For decades, we've known of four fundamental forces: gravitation, electromagnetism, and the strong and weak nuclear forces. If confirmed by further experiments, this discovery of a possible fifth force would completely change our understanding of the Universe, with consequences for the unification of forces and dark matter."

After combing through the data and ruling out matter particles and dark photons as candidates, the UCI team have proposed the signal may have come from a 'protophobic X boson', a new type of force-carrying particle, so-called as it interacts only with electrons and neutrons over an extremely limited range, rather than with electrons and protons like the photons do for the electromagnetic force.

If they are correct, the finding would mean that there is a fifth fundamental force operating alongside the electromagnetic and strong and weak nuclear forces, and possibly even a separate dark sector with its own matter and forces.

"It's possible that these two sectors talk to each other and interact with one another through somewhat veiled but fundamental interactions," said Feng. "This dark sector force may manifest itself as this protophobic force we're seeing as a result of the Hungarian experiment. In a broader sense, it fits in with our original research to understand the nature of dark matter."

"A POSSIBLE FIFTH FORCE WOULD COMPLETELY CHANGE OUR UNDERSTANDING OF THE UNIVERSE"

The four known fundamental forces

FORCE	EXPERIENCED BY	FORCE CARRIER PARTICLE	RANGE	RELATIVE STRENGTH
Gravity acts between objects with mass	All particles with mass	Graviton (not yet observed)	Infinity	Much weaker ↓ Much stronger
Weak force governs particle decay	Quarks and leptons	W ⁺ , W ⁻ , Z ⁰ (w and z)	Short range	
Electromagnetism acts between electrically charged particles	Electrically charged particles	γ (photon)	Infinity	
Strong force binds quarks together	Quarks and gluons	g (gluon)	Short range	

ZOOLOGY

INFANT MONKEYS SMILE IN THEIR SLEEP, JUST LIKE HUMAN BABIES

Who's a cheeky monkey? Researchers from Japan's Kyoto University have discovered that macaques sometimes break out into smiles while sleeping – a behaviour previously thought to be unique to higher order primates such as humans and chimpanzees.

The facial expressions, known as spontaneous smiles, are considered to be the evolutionary origin of human smiles and laughter.

"About a decade ago, we found that chimp infants also display spontaneous smiles," said researcher Masaki Tomonaga. "Since we see the same behaviour in more distant relatives, we can infer that the origin of smiles goes back at least 30 million years, when Old World monkeys and our direct ancestors diverged."

The team observed seven infant macaques during their routine health checks, with all of them smiling at least once. "Spontaneous macaque smiles are more like short, lopsided spasms compared to those of human infants. There were two significant similarities; they both happened between irregular REM sleep, and they show more lopsided smiles compared to symmetrical, full smiles," said researcher Fumito Kawakami. "A major difference, though, is that the smiles were much shorter." It has previously been argued that infants' spontaneous smiles developed to help parent-child bonding. However, the Japanese team think they may simply be used to develop cheek muscles, enabling macaques, chimpanzees and humans to form complex facial expressions.

The smiles of sleeping infant macaques probably help develop the facial muscles



IN NUMBERS

**4.243
LIGHT YEARS**

The distance of the nearest known exoplanet from Earth, Proxima B, discovered by astronomers at the Carnegie Institute orbiting the red dwarf star Proxima Centauri, the closest star to the Solar System.

**1,075
YEARS**

The age of a Bosnian pine tree found growing in northern Greece by a team from the University of Stockholm. It is the oldest living thing known in Europe, they say.

**£5
BN**

The amount of money required to save Australia's Great Barrier Reef from dying of coral bleaching, as estimated by Queensland's Water Science Task force.

ROBOTS

MEET THE FIRST SOFT ROBOT THAT CAN MOVE BY ITSELF



The squishy robot is made entirely with soft components

Here's one bot we definitely have a soft spot for. Researchers at Harvard University have created the world's first entirely soft robot capable of moving around under its own steam.

Dubbed 'octobot' for obvious reasons, the robot is around the size of an SD memory card and is able to move its limbs pneumatically by transforming liquid hydrogen peroxide fuel into a much larger volume of gas. This gas flows from a central reservoir into the bot's arms, inflating them like a balloon and allowing it to move its limbs without the need for rigid electronic components such as batteries and circuit boards.

"One long-standing vision for the field of soft robotics has been to create robots that are entirely soft, but the struggle has always been in replacing rigid components like batteries and electronic controls

with analogous soft systems and then putting it all together," explained researcher Robert Wood. "This research demonstrates that we can easily manufacture the key components of a simple, entirely soft robot, which lays the foundation for more complex designs."

Each part of the robot was custom designed and put together using a combination of various moulding and 3D printing techniques and is simple to assemble.

"This research is a proof of concept," said researcher Ryan Truby. "We hope that our approach for creating autonomous soft robots inspires roboticists, material scientists and researchers focused on advanced manufacturing."

The team is now working on creating an octobot that can crawl, swim and interact with its environment.

THEY DID WHAT?!



SEA LION TAUGHT TO KEEP A BEAT

What did they do?

Researchers at the University of California played a constant click track to a sea lion named Ronan, rewarding her with fish every time she nodded along in time. They then upped the ante by playing her Earth, Wind and Fire's funk-soul floor-filler *Boogie Wonderland* and varying the tempo at random intervals.

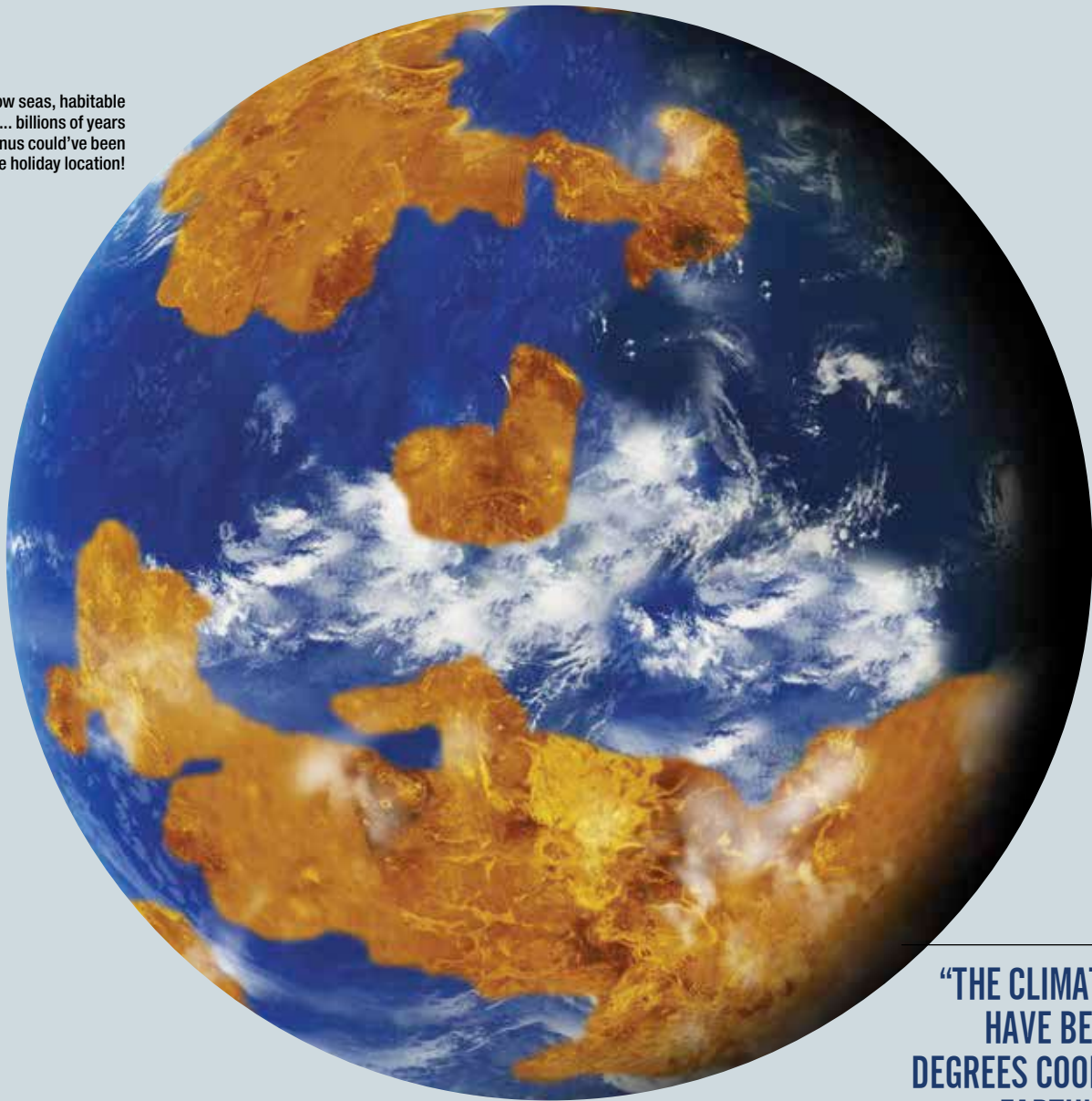
What did they find?

Not only was Ronan able to keep the beat better than any other non-human animal ever tested, she could also quickly adapt to the new tempos. The manner in which she did this suggests that neurons in her auditory brain centres first synchronised with the rhythm and then passed on the timing to the motor centres that control movement.

Why did they do that?

Over the last decade, chimps, bonobos, parrots and budgerigars have all been seen to move in time to music. By further study, the researchers hope to deepen their understanding of the biological roots of musicality in humans.

Shallow seas, habitable conditions... billions of years ago, Venus could've been a prime holiday location!



“THE CLIMATE COULD HAVE BEEN A FEW DEGREES COOLER THAN EARTH’S TODAY”

SPACE

VENUS MAY ONCE HAVE BEEN HABITABLE

With a temperature hot enough to melt lead and a suffocating, toxic atmosphere 90 times thicker than Earth’s, the surface of Venus resembles the classical idea of Hell. But this was not always the case.

A team at NASA’s Goddard Institute for Space Studies (GISS) has found Venus may have had an ocean of liquid water and a surface with habitable temperatures for two billion years of its history.

“Many of the same tools we use to model climate change on Earth can be adapted to study climates on other planets, both past and present,” said researcher Michael Way.

The GISS team plugged information about Venus’s early oceans, taken by the Pioneer mission, into their

model. They combined this with data detailing conditions of a hypothetical early Venus, then gave it an atmosphere similar in density to Earth’s, and a day as long as Venus’s current day (117 Earth days).

“In the simulation, Venus’s slow spin exposes its dayside to the Sun for almost two months at a time,” said researcher Anthony Del Genio. “This warms the surface and produces rain that creates a thick layer of clouds, which acts like an umbrella to shield the surface from much of the solar heating. The result means climate temperatures could have actually been a few degrees cooler than Earth’s today.”

Here’s hoping Earth doesn’t follow in its neighbour’s footsteps.



INNOVATIONS

PREPARE YOURSELF FOR TOMORROW

DO THE ROBOT

Robots set new Guinness World Record

These are just a few of the 1,007 robots that recently set a new Guinness World Record by dancing in unison for 60 seconds. The record attempt was staged as part of China's Qingdao Beer Festival by Chinese battery manufacturer Ever Win. The robots, which stand 43.8cm tall, were reportedly controlled from a single smartphone. Even though 33 of the

robots keeled over during the attempt, those remaining were more than enough to smash the previous world record of 450 dancing robots, which was set by UBTECH Robotics Corp at the CCTV Spring Festival Gala back in January.

To watch the record-breaking robots in action, visit bit.ly/dancing_bot



WELCOME TO AREA 404

Facebook launches new hardware development lab

Facebook is the world's biggest social media network. And, while this brings advantages, it also brings challenges. When around a sixth of the world's population is relying on you for its news, entertainment and communication with friends, family and colleagues, you need a versatile and resilient hardware network to keep things running smoothly.

That's why Facebook has just opened Area 404, a large facility at the company headquarters in Menlo Park, California. Named after the error code for a website failing to load, this state-of-the-art laboratory is where Facebook's engineers will design, build and test new technology intended to keep those Likes and Shares flowing freely.

As well as electrical engineering labs, Area 404 is home to a number of prototyping workshops. Equipped with all manner of machinery such as lathes, milling machines and a high-pressure water jet that can slice through sheet metal, as well as equipment such as electron microscopes and CT scanners, these workshops are where new Facebook-related tech will be developed. Next time you hear Mark Zuckerberg enthusing about bringing internet access to isolated areas via solar-powered drones, or

talking up the new Facebook Surround 360 video capture system for VR applications, be assured he's not just spouting hot air – these are the kind of projects that are being worked on inside Area 404 right now. For example, those lathes we mentioned earlier can be used for making gimbals, which are used in communications lasers, while the electron microscopes can check hardware for faults.

“Connectivity Lab, Oculus, Building 8, and our Infrastructure teams can now work collaboratively in the same space, learning from one another as they build,” says a statement on the company website.

The building of Area 404 isn't a radical move on Facebook's part. But as Facebook continues to acquire start-ups in all kinds of technological fields, the construction of the facility is further proof of the company's wide-reaching ambitions.

Let's just hope that, with a name like that, it doesn't suddenly disappear!

THIS STATE-OF-THE-ART LABORATORY IS WHERE FACEBOOK ENGINEERS DESIGN NEW TECH

NEWS BYTE



GOGORO REACHES BERLIN

Gogoro, the battery-swapping electric scooter network we told you about in August 2015, has launched in Berlin, with 200 scooters available for hire in the city.

MISTAKEN IDENTITY

A US couple is suing IP mapping company MaxMind after it used their address as the default location for over 600 million IP addresses – leading to numerous visits from the police investigating identity theft and other crimes.

NO MORE MOORE?

A new study has suggested that Moore's Law – which says that computer processing speed doubles every two years – will no longer apply by 2021. Then again, its demise has been predicted several times before...



BITCOIN HEIST

At the start of August, hackers managed to infiltrate Hong Kong-based Bitcoin exchange Bitfinex and made off with over \$60m worth of the cryptocurrency.



Imagine that looming over you while cycling to work...

TRANSPORT

China test-drives elevated bus

Back in May, at the Beijing International High-Tech Expo, Chinese engineers showed off a radical public transport vehicle called the Transit Elevated Bus (TEB) that straddles roads, running on rails like a tram while cars pass freely underneath. And now, just a few months later, a working prototype has been demonstrated, completing a 300m test-drive in the city of Qinhuangdao on the northeastern coast of China.

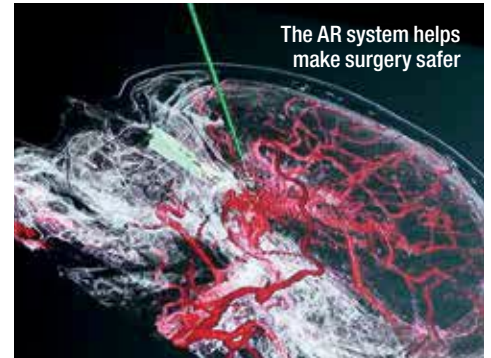
On this first outing, the bus travelled extremely slowly, but the engineers say that eventually the 22m-long bus, which stands

4.8m tall and measures 7.8m across, could attain speeds up to 60km/h (37mph) while carrying 300 passengers. Chief engineer Song You Zhou even suggests it could be running regular TEB services by the end of this year.

However, some experts have cast doubt on the bus's ability to deal with real-world hazards such as pedestrian crossings and bridges, while there's even been speculation in the Chinese press that the whole project may be part of an elaborate financial scam. We'll keep you posted on further developments.

HEALTH

AR comes to ER



The AR system helps make surgery safer

Augmented reality could soon be saving lives, thanks to researchers at New York's Mount Sinai hospital. They've developed an app that enables a surgeon to look through the surgical microscope and see video overlays of, for instance, the precise location of key blood vessels, even if these are physically hidden from view.

Joshua Bederson MD, of Mount Sinai's Dept of Neurosurgery, compares the system to sat-nav in your car. "We know where we're going most of the time," he says, "but, if we have a map that's updated in real time, and can see the position of our car in relation to that map, that can make the drive more efficient. We're trying to bring in other lines of information that make doing these procedures even safer."

CARS

The glide of your life

Back in 2013, Nissan introduced a concept electric sports car called the BladeGlider. It was originally slated to go into production, but then any such plans were quietly shelved.

Now, though, Nissan has been showing off a working prototype of BladeGlider, fuelling speculation that it may one day hit showrooms after all. Let's hope so, because with a top speed of 185km/h (115mph), the ability to go from 0-60 in under five seconds and, perhaps most importantly, very cool butterfly doors, this is one electric vehicle that should spare you all the tree-hugger jibes... even if the three-seater's triangular shape is a little bit odd.



Electric cars: not just for tree-huggers

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PORTFOLIO

Visions of the Future

The **Visions of the Future** posters, from the NASA's Jet Propulsion Laboratory in California, promote travel to planets and moons in our galaxy. These posters show the ultimate holiday 'destinations' in a retro-design format that captures the imagination of space travel; something humans have been dreaming about for years

Images courtesy NASA/JPL-Caltech

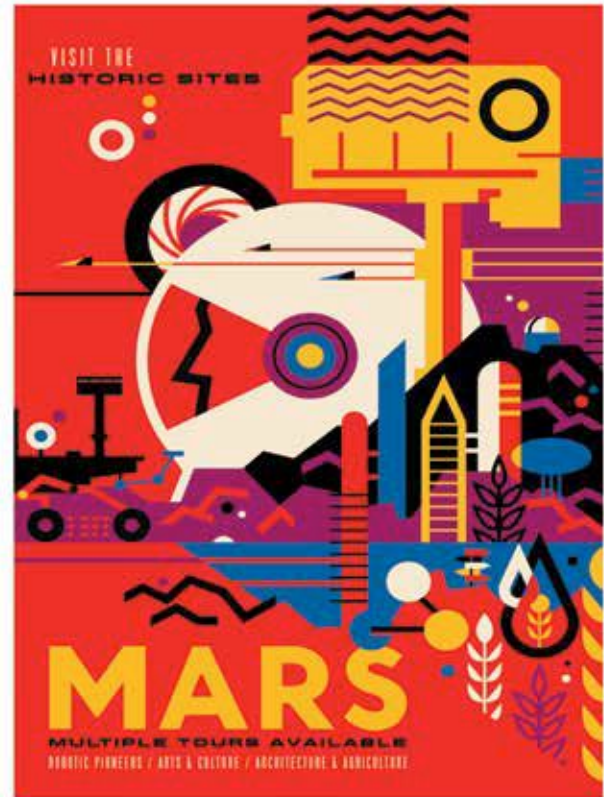
Europa

Astonishing geology and the potential to host the conditions for simple life make Jupiter's moon Europa a fascinating destination for future exploration. Beneath its icy surface, Europa is believed to conceal a global ocean of salty liquid water twice the volume of Earth's oceans. Tugging and flexing from Jupiter's gravity generates enough heat to keep the ocean from freezing. On Earth, wherever we find water, we find life. What will NASA's Europa mission find when it heads for this intriguing moon in the 2020s.



Mars

NASA's Mars Exploration Program seeks to understand whether Mars was, is, or can be a habitable world. Mission like Mars Pathfinder, Mars Exploration Rovers, Mars Science Laboratory and Mars Reconnaissance Orbiter, among many others, have provided important information in understanding of the habitability of Mars. This poster imagines a future day when we have achieved our vision of human exploration of Mars and takes a nostalgic look back at the great imagined milestones of Mars exploration that will someday be celebrated as "historic sites."



PSO J 318.5-22

Discovered in October 2013 using direct imaging, PSO J318.5-22 belongs to a special class of planets called rogue, or free-floating, planets. Wandering alone in the galaxy, they do not orbit a parent star. Not much is known about how these planets come to exist, but scientists theorise that they may be either failed stars or planets ejected from very young systems after an encounter with another planet. These rogue planets glow faintly from the heat of their formation. Once they cool down, they will be dancing in the dark.

RELAX ON KEPLER-16b

Kepler-16b

Like Luke Skywalker's planet "Tatooine" in Star Wars, Kepler-16b orbits a pair of stars. Depicted here as a terrestrial planet, Kepler-16b might also be a gas giant like Saturn. Prospects for life on this unusual world aren't good, as it has a temperature similar to that of dry ice. But the discovery indicates that the movie's iconic double-sunset is anything but science fiction.



THE LAND OF TWO SUNS

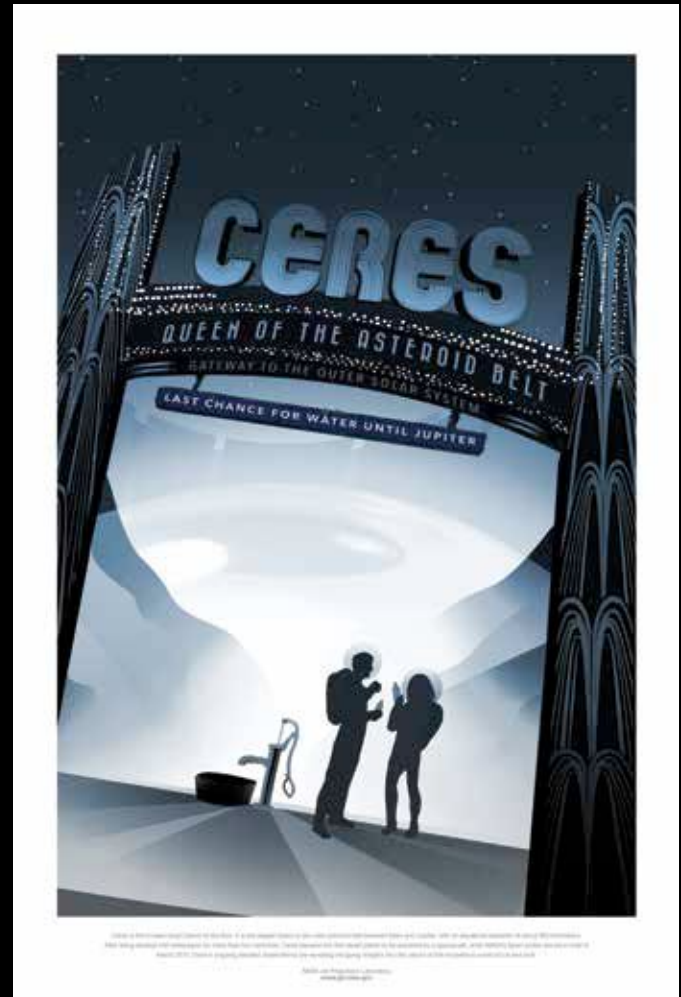
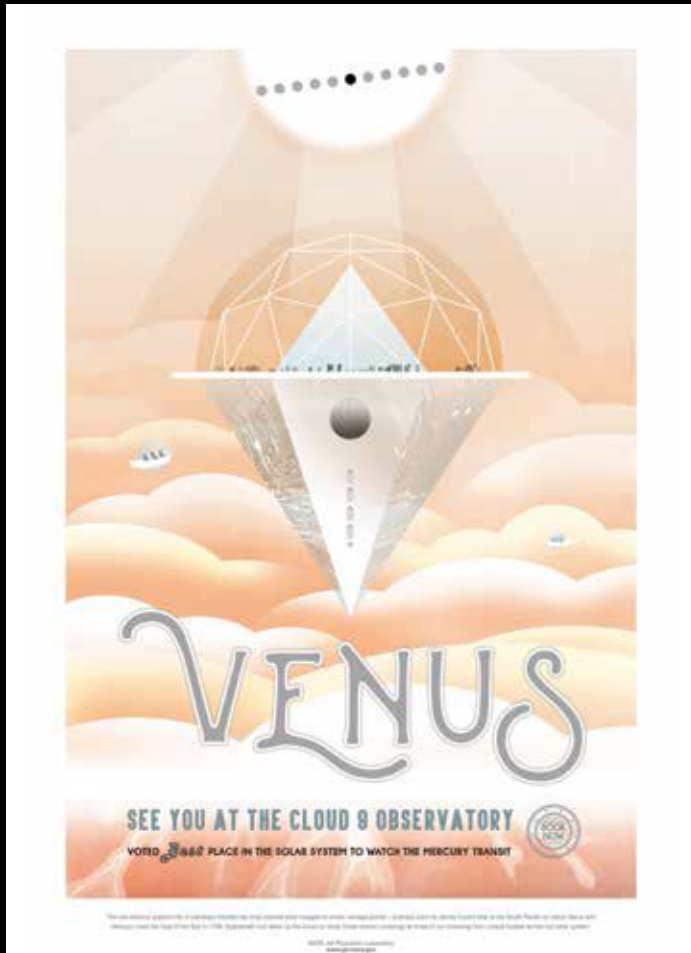
WHERE YOUR SHADOW ALWAYS HAS COMPANY

Like Luke Skywalker's planet "Tatooine" in *Star Wars*, Kepler-16b orbits a pair of stars. Depicted here as a terrestrial planet, Kepler-16b might also be a gas giant like Saturn. Prospects for life on this unusual world aren't good, as it has a temperature similar to that of dry ice. But the discovery indicates that the movie's iconic double-sunset is anything but science fiction.

NASA's Exoplanet Exploration Program, Jet Propulsion Laboratory, Pasadena CA
exep.jpl.nasa.gov

Ceres

Ceres is the closest dwarf planet to the Sun. It is the largest object in the main asteroid belt between Mars and Jupiter, with an equatorial diameter of about 965 kilometres. After being studied with telescopes for more than two centuries, Ceres became the first dwarf planet to be explored by a spacecraft, when NASA's Dawn probe arrived in orbit in March 2015. Dawn's ongoing detailed observations are revealing intriguing insights into the nature of this mysterious world of ice and rock.

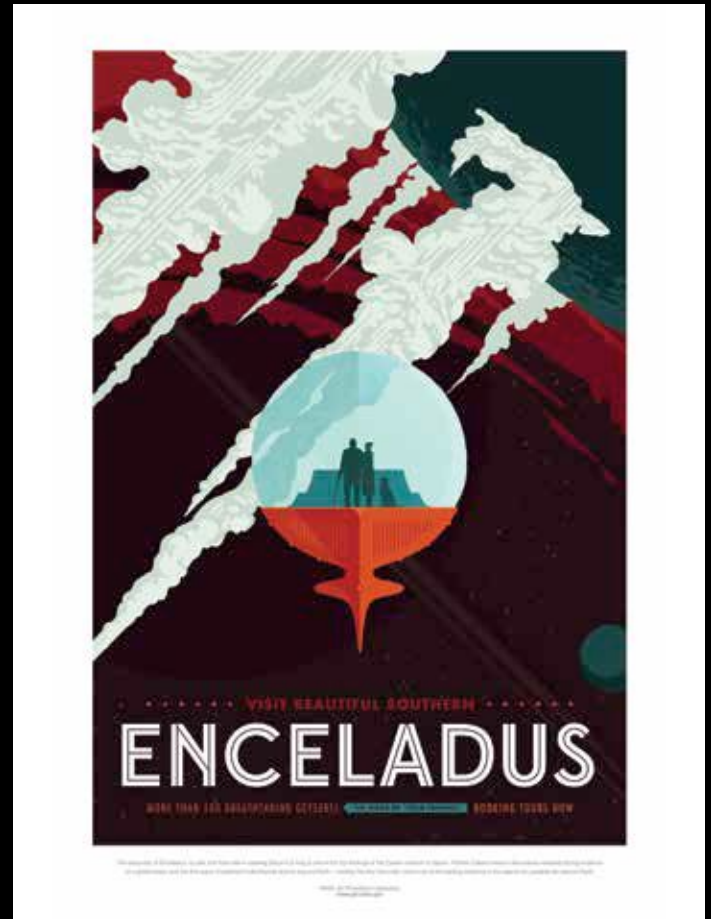


Venus

The rare science opportunity of planetary transits has long inspired bold voyages to exotic vantage points – journeys such as James Cook's trek to the South Pacific to watch Venus and Mercury cross the face of the Sun in 1769. Spacecraft now allow us the luxury of studying these cosmic crossings at times of our choosing from unique locales across our solar system.

Enceladus

The discovery of Enceladu's icy jets and their role in creating Saturn's E-ring is one of the top findings of the Cassini mission to Saturn. Further Cassini mission discoveries revealed strong evidence of a global ocean and the first signs of potential hydrothermal activity beyond Earth – making this tiny Saturnian moon one of the leading locations in the search for possible life beyond Earth.



Kepler-186f

Kepler-186f is the first Earth-size planet discovered in the potentially 'habitable zone' around another star, where liquid water could exist on the planet's surface. Its star is much cooler and redder than our Sun. If plant life does exist on a planet like Kepler-186f, its photosynthesis could have been influenced by the star's red-wavelength photons, making for a colour palette that's very different from the greens on Earth. This discovery was made by Kepler, NASA's planet-hunting telescope. 🟡

To download these posters [click here](#)

#SendMeToSpace

We ran a contest #SendMeToSpace to celebrate our Space Special issue. We asked our fans to wear their creative hats and tell us why they would like to go to space. We received an overwhelming response and, as promised, here are our six winners!



Rahul Jain: #SendMeToSpace

1. I can grow taller in space without the compressive force of gravity.
2. If my coffee mug slips from my hand, it won't break, because zero gravity.
3. I want to see if Pizza Hut will deliver a hot and fresh pizza before 30 minutes.



**Dinesh Mehta
@nishumehtaa**

My wife is always asking for the moon & the stars. This is the perfect opportunity for me to fulfil her wish.

#SendMeToSpace



@gj.garimajain:

I want to experience zero gravity.

#SendMeToSpace



Hiral Gosrani

I need some space!

Hence, #SendMeToSpace already!



**sneha agarwal
@agarwal2sneha**

1 day on Pluto = 6 Earth days.
Will complete my Chartered Accountancy course on Pluto.

So #SendMeToSpace



@rohit_ahuja97:

Because that is where all the astronauts are hanging out.

#SendMeToSpace

NEWS FROM THE WORLD OF TRAVEL & FOOD

INFO NUGGETS FROM ACROSS THE GLOBE

Milford Sound, New Zealand



The Maori name for Milford Sound is *Piopirotahi*, after the thrush-like piopio bird, which is, now, sadly extinct. Milford Sound is a fiord on New Zealand's South Island.

Cumbria, England



At the annual World Gurning Championship in Cumbria, contestants must contort their face into strange and unnatural shapes, with their head poking through a horse's collar.

China



China has a new Coiling Dragon Cliff Skywalk in Zhangjiajie National Forest Park in the Hunan province. You can now walk a thrilling 100-m long glass pathway hugging the side of Tianmen Mountain.

Lalibela, Ethiopia



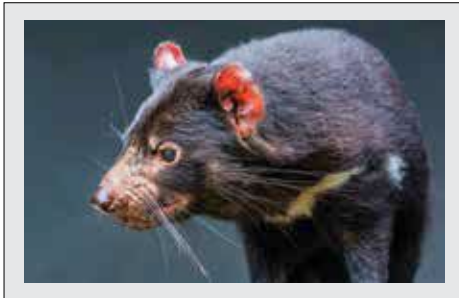
Legend has it that God appeared to King Lalibela in the 12th century and commanded him to build a Jerusalem in Africa. The Ethiopian king built 11 churches out of volcanic bedrock.

The Faroe Islands

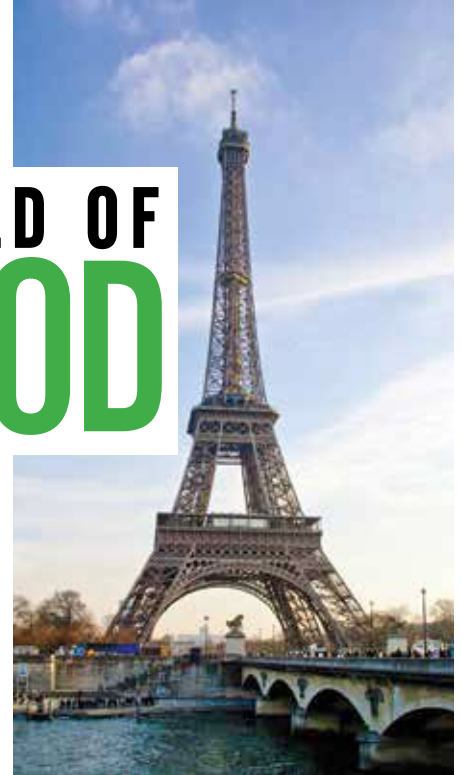


Sheep in the Faroe Islands carry solar-powered cameras on their backs, to shoot the landscapes as they roam. The local authorities hope, this will, in time, help them map the islands.

Tasmania, Australia



Not really fierce as pop culture makes it out to be, the Tasmanian devil is a small, stocky creature that gets its name from the unearthly noises it makes – from low menacing grumbles to high-pitched hysterical shrieks.



5 GREAT-TO-KNOW FACTS ABOUT THE EIFFEL TOWER, PARIS, FRANCE

- *Le Tour Eiffel* was built for the World Fair of 1889, and meant to be a temporary installation.
- It stands 32.4 metres high. In its time, it was the tallest structure in the world, eclipsed in 1930 by the Chrysler Building in New York. It won that honour again in 1957 with the addition of radio masts, but only temporarily.
- The tower has been painted bright red and yellow in the past, but today sports three shades of brown to counteract atmospheric haze and appear one uniform colour.
- To mark the 125th anniversary of the monument in 2014, a new glass platform was added to the first floor, which visitors can now gingerly tiptoe across.
- It remains one of the most popular paid-for attractions in the world, with more than 250 million visitors since its opening.

TRAVEL WITH FOOD *SOM TAM*, THAILAND

Som tam, a crunchy salad, is a perfect example of Thai food's spicy, sour, sweet and salty flavours. Made with shredded raw papaya, it comes studded with bird's eye chillies, peanuts, and dried shrimp, and dressed in a tangy dressing, making it a refreshing snack or light meal.



THE MOST EXTREME JOBS IN SCIENCE

From crocodile behaviourist to faecal transplant technician, **Katherine Nightingale** and **Jo Carlowe** look at some of the most extraordinary jobs in science

Volcanologists get up close to erupting volcanoes to find out more about how lava flows



THE LAVA LOVER

NAME: **Dr Hugh Tuffen**

JOB TITLE: **Volcanologist**

BASED: **Lancaster University, the UK**

I first became interested in volcanoes when I was about seven. I slept with a volcano picture book under my pillow.

There have been a few moments of concern. One night in Chile, heavy ash and pumice rained down on our camp and we had to decide whether to stay or go. Or there was the time we were digging increasingly desperately into the mountainside to find uncontaminated snow to melt for drinking water. I also spent months camping in Iceland for my PhD, enduring days of wind and rain. It's not much fun putting on wet clothes for the fourth day in a row, but the exquisite beauty and isolation of the environment makes up for it.


I study what makes volcanoes explosive and how the gas trapped in magma drives violent eruptions, forcing out lava and throwing ash kilometres into the air. We're also trying to figure out what controls the way that lava flows, in the hope of helping people who live in its path. This means travelling abroad to erupting volcanoes, often at short notice, to witness these explosions.

Sometimes, it's possible to walk up to lava as it flows and take samples with a shovel. Back in the lab, we'll heat a sample to over 1,200°C so it'll behave like it's in the volcano. This means we can see what's happening on a microscopic scale.

Knowing that my work can help lots of people is motivating. But it's annoying that there are far too many interesting volcanoes to study, and that's before you even include the ones on other planets and moons in our Solar System. ►

THE CROC PSYCHOLOGIST

NAME: CHERIE CHENOT-ROSE
JOB TITLE: RESEARCH BIOLOGIST AND
CO-FOUNDER OF THE AMERICAN
CROCODILE EDUCATION SANCTUARY
BASED: FLORIDA, THE USA & BELIZE



A member of Cherie's team holds one of the smaller residents at the American Crocodile Education Sanctuary

I've been bitten by three species of crocodylians, and one broke my shin with a whip of its head. I don't carry a weapon but my teammates have large knives. Our intent is not to harm the animal, and we never have, but human safety always comes first.

We normally get called out when a crocodile is under someone's home. We wait through the night, wet, muddy and stinking of rotten chicken, which we use to tempt the crocodile out. Then, game on! My husband, Vince, snares the croc and drags it onto land while I position myself behind it. When the time is right, I leap onto the head of the animal. An assistant secures the back legs, then we tie up the croc, collect data and tag it before releasing it. If people's safety is at risk, we relocate the croc, or place it in captivity.

To know how to respond, we need to study the behaviour of the animals. The crocodile to worry about is the one at the water's edge, totally submerged but for the tip of its nose, watching you through its translucent third eyelid. While you are distracted, it's waiting for the right moment to strike. A croc can strike three times faster than a rattlesnake.

One time, while capturing a three-metre male crocodile, the rope broke. I felt the vibration from its teeth smashing together just inches from my upper thigh. Crocodiles smack their jaws together so hard that they can shatter their own teeth.

The toughest part is not capturing the crocodiles, it's obtaining funding. The most rewarding part of my job is rescuing an injured crocodile, rehabilitating it and setting it free.

THE GUT DETECTIVE

NAME: DR ENID TAYLOR
JOB TITLE: CLINICAL DIRECTOR
OF THE TAYMOUNT CLINIC
FOR DIGESTIVE HEALTH
BASED: HERTFORDSHIRE, THE UK

The first time a caller asked if we did faecal transplants, I was so horrified I cleaned the phone in disdain. Back then, the Taymount was a naturopathy clinic, but my husband, Glenn, had a light-bulb moment – he saw faecal microbiota transplant (FMT) as the answer to a huge problem, and the FMT clinic evolved from there. We now use FMT to treat patients with various gut conditions.

We extract good bacteria from donor stool and refine it. We wear protective clothing as nobody wants to be splashed in poo, refined or not! Early in our equipment development, a tube blew out of a lid and a jet of liquid faecal material shot into the



A steady hand, a tiny collection tube and a respect for animals are necessary requirements for milking a venomous spider

THE SPIDER MILKER

NAME: **STEVE TRIM**

JOB TITLE: **FOUNDER OF VENOMTECH**

BASED: **SANDWICH, THE UK**

ceiling extractor. We had to laugh as the s**t really had hit the fan!

Once we've refined the donation, we ultra deep-freeze it. When it's ready to be used, it is thawed, warmed and introduced into the patient's body using a rectal catheter. There's little smell as it's all contained within syringes. During administration, you have to be gentle; I get the patient to lie in relaxing positions and talk to them about diet and how to look after their new internal 'pets'.

It's a personal journey that brought me into this work. I had Irritable Bowel Syndrome, and have always been interested in food and digestive health. When you painfully need the toilet every 45 minutes, it's hard to keep a job and maintain relationships. Helping people regain normal function is heart-warming.

When people ask what I do, I take a deep breath and decide whether to give the short answer or the longer, more scientific one. Sometimes, I joke that I'm a 'poo doctor'. My husband and I have five grown-up children. At first they didn't know what we did, but, now they ask advice. I have a sneaking suspicion they might be a little bit proud.



KEEPING spiders and reptiles fascinates me. I kept non-dangerous spiders and snakes as pets, but, following redundancy, I used my previous experience working in pharmaceuticals to set up Venomtech in the back of a pet shop in Ramsgate. Six years on, we now occupy a large lab.

Venomtech is the UK's only commercial venom supplier. We collect venom from, 70 species of theraphosidae, which is a family that includes tarantulas; 30 scorpion species, several true spiders such as black widows, brown recluses and Brazilian wandering spiders, jellyfish and anemones, centipedes, millipedes, some ground beetles, and 65 species of venomous snakes.

Clad in lab coats, gloves and safety glasses, we hold the snakes behind the head using a handling tool. They are happy to deliver venom into anything in front of them, including our polypropylene pots.

The toughest work is with small spiders such as black widows (the most toxic creature in our lab). Their fangs are so tiny, you need a steady hand, great discipline and a methodical approach. We place their fangs into little collection tubes and stimulate the venom glands with tiny electrical impulses. If the venom misses, it is unusable. Even anaesthetised, black widows are handled with forceps and given a constant flow of CO₂ to ensure they stay asleep.

My family worries, but my wife shares my passion for venomous animals, and we have not had any incidents. The best part is seeing our venoms killing *E. coli* and *Staphylococcus*, which could help with antibiotic resistance. ▶



Forensic entomologists study the insects that colonise dead bodies

THE INSECT INVESTIGATOR

NAME: **DR AMORET WHITAKER**
 JOB TITLE: **FORENSIC ENTOMOLOGIST**
 BASED: **UNIVERSITY OF WINCHESTER & THE NATURAL HISTORY MUSEUM, THE UK**

THE first time I looked at insects down a microscope at university, I thought they were amazing. I'd never really thought about insects before, as I wasn't one of those kids who collected butterflies from an early age. I began my zoology degree imagining I'd end up saving big, furry animals.

I study insects in a legal context, usually the flies and beetles that colonise dead bodies. It's a mixture of research, where I study the development of flies and beetles in different conditions, and work with the police, where I use that knowledge to determine when a person died. Blowflies are usually the first insects to find a body, so they're useful for estimating the time since death.

In this job, you never know what's going to happen. There are just a handful of forensic entomologists to cover the whole country, so I'm on call 24 hours a day, seven days a week. Sometimes, I can be working on six cases, and, other times I might go months without a call-out. I also teach at the University of Winchester, and do research at London's Natural History Museum and the 'body farm' at the University of Tennessee, where corpses are left to decay and be studied.

The case work can be distressing. And there are scary moments too, such as working on the body farm at night. It's incredibly satisfying though, particularly helping bring closure to families. Unlike the three years that I spent studying fleas earlier in my career, no one ever asks me what the point of it is.



Amoret needs to understand all stages of insect development, to help her determine how long a person has been dead for

BARBARA WINTER/SIMON FRASER UNIVERSITY; ROBBIE SHONE





THE CAVE RAIDER

NAME: **DR HAZEL BARTON**
JOB TITLE: **MICROBIOLOGIST**
BASED: **UNIVERSITY OF
AKRON, OHIO, THE USA**

Hazel spends days at a time in cave systems, like this massive one in China, hunting for microbes

I started caving back in sixth form at school, long before I became a scientist. When I started working as an environmental microbiologist, it seemed natural to combine the two.

I study microbial ecosystems in deep and remote caves, trying to work out how microorganisms can grow in the dark with so few nutrients. We work at depths of up to 500m – the microbiology gets more interesting the deeper you get. We'll spend around a week in a cave, exploring its structure and taking samples of microbes. The expeditions are huge undertakings, about as logistically technical as climbing Everest. We rig our own ropes, and carry all our camping gear and research equipment, sometimes through gaps as small as 20cm.

When you spend a week in complete darkness, you have to be careful that your circadian rhythm doesn't slip into 27-hour days. I make sure that everyone's in bed by 10pm and up at 7am. On the first few trips, you get really cranky because of the lack of sunlight. And you need to make sure that you like and trust the people you're with. If something goes wrong, your life is in their hands.

The best thing about my job is the travel – as well as the USA, we also work in Venezuela, Brazil, Belgium and China. You never know what you're going to find. In China, we discovered the third biggest cave room in the world by following a river into a mountainside and ending up in a vast space 600m long, 200m wide and 400m high. It was an incredible feeling. 📍

Katherine Nightingale and Jo Carlowe
are science writers who write for *BBC Focus* magazine.

Shakespeare's history plays were influenced every bit as much by contemporary events as episodes from the past. **Jerry Brotton** reveals how eight of Shakespeare's works reflected political crises of the day – much to the ire of Queen Elizabeth's censors



HOW SHAKESPEARE REWROTE HISTORY

HENRY VI, PART 1

ENGLAND BLEEDS AGAIN

The military reversals dramatised in *Henry VI, Part 1* would have been all too familiar to Shakespeare's audience

In the early 1590s, an exciting young playwright called William Shakespeare burst onto the Elizabethan theatre scene with three popular plays about the Lancastrian king Henry VI (1421–71) and the civil discord that eventually culminated in the accession of the Yorkist Richard III in 1483. The cycle catalogues the young king's weakness and how, as Shakespeare wrote later in *Henry V*, "so many had the managing" of his state that "they lost France and made his England bleed".

The action in *Henry VI, Part 1* is driven by the wars in France and the contrast between the heroic Lord John Talbot (c1387–1453) and the French warrior Jeanne la Pucelle, known in Britain as Joan of Arc (1412–31). They fight over various French cities, including Rouen, which changed hands in 1418–19.

In the play, the English soldiers "sit before the walls of Rouen". That historical siege displayed direct parallels with events that were taking place as Shakespeare wrote his play. In 1589, Elizabeth sent an army to France to oppose the Catholic League and support the Huguenot king Henry IV. During the winter of 1591–92, the English forces besieged Rouen, but political confusion, military mismanagement and disease led to the abandonment of the siege, with huge loss of English life and disillusionment with the whole campaign. No wonder the three parts of *Henry VI* were so successful: They were effectively military and political reportage of current events, as well as broader reflections on pre-Tudor English history.



Fiona Shaw plays *Richard II* in a 1995 production. The play ponders the justifications for deposing a monarch, a topic too contentious for Queen Elizabeth's censors

RICHARD II

SCRIPTING SEDITION

Was Shakespeare's *Richard II* a thinly veiled swipe at the ageing Queen Elizabeth?

In 1595, Shakespeare began work on a second tetralogy of English history plays covering a period even earlier than his previous series. His new cycle began with *Richard II* (1367–1400), and ended in 1420, five years after Henry V's triumph at the battle of Agincourt.

Today *Richard II* is often performed as the tragedy of the downfall of a querulous poet-king who belatedly discovers his humanity after his deposition at the hands of Henry Bolingbroke, the future King Henry IV. But, in the mid-1590s, it engaged in a politically dangerous debate on the rights and wrongs of overthrowing a legitimate monarch. As Bolingbroke prepares to depose Richard, the bishop of Carlisle asks: "What subject can give sentence on his king?"

When the play was first printed in 1597, the climactic deposition scene was missing, suggesting that Elizabeth's censors deemed it too provocative. Inviting parallels between the weak Richard and the elderly Elizabeth in the 1590s was certainly dangerous. Others, such as the historian John Hayward, were arrested for comparing Elizabeth's former favourite Robert Devereux, 2nd Earl of Essex, to Henry IV. On the eve of Essex's rebellion against the queen, his supporters paid Shakespeare's company to perform a play about Richard II at the Globe Theatre, to show the righteousness of deposing a monarch like Richard – for example, Elizabeth. Though the performance did not have the desired effect of inciting rebellion, a subsequent anecdote claimed that Elizabeth knew exactly how her enemies saw her, saying: "I am Richard II, know ye not that?"

THE MERCHANT OF VENICE

JEW IN THE FIRING LINE

The Merchant of Venice mirrors the dark fate of Elizabeth's personal physician

Written around 1596, *The Merchant of Venice* remains one of Shakespeare's most controversial plays. Modern audiences understand it as being about Shylock, a Jewish moneylender living in Venice, though its title actually refers to his Christian adversary, the Venetian merchant Antonio. It is called a comedy but revels in attacking Jews, with Shylock pursuing the murderous settlement of a bond that enables him to take a "pound of flesh" from Antonio's body.

Shakespeare's interest in Shylock might seem odd, considering that Jews had been officially expelled from England in 1290 and were only readmitted under Cromwell in 1656. Yet a small number of Jews did live in Elizabethan London, inspiring several plays that influenced Shakespeare, including Christopher Marlowe's *The Jew of Malta* (1589–90).

But Shakespeare probably knew more about Jews from England's trade with Morocco, conducted almost exclusively

through Jewish intermediaries. Perhaps the greatest influence on the play was the public execution in 1594 of Elizabeth I's personal physician, Dr Roderigo Lopez, a Portuguese-born Jewish convert to Protestantism, convicted of treason for allegedly trying to poison the queen. Before he was executed, it was reported that he said "he loved the queen as well as he loved Jesus Christ; which, coming from a man of the Jewish profession moved no small laughter in the standers-by".

The cruel but uneasy laughter that accompanied Lopez's death permeates Shakespeare's play. Shylock calls his bond with Antonio "a merry sport", and though his famous speech "Hath not a Jew eyes?" inspires sympathy, its conclusion is somewhat darker: "If a Christian wronged a Jew, what should his sufferance be by Christian example? Why, revenge. The villainy you teach me, I will execute." Perhaps the Christians are more of a problem than the Jews.

Henry Urwick plays Shylock in *The Merchant of Venice*, a play that "revels in attacking Jews"

By comparing the Earl of Essex, shown in a 1599 portrait, to Henry V, Shakespeare was playing a risky game



HENRY V

THE DISGRACE OF ESSEX

Henry V was written at a time when another, less accomplished military leader floundered in Ireland

Shakespeare's second tetralogy ended with *Henry V*—and also nearly got him into hot water, again involving the troublesome Earl of Essex. The play dramatises the reign of Henry V (1386–1422), depicting his victories at the siege of Harfleur and battle of Agincourt in 1415, and his famous rallying cry of “God for Harry, England, and Saint George!” But, at the time it was written, in late 1599, the aged Queen Elizabeth was under pressure to name a successor, and struggling with rebellion in Ireland. In spring 1599, she sent the Earl of Essex to defeat the Irish. The campaign was a disaster, and the disgraced Essex returned to London. Arrested in September

1599, he was executed after a botched uprising in 1601.

In Henry V's penultimate Chorus speech, probably written as London awaited news of Essex's Irish campaign, Shakespeare made his only reference to contemporary political events, comparing Henry V to Essex, “the general of our gracious empress”, “from Ireland coming”, and bringing “rebellion broached on his sword”. Was this an endorsement of Essex and a criticism of Elizabeth? We may never know because the rebellion failed. But writing a play about a virile young monarch when Essex was challenging the authority of an elderly queen was certainly a risky move.

OTHELLO

FEAR OF THE MOORS

Was *Othello* modelled on a Moroccan ambassador to the English court?

Subtitled ‘The Moor of Venice’, *Othello* is one of Shakespeare's greatest high tragedies, written either just before or after Queen Elizabeth's death and King James VI and I's accession in 1603. The play contained highly topical resonances for its English audience. ‘Moors’ came from Mauretania (as Iago says), in what's now Morocco, and inspired both racial and religious anxieties for Elizabethans.

The region was predominantly Muslim, under the control of the Sa'adian dynasty. Elizabeth allied herself with Morocco, establishing the Barbary Company to trade English munitions for sugar (which wreaked such havoc on her teeth). In the summer of 1600, the Moroccan ambassador Muhammad al-Annuri and his retinue arrived in London and stayed for six months, negotiating treaties with Elizabeth. Al-Annuri, rumoured to be a Morisco (a Spanish-born Muslim forced to convert to Christianity, but who in this case then reverted) even had his portrait painted.

Was al-Annuri the model for Othello? Shakespeare's Othello describes himself in ambiguous terms, speaking “Of being taken by the insolent foe”, which we assume to be the Ottomans, and then of being “sold to slavery”; his “redemption thence” suggests his conversion to Christianity. But, by the end of the play, after killing Desdemona, he compares himself to “a malignant and a turbaned Turk”. His identity is clearly far more complex than that of being simply ‘black’, and suggests how conflicted the Elizabethans felt about the Muslim world.

MACBETH

A WAR ON CATHOLICS

Macbeth reflected the paranoia of London in the aftermath of the gunpowder plot

The ‘Scottish play’ is perhaps Shakespeare's most topical. James VI of Scotland's accession to the English throne led Shakespeare to consult the historian Raphael Holinshed's *Chronicles* (1587). He rewrote Holinshed's story of Macbeth's murder of Scottish king Duncan and the role of the witches in his downfall, while celebrating the importance of Banquo, from whom it was believed James was descended.

The king had written a book about his belief in witchcraft, called *Daemonologie* (1597), so he was

probably delighted to watch a play showing “weird” witches that “trade and traffic with Macbeth / In riddles and affairs of death”.

But Shakespeare also exploited London's tense atmosphere following the unsuccessful gunpowder plot of November 1605. One of the executed conspirators was the Jesuit father Henry Garnet, who had written a book on equivocation, directing Catholics to give misleading or ambiguous answers if arrested by the Protestant authorities. Many regarded equivocation as a sign of

Catholicism's duplicity.

It's an idea that suffuses Shakespeare's play. Macbeth condemns the witches as spirits who “palter [equivocate] with us in a double sense”. Immediately after Duncan's murder the porter answers the knocking at the castle's gates by saying: “Here's an equivocator,” someone “who committed treason enough for God's sake, yet could not equivocate to heaven.” This alludes to Garnet's presumed failure to argue his way into heaven.





Romans attempt to make peace with the famously authoritarian Coriolanus in a 14th-century illumination

CORIANUS

DEATH BEFORE STARVATION

Class conflict looms large in the tale of the Roman warrior, *Coriolanus*

The central character of Shakespeare's last Roman play, usually dated 1608, is the semi-mythic Roman general Caius Martius, who took the name Coriolanus after his siege of the Volscian city of Corioli. Coriolanus is a warrior who tries and fails to forge a political career, and is banished from Rome.

Shakespeare took his story from the Greek historian Plutarch, but deviated from his source to write a play obsessed with food, starvation, blood and bodies. The reasons for this were closer to home than ancient Rome. In spring 1607, with rocketing corn prices, the fear of famine and the escalating enclosure of common land, more than 5,000 protestors rioted across the Midlands, including Shakespeare's home county, Warwickshire.

King James brutally crushed the rebellion, hanging its ringleaders, but the Midlands Rising

– just one of the more significant rural rebellions throughout the late Elizabethan and Jacobean period – exposed a faultline running throughout English society that found its expression in *Coriolanus*. The first act opens with mutinous armed citizens “resolved rather to die than to famish”. When the patricians enter, the citizens protest they “ne'er cared for us yet; suffer us to famish, and their storehouses crammed with grain”.

One of the senators tries to calm the citizens with the famous ‘belly fable’, arguing that all parts of the body need to work together. When Coriolanus enters he condemns the rebels as “fragments” of uneaten food.

Such class conflict would only intensify throughout the Jacobean and Caroline period, and came to define the battles between royalists and republicans in the 1640s.



A map shows the English arriving in Virginia in 1607 and establishing their first ever colony

THE TEMPEST

BRAVE NEW WORLD

The Tempest may have been inspired by English forays to the Americas

Written in late 1610 or 1611, *The Tempest* is often regarded as Shakespeare's farewell to the stage, in which he announces “now my charms are all o'erthrown”. It is a strange, unclassifiable play about Prospero, the deposed Duke of Milan (seen as Shakespeare's self-portrait) who, set adrift on a boat, finds his way to an island where he uses magic to engineer the marriage of his daughter Miranda to Ferdinand, heir to the kingdom of Naples.

The play's ethereal atmosphere belies its acute political contexts. There is a colonial dimension to Prospero's relations with the island's compliant Ariel, who begs for “freedom”, and with the rebellious Caliban, whom Prospero calls “this thing of darkness I acknowledge mine”. The colonial element seems to have been inspired by pamphlets written in 1610 describing an English fleet shipwrecked in Bermuda – Ariel's ‘still-vexed Bermudas’ – en route to the fledgling Jamestown colony in Virginia. This suggests that the play is set in what it calls the “brave new world” of the Americas.

In 1613 the play was performed as part of royal celebrations for the eagerly anticipated marriage of King James's daughter Elizabeth to the Protestant Frederick, the Elector Palatine. *The Tempest* also contains a masque that Prospero calls a “contract of true love to celebrate” Miranda and Ferdinand's nuptials.

Though not necessarily written for the marriage, the play seems to reflect the belief that dynastic marriages could establish peace and security within Europe. It was a forlorn hope: in under a decade, Shakespeare was dead and the Palatinate dispute led to the horrors of the Thirty Years' War. 🟡

Jerry Brotton is the author of *This Orient Isle: Elizabethan England and the Islamic World*, which is published by Allen Lane in March

KING OF THE MOUNTAINS

Picture a primate that grazes like a cow, climbs cliffs like a mountain goat and forms groups as big as shoals of fish. **Noah Snyder-Mackler** introduces Ethiopia's gelada

Photos by Anup Shah and Fiona Rogers



The gelada's pale eyelids stand out against their dark faces and are used to communicate

A male gelada will fight against a rival bachelor using his large canines to inflict injury to defend his position as leader of his unit



CECILIA and her sister, Carmen, were a bit unsure of the new guy, Orion, who had just joined their group. They stayed far away from him and kept their babies close by. There was a good chance that he could hurt them or, more likely, their infants. Fortunately, Doug, the father, was around to protect them. No, this isn't a recap of a recent soap-opera episode – it's just a day in the life of a group of geladas.

If you're ever above the clouds on the lush plateaus of East Africa, you might find yourself surrounded by thousands of monkeys diligently foraging for food. But these animals aren't swinging from tree branches like some of their close relatives. Instead they spend the majority of their time scooting around on their 'bums', grazing like cows. These are a one-of-a-kind species that can only be found among the escarpments and gorges of the Ethiopian highlands.

These gregarious primates are often called 'bleeding-heart baboons', which, though poetic, is misleading. Not because they don't have blazingly red chests, but because geladas are not actually baboons, they are just their close relatives. Monkeys from the genus *geladas*, *Theropithecus*, used to range all over East Africa. Now, however, the gelada is the sole species left – a unique survivor.

One of the main reasons these monkeys outlived their

relatives is due to a panoply of unique adaptations that enables them to survive in a resource-poor, high-altitude environment. In the thin air of the gelada's habitat (often about 3,000m above sea level) there is a dearth of nutrient-rich foods, so they depend almost entirely on the grasses and tubers that carpet the plateaus.

In order to acquire enough nutrients to survive, geladas need to forage from dawn until dusk. And forage they do. Shuffling about on their rears, they methodically poke at the grasses and roots, stabbing at the vegetation like office workers busily typing away on computers.

This *derrière*-guided movement is often credited as the driving force behind another of their defining characteristics – a bare red patch of skin on the chest, which is an important communicative feature. While their baboon relatives have

BECAUSE OF THEIR DIET, GELADAS FORM SOME OF THE LARGEST AGGREGATIONS OF ANY NON-HUMAN PRIMATE

The patch on the chest of the females blazes deep red when they are in oestrus



similar reproductive signals on their rear ends, geladas have them on their chests where they're clearly visible as, owing to the way they move, their behinds often can't be seen.

The hourglass-shaped chest patch on a gelada's chest ranges in colour from light pink to deep red. After studying this particular characteristic, Gelada Research Project researchers at the University of Michigan, US, found that dominant gelada males possess darker red chest patches than their subordinate, pink-chested counterparts. In females the colour of the chest patch reflects her reproductive state.

The geladas also have a number of other adaptations perfectly suited to their alpine environment. Because so few trees survive in their habitat, the species uses the surrounding cliffs as their nightly refuge. Here, they can sleep while staying safely out of reach of their primary predators – hyenas and leopards. Daily trips scaling near-vertical cliffs have made the monkeys excellent and fearless climbers, which may be associated with their extremely high finger-thumb opposability. But it's their grass-rich diet that has led to a fascinating discovery about geladas. Relying on such an abundant resource has resulted in less competition for food and, because there is strength in numbers, geladas form some of the largest aggregations of any non-human primate. ►

A young gelada





Females form very strong bonds with other females in their group

Group structure

At the core of gelada society is the reproductive unit, similar to a human nuclear family. It usually includes one dominant male 'leader', anywhere from zero to a handful of subordinate 'follower' males, and one to 12 adult females along with their immature offspring. The reproductive unit is the level where the majority of affiliative social interactions occur. Females, in particular, form strong social relationships exclusively with other females in their unit – and these tight bonds, which primarily occur between close relatives, help to keep the unit together under all circumstances.

These reproductive units associate with each other to form a 'multi-level society' that shares similarities with the structure of human society. Units that spend at least 90 per cent of their time together are called 'teams', similar to an extended family. Units in the same 'band' are found together at least 50 per cent of the time, like a group of friends. And units that range in the same area are all part of the same 'community'.

Genetic studies of one population of geladas in the Simien Mountains National Park found that this multi-level association is tightly correlated with relatedness among female geladas, but not the males. A female is most closely



Grooming helps to maintain bonds and forge alliances between unit members



Simien Mountains National Park is one of the best places to see gelada monkeys

related to the other females in her unit, a little less related to females in her team, even less related to females in her band, and the most distantly related to the females in her community. This tiered social and genetic structure prompted researchers to propose that this multi-level society has the result of females maintaining ties with their female relatives after repeated fissions of reproductive units.

Males leave their mothers, sisters and aunts once they reach sexual maturity. While this reduces the chance of inbreeding, it means that they must find and be accepted into a new social group. Once they've dispersed from their natal groups, they join all-male groups, which are aptly named 'bachelor groups'. In these groups, the young males hone their competitive skills by sparring with other males and forge coalitions by forming strong grooming relationships with other bachelors.

A fight to the top

The ultimate goal of each and every mature male is to become the leader of a reproductive unit in order to sire offspring with the females in that unit. To do so, a bachelor needs to defeat the current leader in what is called a 'takeover'. During a takeover, which can last anywhere from a couple of hours to a few days, the bachelor challenges the leader to a series of competitive chases around the herd. Only when the bachelor and leader are evenly matched does the interaction escalate to an all-out brawl. At this point, the leader and bachelor use their lion-sized canines to harm their opponent until either party submits. At the end of the battle, the females in the unit choose the male they want as their leader.

In the event of a successful takeover, the bachelor will become the new leader and the deposed male will often remain in the unit as a follower. These former leaders are likely to remain in their units to defend their



MOUNTAIN MUSIC: GELADA COMMUNICATION

Grunt

A soft call that is used when a gelada approaches or grooms a group member

Display call

A loud call uttered by males during competitive interactions

'How' bark

A loud bark used in similar situations to a display call

Wobble

A soft call produced by males while 'lip-smacking'. This closely matches the cadence of human speech

Yawn

A vocalised yawn, usually given while grooming, after mating or in competitive situations; in males, this is often accompanied by a 'lip-flip'

Copulation call

A loud grunt given by both sexes before and after mating



BEING AROUND THESE CHATTY MONKEYS CAN MAKE OBSERVERS FEEL THAT THEY ARE SITTING IN THE MIDDLE OF A CROWDED CAFE

By night geladas sleep on rocky outcrops, and forage on nearby grasslands during the day

HOW TO SEE GELADAS

- Geladas are unique to north-central Ethiopia, grazing in high-altitude meadows above 1,500m. The best place to see them is the Simien Mountains National Parks, where hikers meet bands dozens strong. Tours often also take in Bale Mountains National Parks, home to Ethiopian wolves.

- Two new mountain 'ecolodges' to consider are **Limalimo** (www.limalimolodge.com) and **Simien Lodge** (www.simiens.com).

young, dependent offspring from being killed by the new leader. The risk of infanticide pressures females to become sexually receptive more quickly than they would otherwise, because they would be infertile until their offspring are weaned. Therefore, takeovers are extremely costly to mothers with youngsters because they could lose up to two years of reproductive effort. Gelada females therefore enlist an interesting counterstrategy to infanticide. Instead of giving birth to an infant that is likely to be killed, females who were pregnant at the time of the takeover will terminate the pregnancy. These spontaneous miscarriages ultimately mean that females no longer invest time and effort rearing offspring that could be killed.

Misleading tactics

The new male leader now gets the ultimate prize: he sires the majority of the offspring in the unit. It is the 'majority' and not 'all' of the offspring because, in 'multi-male units' (those with subordinate follower males), the follower males sire one fifth of the offspring. They achieve this reproductive success through furtive copulations. During these surreptitious encounters, both the female and follower male suppress their loud copulatory vocalisations, which decreases the chance that the leader will notice them. Deceptive

behaviour such as this is rarely found outside of human society and is therefore a fascinating revelation.

Despite this loss of paternity, the leaders of the multi-male units still sire 80 per cent more offspring than leaders of single-male units. In all likelihood, this is because the follower male helps to defend the unit from the constant challenges of other bachelors. This male-male tolerance can even be considered to be a form of cooperation between unrelated males – something that is found across most modern *Homo sapien* societies.

Spending most of their time with their heads down and surrounded by hundreds of other monkeys, geladas needed to develop an exceptional communication system. They have



Young geladas are vulnerable when a new male becomes the leader of a unit

RATHER THAN GIVING BIRTH TO AN OFFSPRING THAT'S LIKELY TO BE KILLED, FEMALES WILL TERMINATE THE PREGNANCY

one of the most complex vocal repertoires of any primate, and use their wide array of vocalisations in specific situations. One of their most unique sounds, the 'wobble', has the cadence of human speech. Being around these chatty monkeys often makes observers feel like they're sitting in the middle of a crowded café.

Complex society and communication

Geladas also combine their diverse repertoire of calls to form long strings of vocalisations, which follow a linguistic principle called Menzerath's Law that had, until recently, only been observed in humans. Much like longer sentences tend to be composed of shorter words, longer gelada sequences are comprised of significantly shorter individual calls.

By combining different individual vocalisations and altering their duration in the sequence, geladas are able to generate an immense number of unique vocal 'sentences'.

With so many individuals and vocalisations to keep track of, one would think that geladas have sophisticated social cognition. Yet research so far has found that males have a very limited ability to vocally recognise other males outside their units. This may be because geladas don't need to keep track of individuals outside their unit if they can rely on the information encoded in their complex vocal sequence, but further research is needed.

There are so many questions about these intriguing animals that still need answering, and this is why researchers will keep returning to the spectacular Ethiopian highlands. Observing the behaviour and interactions of geladas like Cecilia, Carmen, Orion, Doug and their intricate community has revealed how their society functions. Studying these unique and colourful primates in their natural habitat is helping experts to understand more about the evolution of communication and relationships in their complex societies and the many ways in which they share similarities with our own. 🍌

Noah Snyder-Mackler is a primatologist and gelada expert, based at Duke University, North Carolina, the USA.



HOW SAFE IS YOUR PLANE?

So many of us take to the skies so often. **Neil Ashton** looks at the rigorous tests that planes undergo to ensure flying remains one of the safest modes of transport

AIR travel is more popular than ever. Although aeroplanes have made it easier for us to explore the world, nearly one in three of us claims to be anxious or fearful of flying.

Is this fear justified?

US statistics taken from between 2000 and 2009 show that car drivers or passengers suffer 7.3 deaths per billion

miles. In contrast, air travel comes in at just 0.07 deaths per billion passenger miles. Of course, statistics can't cure someone's fear of flying, but they do prove that it's one of the safest ways to get from A to B. This safety is thanks to the testing that every single part of the aircraft has to go through before it's allowed to undertake its first flight.



IN THE FREEZER

While passengers get to enjoy the comfort of air conditioning, the engines have to be able to cope with temperatures as low as -55°C during cruise conditions. Here, one of the latest engines is being pushed to its limits at a General Electric testing facility in Winnipeg, Canada. It's being blasted with icy water from hundreds of nozzles at sub-zero temperatures to check that it will maintain power in cold environments. Temperature tests are important to the airlines because they want to make sure that their planes can operate in as many environments as possible. Each time they have to ground an aircraft because of bad weather, they lose money. ▶

TURBULENT TIMES

For many, turbulence is one of the greatest contributors to the fear of flying. But, while turbulence can be uncomfortable, most of the time the plane is moving very little, and is well within the design limits. Rarely, severe turbulence can cause a sudden drop in altitude, resulting in a strong upwards force on the wings. Therefore, manufacturers design the wings to tolerate far higher loads than would ever be seen in reality. Here, a Boeing 787 is being subjected to a 'maximum stress' test, where the wings are exposed to over 1.5 times the normal load, bending in excess of 7m. Even then, the structure didn't break, which should give some reassurance the next time you're worried about wobbly wings.



SAFEST SEATS ▼

Travellers often wonder which the safest place to sit is. Is it the front of the plane, the middle, or the back? In 2012, a TV production company bought a Boeing 727 and crashed it into the Mexican desert to find out. The craft hit the dirt at 257km/h (160mph). While the front broke off, the rest of the plane came to a halt with relatively little damage.

They concluded that individuals in the first 11 rows would have died, but that 78 per cent of the other passengers would have survived. But before you clamour for a place at the back, rest assured that manufacturers use sophisticated modelling tools to optimise the ability of the entire structure to withstand unexpected landings on land or sea.



BEWARE THE BIRDS ▲

On an outdoor test stand at General Electric's Peebles testing facility in Ohio, a new engine is being put through its paces. It's about to be splattered by a high-speed bird carcass, to simulate a bird strike. Migrating birds can travel at altitudes of over 8,000m and threaten the cruise phase of the flight, although the greatest risk is during take-off, when the craft is at its heaviest and the engines are at close to maximum power. The bird cannon test makes sure that the engine can either continue working or successfully shut down after a physical strike, limiting the risk of an explosion. If the engine fails the test, it's time to go back to the drawing board. ►

COLD COMFORT ▶

No, it's not the strangest package holiday in existence. These mannequins are part of an experiment to improve the comfort of long-haul air passengers. They're equipped with temperature sensors, helping engineers at the German Aerospace Centre to design a new ventilation system.

With more electronic devices being used inside cabins, improved ventilation systems are needed to remove the extra heat. The system being tested here delivers low-speed air from inlets in the floor, rather than pumping in air from the cabin's roof as in conventional aircraft. This cools the plane without causing cold draughts.



ENGINE ROOM ▼

This mechanical marvel is one of General Electric's latest jet engines, undergoing testing at the Peebles facility in Ohio. The 5.6-tonne GEnx-2B engine is used on the Boeing 747, delivering around 67,000lb of thrust – the equivalent horsepower of more than 700 small hatchbacks. The testing rooms are made from 6m-thick walls of high-density concrete in order to withstand the incredible power of the engine, and are packed full of performance-measuring sensors.

Over the past decade, the desire for greater fuel efficiency has driven aircraft designers to switch from four-engine configurations to just two engines for long-haul aircraft, such as the Boeing 787 Dreamliner and the Airbus A350. These engines are designed to ensure that even if one of them fails, the remaining engine still has enough power to complete take-off and landing.



DLR, GERMANY/ERNSTING, AIRBUS, GETTY



◀ WATER WAY TO LAND

Planes are designed to operate in the most extreme weather conditions, from desert heat to rain-soaked runways. Here we see the latest Airbus A350 undergoing 'water ingestion' tests at a facility in Istres, France. These tests assess whether the engines and aircraft systems are able to operate on waterlogged runways, where the standing water might be a couple of centimetres deep. In these conditions, huge volumes of water are being sprayed into the engines, so the aircraft must be able to cope with this sudden deluge. 🟡

Neil Ashton is an aerospace engineer and a senior researcher at the University of Oxford's e-Research Centre.



WAS THE GUPTA EMPIRE INDIA'S GOLDEN AGE?

Professor **Himanshu Prabha Ray** digs into the enduring legacy of the Gupta period through its art, architecture, coinage, mathematics, astronomy and Sanskrit literature

Historians of ancient India have often debated whether the Gupta Empire (300-600 CE) was indeed the Golden Age of Ancient India. Opinions have been divided on whether it is a period that marked the beginning of feudalism or a period of major cultural development.

Architecture

THERE was an increase in the number of temples from the 4th and 5th centuries onwards. Even though historians often associate these temples with ruling dynasties, there is little to suggest royal initiative. Of the 28 Gupta temples, there is only one definite inscriptional record of patronage by a Gupta king. The ruined brick temple at Bhitari, Uttar Pradesh, has a record of Skandagupta on the *garudadhvaja* (having garuda in its banner), which states that the king consecrated an image of Sarnghi or Vishnu and endowed a village for the maintenance of the temple.

Bhitargaon in Kanpur district hosts one of the oldest brick temples dated to the Gupta period. A total of 143 terracotta panels were recovered from the site. Only one of these contained

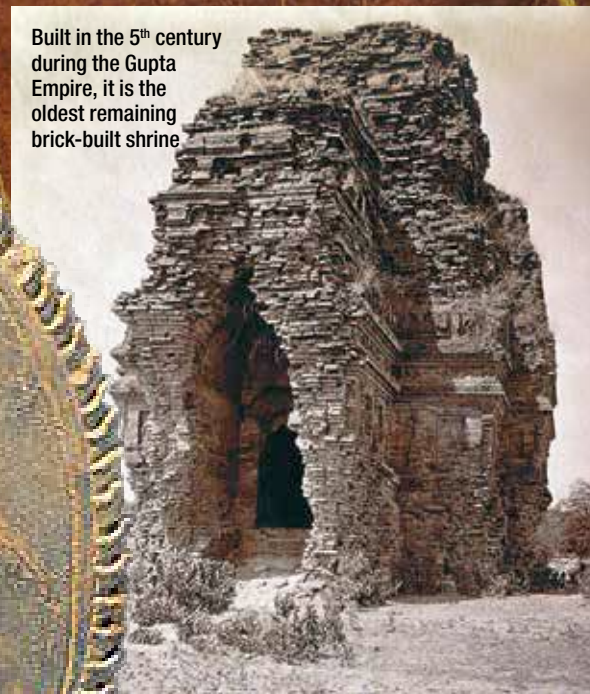
Architecture rose in prominence during the Gupta period



Deogarh Dasavatara tempel

Of the 28 Gupta temples, the ruined brick temple in Bhitari is the last remaining evidence of the Gupta patronage of temples

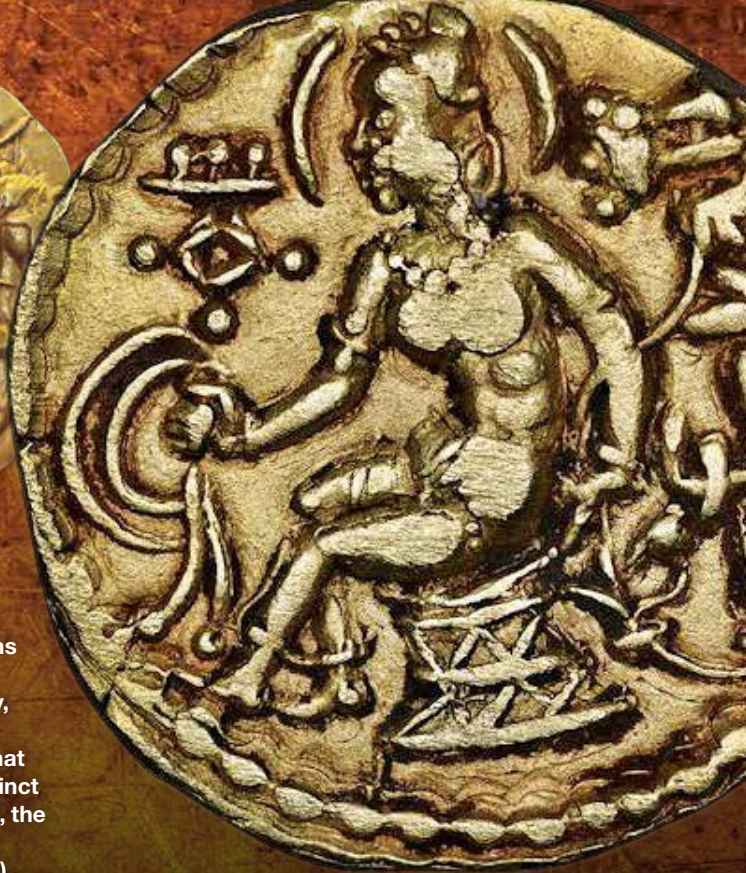
Built in the 5th century during the Gupta Empire, it is the oldest remaining brick-built shrine



a depiction of a *Ramayana* theme. The story relates to Kakasura, the son of Indra who appeared in the form of a crow and repeatedly pecked at Sita while Rama was sleeping in her lap. Rama awoke, picked up a blade of grass and, after pronouncing it the *Brahmastra* (a weapon created by Brahma), flung it at the crow, which immediately begged for forgiveness.

Especially significant is the Dasavatara Temple at Deogargh on the right bank of the river Betwa in the district of Jhansi, dated to the Gupta period, which shows the continued presence of both Hindu and Jain temples well into the later periods. Ten panels were identified from the plinth of the temple and depict several scenes largely relating to Rama's exile.

Asvamedha-type coins during the reign of Chandragupta II



Coinage

Another remarkable aspect of Gupta rule can be seen in the gold coins minted at the time, which displayed the kings' power and grandeur. Each coin visually portrayed some aspect of the ruler's power and at least 19 different images of Gupta kings are found on the obverse of coins. Most of the portraits show the kings in three-quarter or profile view, rather than in frontal pose. The king was expected to set an example to his subjects by his righteousness and advocacy of truthfulness. These are qualities that are represented on Gupta coins, as the king is shown making offerings at an altar. Gupta kings, especially Samudragupta and Kumaragupta I (c. 41 - 450 CE), are known to have performed the *asvamedha* (horse sacrifice) and celebrated this by minting

asvamedha-type coins. The reverse of the coins shows Lakshmi or Shri, the goddess of prosperity. Thus, Gupta gold coins presented to the populace a powerful message of sovereignty, royal virtues and heroic feats.

King Samudragupta minted what can be categorised as seven distinct types of coins: the standard type, the archer type, the battle axe type (referring to his military activities), the *asvamedha* type (commemorating the horse sacrifice ceremony), the tiger slayer type, the king and queen type, and the lyrist type. Most Gupta gold coins weighed

close to eight grams and had Shri-Laxmi on the reverse. A hoard of over 1,821 gold coins belonging to the Gupta Dynasty was discovered in February 1946, near Bayana village, Rajasthan.

The largest hoard of gold coins belonging to the Gupta period unearthed comprised of 1,821



Shakuntala as painted by Raja Ravi Verma

Literature

The Gupta Period is often described as the classical age of Sanskrit literature. It is generally accepted that the Sanskrit poet Kalidasa lived and wrote during this period, though some uncertainty persists. He is well known for three plays: the *Abhijnanashakuntalam* (The Recognition of Shakuntala), *Vikramorvashiyam* (Urvashi Won by Valour), and *Malavikagnimitram* (Malavika and Agnimitra); the epic poems *Raghuvamsam* (Dynasty of Raghu) and *Kumarasambhavam* (Birth of the War God); and the lyric *Meghadutam* (Cloud Messenger).

Bhasa was another important playwright of this time. In addition,

several important works in poetry and dramaturgy were produced in the Gupta period. Many of the Puranas are dated from between 300 and 600 CE.

It is this proliferation of Sanskrit writing on a variety of subjects and achievements in art and architecture that have accorded the Gupta period a special place in ancient Indian history. Literary texts such as the encyclopedic *Brihatsamhita* by Varahamihira cover diverse subjects such as architecture, perfume manufacture, matrimony, domestic relations, gems, pearls, etc, while Vatsyayan's *Kamasutra* provides insights into the opulent life style of

urban dwellers. While these texts cannot be taken literally, they provide an awareness of the flourishing urban culture in the period. Archaeological evidence of settlements and urban centres of the period further corroborate this, such as at Purana Qila in Delhi, Ahichhatra in Bareilly district, and several other sites.

This brief overview of achievements of the Gupta Empire needs to be framed within the context of the mobility of the occupational groups of the time. Mobility also helped the common people resist the state-sponsored effort to control labour. The best-known example of this is the sixth-century Sanskrit inscription by the chief of a guild of silk weavers from a now-lost temple at Mandasor in central India. The guild moved from Lata, identified as the region between the Narmada and Tapti rivers, to Dasapura (modern Mandasor) "bringing their children and kinsfolk". In spite of having adopted a variety of occupations, the silk weavers retained their corporate identity and met together to make an endowment to a temple of the Sun god "with hoarded wealth". The inscription describes designs woven by them on silks "with varied stripes of different colours". It is in the context of this environment of movement associated with trade that the history of the Guptas needs to be understood.

Dhanvantri's discoveries in medicine helped refine the Indian medical system of ayurveda

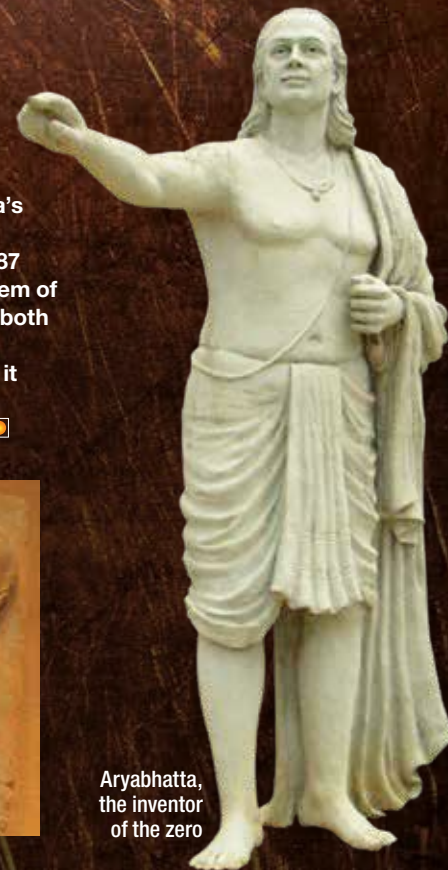
Mathematics and Astronomy

Major breakthroughs were achieved in the fields of mathematics and astronomy during the period. An important figure was the mathematician and astronomer, Aryabhata (476 – 550 CE). His major work, *Aryabhatiya*, a compendium of mathematics and astronomy, was extensively referred to in Indian mathematical literature and has survived to modern times, while the *Arya-siddhanta*,

a lost work on astronomical computations, is known through the writings of Aryabhata's contemporary, Varahamihira (505 – 587 CE). The decimal system of notation was used by both Aryabhata and Varahamihira, though it was still not known in Europe at that time. ■



Scene from the Ramayana captured in terracotta



Aryabhata, the inventor of the zero



Ayurveda is the oldest form of medicine practised in India



Professor Himanshu Prabha Ray is Research Fellow, Oxford Centre for Hindu Studies and Honorary Professor, Ludwig Maximilian University, Munich. She is former Professor, Centre for Historical Studies, Jawaharlal Nehru University, New Delhi, where she taught until 2012 and the first Chairperson, National Monuments Authority, Ministry of Culture. Her research interests include maritime history and archaeology of the Indian Ocean, the history of archaeology in South and Southeast Asia, and the archaeology of religion in Asia. She is the editor of the Routledge series on Archaeology and Religion in South Asia.

ON THE SHELVES

NEW READS



TALES OF THE PECULIAR
BY RANSOM RIGGS

It's a book within a book (very meta), and it contains 10 original fairy tales. *The Tales of the Peculiar* was a fairy tale book that was read out by the many characters in the *Miss Peregrine's Home For Peculiar Children*. These peculiar folktales are collected and annotated by Millard Nullings, a character from the novels and are, in spirit, peculiar. You have the *Splendid Cannibals*, where townfolk have the ability to regrow body parts that they regularly sell to the wealthy cannibals in the area, and *Cocobolo*, a poignant story about a father and son in China who steadily transform into islands as they mature, among others.

ENTER TITLE HERE
BY RAHUL KANAKIA

What does a top record student at a prestigious school with a spotless academic record do when her SAT scores aren't good enough? She writes a novel, that's what. But who, she wonders, would want to read

a story of an overachiever? So Reshma, the protagonist, throws off her studious-girl shackles and does whatever a girl her age would do – makes friends, gets a boyfriend, gets into trouble... you know, the usual teenage fun. With enough material, the novel runs into 300 pages, and she now has the perfect ending. Or does she? How far will Reshma go to achieve her scholarly dreams? Pretty far...

THE FEMALE OF THE SPECIES
BY MINDY MCGINNIS

Alex knows how to kill and doesn't feel guilty about it. She learned the language of violence three years ago when she murdered her sister's killer, after he was let

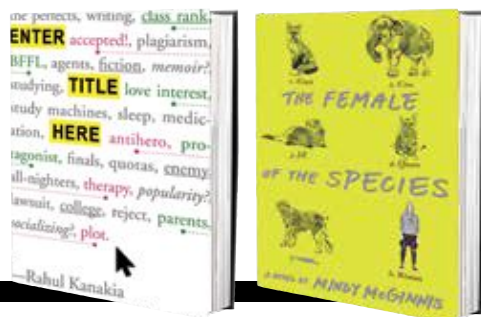
out of prison? But now, as senior year approaches, Alex knows that she can't let others in on her secret. That, however, is proving increasingly difficult. There is Jack, the star athlete who wants to know her better; there is Peekay, the preacher's son, whom she met at an animal shelter. As senior year plays out, so does Alex's dark secret and sets her and her two friends on a course for collision.

GHOSTS BY RAINA TELGEMEIER

Catrina is not happy about leaving her friends and life behind to move to northern California to live near the coast, though she knows the bracing sea air will help her little sister Maya breathe better. But their new house in Bahia de Luna is different. This town, everyone says, has ghosts. Catrina scoffs at this, but close encounters with the spirits leave her spooked, especially when one encounter leads Maya to be hospitalised. As the Day of the Dead celebrations draws near, Catrina must decide to overcome her fears and face them with a smile on her face and a song in her heart. Telgemeier's illustrations match the sombre but vivid display of emotions that the characters undergo and display.

I'M NOT YOUR MANIC PIXIE DREAM GIRL
BY GRETCHEN MCNEIL

Bea comes up with the perfect formula against her bully Toile to beat her at her own game. Unfortunately, being a Manic Pixie Dream Girl, isn't all that it is built up to be. The formula unravels, following a series of unfortunate events and misunderstandings. Will Bea ever go back to being her true self or has the experiment gone too far to be stopped?



THE BIG 5 – BOOKS SET IN SPACE



THE HITCHHIKERS GUIDE TO THE GALAXY BY DOUGLAS ADAMS

This sci-fi comedy series of four books follows the adventures of bumbling Englishman Arthur Dent and his alien friend Ford Prefect. Seconds before Earth is destroyed by the Vogons to make space for an intergalactic freeway, Galactic

president Zaphod Beeblebox unknowingly saves the two of them. Aboard his ship, the Heart Of Gold, they become part of a motley crew – there's Marvin, the paranoid android who is manic-depressive, and Trillian, a woman Arthur unsuccessfully flirted with at a party. Together, they make their way to the famed planet of Magarathia and the question to the Ultimate Answer in the Universe. The answer to which, btw, is 42.



DUNE BY FRANK HERBERT

Winner of the Hugo Award in 1966 and the Nebula Award, *Dune* is often cited as the world's best-selling science fiction novel series? It's set in an intergalactic feudal future, where planets are under the control of

noble dynasties that pledge their allegiance to the imperial house Corrino. The first book in the series follows the Atreides family, which are given control of the desert planet Arrakis, the only place where the spice mélange – the most powerful and essential drug in the cosmos – grows. He who controls Arrakis controls the entire Universe. Unknown to the Atreides family, they are headed for a trap, for Baron Harkonnen invades the planet. The heir of the Atreides family, Paul, along with his mother, escapes; they seek shelter with the native Freemen, who can control the mighty sand world. Paul's true destiny is revealed – he is part of a genetic experiment that leaves him with tremendous mental prowess. Using his powers, Paul prepares his army to wage war against Harkonnen.



ENDER'S GAME BY ORSON SCOTT CARD

Andrew 'Ender' Wiggin is playing the game of his life... literally.

The six-year-old boy doesn't realise that his militaristic precision in winning the war in a stimulation game has made him just the leader

that Earth desperately needs. The planet is engaged in war with an alien enemy seeking to destroy all

human life. Ender, with his precise tactical imagination and strategic planning, is pushed into a more brutal training programme to prepare him for a real battle. Or is it? And what role does the former army man, Mazer Rackham, play in this game? Winner of the Hugo Award in 1986 and the Nebula Award in 1985, the *Ender's Game* series is a match made in the stars for those who love their science fiction with a healthy dose of politics and warfare.



HYPERION BY DAN SIMMONS

Winner of the Hugo Award in 1990, *Hyperion*, is a science-fiction space opera that merges the narrative element of The Canterbury Tales with a futuristic twist in the 28th century. On the eve of

Armageddon, the entire galaxy is at war. Seven pilgrims set out on a pilgrimage to Time Tombs, located on the planet of Hyperion, to meet the Shrike, a creature who inspires both awe and dread in same measure, to ask for his help in saving the galaxy. Their journey is also marked by their own hidden preoccupations. On their travels, each carries his hope and a dreadful secret. And one of the seven may hold the fate of humanity in his hands.

A stunning piece of science fiction in its unparalleled excitement and imagination, *Hyperion* is a masterpiece.



CONTACT BY CARL SAGAN

What would we, as a human race, do if we received messages from space? How would it change our self perception of being the only intelligent species in the universe? How would we as a race react to

this socially and politically? These are the questions Sagan attempts to answer in his bestselling book, *Contact*. Ellie Arroway, a radio astronomer, stumbles upon a looped message coming in from the star Vega during her research. The coded message lists a set of instructions to build a machine whose purpose is unknown. As space organisations race against time to build the machine, Ellie prepares herself for the possibility of interacting with an intelligent life force out of Earth. Sagan uses his knowledge of astronomy along with factual science to weave a story that explores the possibility of SETI, time travel and the idea that, maybe, just maybe, we aren't as alone in this Universe as we thought.

Teen bestsellers booklist



Fairy Tale Romance Collection: The Healer's Apprentice, The Merchant's Daughter, The Fairest Beauty, The Captive Maiden, The Princess Spy
by Melanie Dickerson
Zondervan



Star Wars Ahsoka
by E. K. Johnston
Disney Press



Children of Eden
by Joey Graceffa
Atria/Keywords Press



Miss Peregrine's Peculiar Children Boxed Set
by Ransom Riggs
Quirk Publishing



The Fever Code (Maze Runner Series #5)
by James Dashner
Random House Children's Books



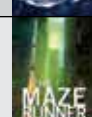
Harry Potter Paperback Boxed Set, Books 1-7
by J. K. Rowling
Scholastic, Inc.



The Sister Pact
by Stacie Ramey
Sourcebooks



The Midnight Star (Young Elites Series #3)
by Marie Lu
Penguin Young Readers Group

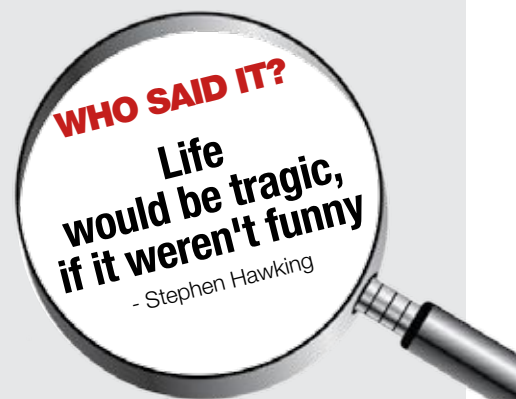


Miss Peregrine's Home for Peculiar Children (Barnes & Noble Exclusive Movie Tie-In Edition)
by Ransom Riggs
Quirk Publishing



Five Nights at Freddy's: The Silver Eyes
by Scott Cawthon
Scholastic, Inc.

- List by www.barnesandnoble.com



GADGETS

QUAD VA-ONE

Combine the convenience of digital music with the rich, warm sound of analogue with this new integrated valve amp from Quad. A built-in digital-to-analogue converter (DAC) turns digital audio signals into analogue before passing them on to its high-end, valve-based preamp and two 15W power amp stages. There are coaxial, optical and USB as well as RCA inputs, and it'll stream music from digital devices using Bluetooth, too.

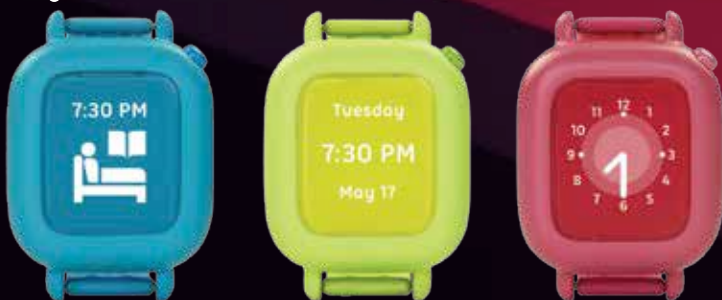
Price: On request | quad-hifi.co.uk



OCTOPUS

Dubbed 'the training wheels for good habits' by its makers, Octopus is a watch and scheduler/personal assistant designed for children aged three to eight. Available in a range of bright, kid-friendly colours, the watch displays the time alongside relevant, parent-selected icons (a toothbrush for 7.30am, a bowl of cereal for 8am and so on) so that little 'uns don't just learn to tell the time – they get to grips with the concept of time itself. It's already smashed its Indiegogo funding target 15 times over, and will start shipping next spring.

Price: On request | octopus.watch



BLACKBERRY DTEK50

BlackBerry may no longer be the high-flying executive's go-to smartphone, but the company isn't taking the loss of its market-leading position lying down.

Its latest attempt to revive its fortunes is the DTEK50, an Android phone that it's touting as "the world's most secure". The phone has a 5.2-inch touchscreen, 16GB of storage and a 13MP camera, but it's the custom, security-first build of Android Marshmallow that BlackBerry is hoping will bring the suits rushing back.

Price: On request | blackberry.com



NINTENDO CLASSIC MINI

There's no shortage of retro-themed gaming devices on the market, but this miniature, HDMI-enabled version of the classic NES console is slightly unusual in that it actually comes from Nintendo itself. Coming preloaded with over 30 games including the likes of *Pac-Man*, *Final Fantasy*, *Super Mario Bros* and *Donkey Kong*, it's due to go on sale in November – and we could be looking at one of Christmas 2016's biggest sellers.

Price: On request | nintendo.com



EVALUATING THE YEAR'S MOST ANTICIPATED RELEASES

2016 was the year that consumer technology finally left the desk and became truly portable. The most anticipated gadgets of the year were either smartphones or wearable tech. With that in mind, let's look at some of the biggest releases of the year and see whether or not they lived up to the hype



IPHONE 7

Love it or hate it, Apple's iPhone is probably the most eagerly anticipated smartphone on the market. The latest edition promised huge changes, and it definitely delivered, though those changes weren't well received by all.

The most notable change was Apple's decision to remove the 3.5mm headphone jack, replacing it with a Lightning-to-3.5mm adapter intended for those who still wished to use wired headphones. This design choice, which made it impossible to charge the phone while using wired headphones, was met with criticism. However, Apple also announced AirPods, wireless headphones that are ostensibly designed to be used with the new iPhone 7.

Other features announced include the phone being made water- and dust-resistant. The phone also comes in two models: iPhone 7 and iPhone 7 Plus, with 4.7-inch and 5.5-inch screens respectively. The Plus model also boasts 3GB of RAM, more than any previous iPhone. The iPhone 7 continues the tradition of pressure-sensitive touch screens. The phone comes with iOS10 preinstalled

Price: On request | www.apple.com

OCULUS RIFT

When it was announced in 2012, Oculus Rift had everyone excited about virtual reality again. Finally, four years later, the Oculus Rift was released for consumers.

The Rift houses two OLED panels, one for each eye. Headphones are integrated into the headset and provide real-time 3D audio effects. The key element is the Rift's tracking system, called Constellation. Constellation is a desk lamp-shaped sensor that can be mounted on any surface the user desires. With extremely accurate tracking of the headset's position, it allows users to navigate a VR environment unhindered. Constellation can also track the position of the Rift's handheld controllers, which feature a joystick and buttons, allowing them to be rendered in the VR environment.

After all the anticipation, when Oculus released this year, reviews were mixed, but skewed towards the positive. Critics declared that Oculus Rift marked a very important step on the road to completely immersive VR entertainment.

Price: On request | www.oculus.com



APPLE WATCH SERIES 2

Once again, we're back with Apple. The tech giant made waves when it announced its plans to release a smartwatch in 2015. The initial offering received a tepid response, and Apple has tried to compensate this year with the Apple Watch Series 2. So was it a worthy successor?

If you've had a chance to check out the first Apple Watch, you aren't in for too many surprises. The manufacturer decided to play it safe, leaving the design relatively unchanged, except for scaling up in terms of size.

The Series 2 is compatible with Apple's other big offering this year, the iPhone 7. Apart from this, the smartwatch also allows you install apps, use the Apple AI assistant Siri, features customisable watch faces and is also geared towards fitness, with a heart-rate monitor and an inbuilt breath-tracking app. The Series 2 is also more rugged than its predecessor, being water-resistant for up to 50m. In terms of smartwatches, this product might not be groundbreaking, but it still manages to show off the innovative spirit that has become synonymous with Apple.

Price: On request | www.apple.com

GAMES

A GENRE-WISE LIST OF THE BEST FREE-TO-PLAY GAMES

PATH OF EXILE GENRE: RPG

The Role Playing Game (RPG) genre has been around a long time, which is why it's so refreshing to see a truly free-to-play title that offers you a complete RPG experience.

Developed by Grinding Gear Games, *Path of Exile* is a critically-acclaimed, award-winning RPG that can easily hold its own against other classic titles.

The fantasy setting of the game is given a dark slant, set as it is amid the ruins of a formerly great empire on a harsh and hostile continent. The land serves as a penal colony and a place of banishment, and the player must survive his exile in this unforgiving place. The initial game also has three expansion packs:

Sacrifice of the Vaal, *Forsaken Masters* and *The Awakening*, which add to the story and introduce new features to the gameplay.

In fact, the gameplay offers a very authentic RPG experience, with six playable character classes and an intricate skill chart, which players can progress along as they level up their characters.

Much like any other title in the genre, such as *Diablo*, the game is centred around exploring large swathes of terrain while fulfilling quests and dueling monsters, raiders and many other assorted foes. Various play modes, such as Standard and Hardcore, also ensure replay value, making it all but certain that you'll be coming back to *Path of Exile* over and over again.



DOTA 2 GENRE: MOBA

No list of free-to-play games would be complete without *DOTA 2*, developed by Valve. In fact, the Multiplayer Online Battle Arena (MOBA) genre might be the most crowded when it comes to free-to-play offerings, but *DOTA 2* still stands out from the crowd. It's also one of the fastest growing e-sports titles, with a preposterous cash prize pool of over 10 million USD for its biggest annual tournament, The International.

In *DOTA 2*, teams of five players square off against one another in a quest to destroy the opponents' Ancient, a well-defended structure located at the heart of the team's base. Waves of creeps spawn at 30-second intervals and progress along defined paths towards the enemy base. Players must break through obstacles such as enemy towers and creeps on their way to their goal.

The essence of free-to-play can be seen in *DOTA 2*, which offers players the entire experience for free, with the only purchasing options being cosmetic and ancillary items that have no effect on the gaming experience. The fact that each of the over 100 Heroes is different, and the co-operative element are what make *DOTA 2* an addictive, free-to-play classic.



ALIEN SWARM GENRE: SHOOTER

Many free-to-play games opt to secure content behind paywalls to ensure gamers shell out some cash for the content, but *Alien Swarm* from Valve is completely free of any microtransactions and gives you access to the entire campaign right out the gate.

The storyline sets the action on a far-flung colonised planet that has been overrun by aliens. The game is a co-operative multiplayer shooter, where players band up in teams of up to four and tackle level after level. The top-down perspective gives *Alien Swarm* a fresh aesthetic when held up against other titles in the genre. Also, the wide range of equipment available and the full access to all the classes of characters in the game, coupled with the frequent unlockable rewards, ensure that you will not get bored with *Alien Swarm* for a long time.



THE PINBALL ARCADE GENRE: ARCADE

A classic staple of both real-world and virtual gaming, pinball has been a hit with gamers worldwide. *The Pinball Arcade*, developed by Farsight Studios, is a free-to-play game that brings the two together by allowing players to play virtual pinball on a collection of simulated replicas of real pinball machines with classic themes.

As far as the setting goes: it's pinball! Players use two flippers to knock a tiny ball about on an angled surface covered in obstacles, diversions and traps in their quest to achieve a high score. In terms of variety, there are over 77 tables for players to enjoy. Each month, a single table is selected for unlimited free play, while all other are also accessible for demo play. The game does offer the option to access all tables at once, but that is restricted behind a paywall. What really sets *The Pinball Arcade* apart is its portability, as there is a version for a wide range of platforms, including Microsoft Windows, MacOS, iOS, Android, PlayStation 3, PlayStation Vita, Xbox 360 and Xbox One.



EXPERT TIPS:

MULTIPLAYER ETIQUETTE

Here are a few things to remember when playing multiplayer online to better your experience



Bossy is bad Nobody likes taking time away from their parents, teachers or bosses to play a game, only to be told what to do by a stranger. You'll find your teammates respond better to you when you share tips and offer advice without sounding like you're giving orders.

Be kind Sometimes, there will be players on your team who are total novices, stumbling their way through the game. Instead of raging at them and losing your cool, accept them as part of the game. The only bad players you

should concern yourself with are the ones on the opposite team!

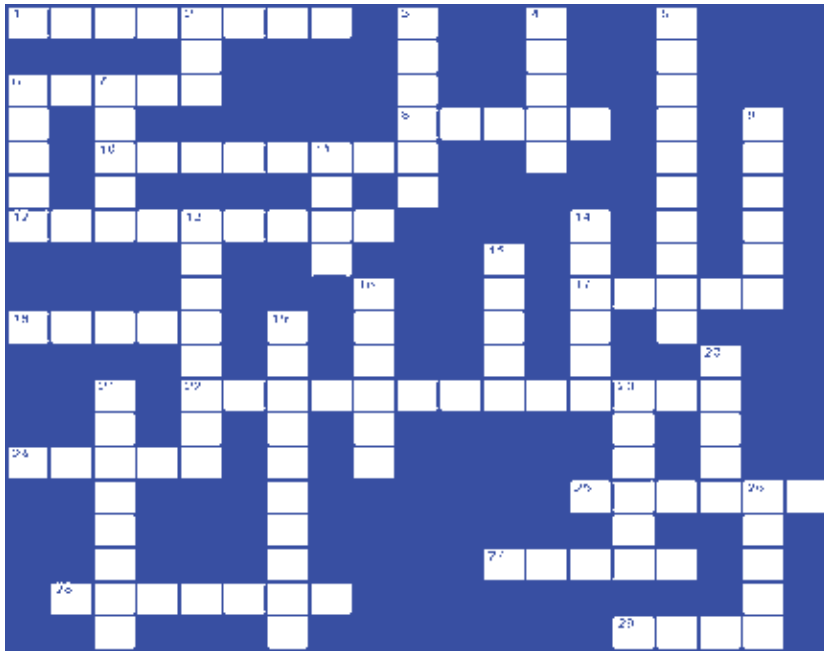
Don't be a hero It might be tempting to think of yourself as an unbeatable player, especially when your team has players less proficient than you. The worst thing to do in this case would be to abandon cooperation with your teammates and try winning the game by yourself. Communication is paramount in multiplayer, so resist the urge to go rogue and help your team win the game instead.

- Dushyant Shekhawat

PUZZLE PIT



SEND IN YOUR
ENTRIES AND
WIN EXCITING
PRIZES



CROSSWORD NO. 35

ACROSS

- 1 Popular sci-fi show that starts with the words "Space, the final frontier.." (4,4)
 - 6 The Milky Way is a part of this galaxy supercluster (5)
 - 8 The sighting of this interstellar body used to be considered a bad omen (5)
 - 10 The largest satellite in the solar system (8)
 - 12 Venus is covered with clouds composed of this acid (9)
 - 17 Prominent constellation named after a mythical Greek hunter (5)
 - 18 ___ planets: Mercury, Venus, Earth and Mars (5)
 - 22 Type of fields that are very strong in black holes (13)
 - 24 Country that is home to the world's largest optical reflecting telescope (5)
 - 25 The smallest of Jupiter's Galilean moons (6)
 - 27 Saturn's largest moon (5)
 - 28 The only planet in the solar system that does not have an atmosphere (7)
 - 29 The number of gas giants in our solar system (4)
- 4 The Moon's gravity is responsible for this phenomenon on Earth (5)
 - 5 Second man to walk on the moon (4,6)
 - 6 This planet has the longest rotation period of any planet in the solar system (5)
 - 7 Brightest star in 17 across (5)
 - 9 This line represents the boundary between Earth and outer space (6)
 - 11 This dwarf planet discovered in 2005 is named after the Greek goddess of strife and discord (4)
 - 13 This gas makes up a little over 70% of the sun's chemical composition (8)
 - 14 USA's lunar programme (6)
 - 15 It takes the Sun's light a little over ___ minutes to reach Earth (5)
 - 16 This star is popularly known as the Dog Star (6)
 - 19 Hypothetical invisible star (5,5)
 - 20 The largest object in the Kuiper belt (5)

DOWN

- 2 Number of planets in the solar system that do not have a moon (3)
- 3 Elon Musk's aerospace
- 21 The Moon's ___ is a quarter that of Earth's (8)
- 23 An interstellar cloud (6)
- 26 P in PSLV (5)

YOUR DETAILS

NAME: _____

AGE: _____

ADDRESS: _____

PINCODE: _____

TEL: _____ MOBILE: _____

SCHOOL/INSTITUTION/OCCUPATION: _____

EMAIL: _____



How to enter for the crossword: Post your entries to BBC Knowledge Editorial, Crossword No.35 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Naoroji Road, Mumbai 400001 or email bbcknowledge@www.co.in by **10 December 2016**. Entrants must supply their name, address and phone number.

How it's done: The puzzle will be familiar to crossword enthusiasts already, although the British style may be unusual as crossword grids vary in appearance from

country to country. Novices should note that the idea is to fill the white squares with letters to make words determined by the sometimes cryptic clues to the right. The numbers after each clue tell you how many letters are in the answer. All spellings are UK. **Good luck!**

Terms and conditions: Only residents of India are eligible to participate. Employees of Bennett Coleman & Co. Ltd. are not eligible to participate. The winners will be selected in a lucky draw. The decision of the judges will be final.

WINNERS FOR CROSSWORD NO. 34

Ayesha Ahmad, Chennai
•
Vaaruni Suresh, Bangalore
•
Jeswin C Joshy, Thrissur

SOLUTION OF CROSSWORD NO. 34



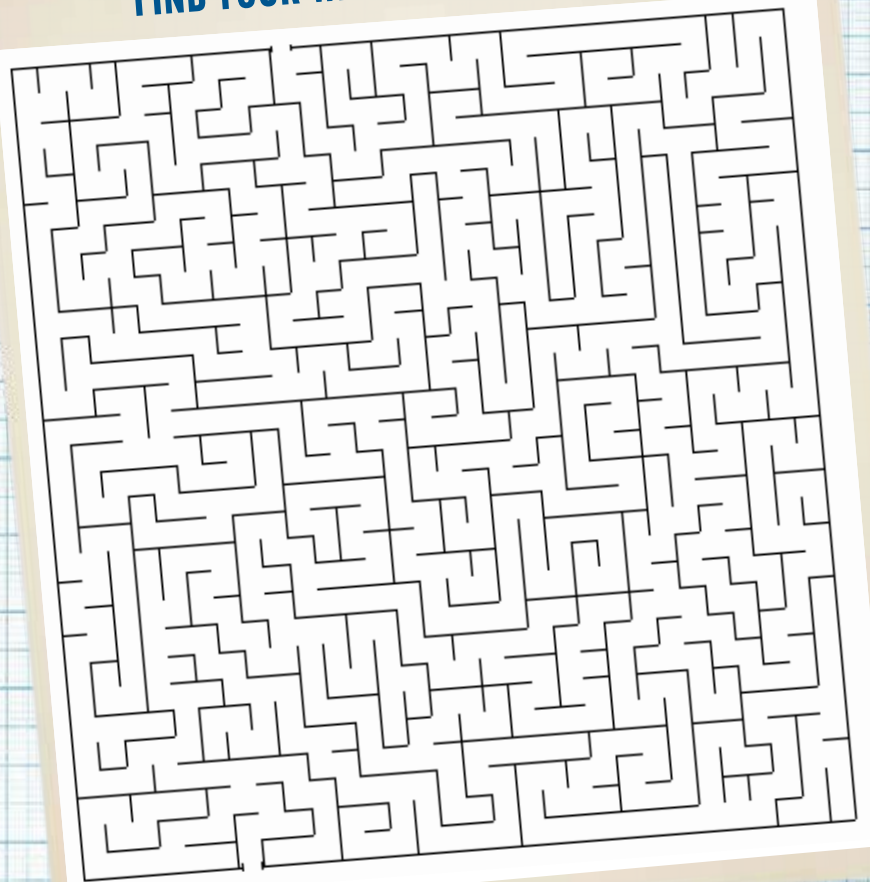
PUZZLE PIT

Q1 PICTURE SEARCH

In the jumble below, the words represented by each of the 16 pictures are hidden either horizontally, vertically or diagonally forward or backwards but always in a straight line. See how many of them you can find? Look out for descriptive names.

F	C	D	I	S	M	V	X	H	Y	E	N	A
U	R	C	C	L	A	R	I	N	E	T	G	D
A	T	A	A	H	V	O	E	L	L	O	U	Z
T	C	D	M	R	I	K	B	T	I	C	Q	V
T	M	G	N	E	D	A	R	J	K	I	P	Z
X	E	Q	J	I	T	I	E	N	O	R	H	T
G	T	P	U	Z	S	V	G	I	S	P	P	N
D	A	Q	E	R	X	A	F	A	P	A	U	W
K	S	L	R	E	M	V	M	O	N	G	Z	G
O	Q	Q	A	V	E	O	H	O	R	U	A	N
A	K	D	S	X	G	R	T	F	S	K	H	M
Z	R	I	U	B	Y	M	P	A	Q	A	U	D
L	E	I	N	A	P	S	R	E	K	C	O	C

FIND YOUR WAY OUT OF THE MAZE



Q2 SCRAMBLE

Solve the four anagrams and move one letter to each square to form four ordinary words. Now arrange the letters marked with an asterisk (*) to form the answer to the riddle or to fill in the missing words as indicated.

EPAOR * * *

ENROS * *

GHIKNT * *

AFIRMY * *

I got into science fiction by being interested in ___ first. - Terry Pratchett (9)

Q3 HEAD AND TAIL

Look at the clue to find the answer in the form of a compound word. The second part of the next answer is the first part of the next answer, etc.

Morning meal Break

Quick or easy earnings

Coarse cotton fabric

Hammer in

Pessimistic

Search anxiously

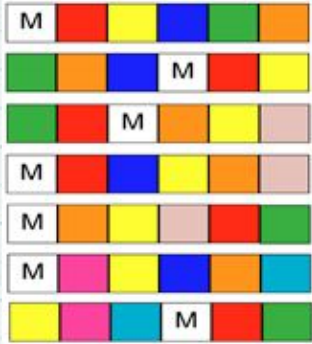
It should have happened sooner! Time



Q4 ENIGMA CODE

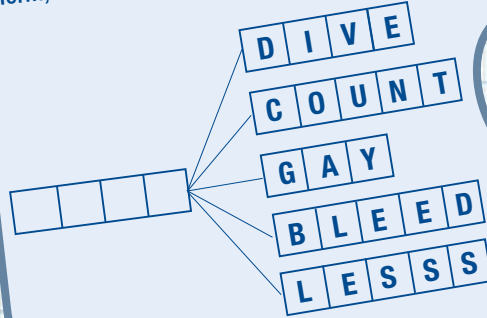
Each colour in our code represents a letter. When you have cracked the code, you will be able to make up seven words. The clue to first word is given to help you get started.

The Clue: *Mutilate*



Q5 DOUBLE BARRELLED

What word can be placed in front of the five words shown to form, in each case, another word?



Q6 BRAIN TEASERS

- Remove seven letters from this grid to leave two numbers.
SFEVE • INLVE • TETFE • ROSUR
- A cricketer scores an average of 16 runs in his first 15 innings. Brilliant play! He then has a further ten innings, and his batting average per innings increases to eighteen. What was his average for the last ten innings?
- What can be driven, but has no wheels. And can be sliced, and still remain whole?
- What's this rebus?
 - Ptimetitime
 - Etimetitime
 - Etimetitime
 - Ktimetitime

Q7 PICK AND CHOOSE

Solve the six clues by choosing the right combination of sets of letters given below. Each set of letters can be used only once and only in the order given. The number at the end of the clues specifies how many sets of letters are used in the solution.

1. Title-holder or victor (3)

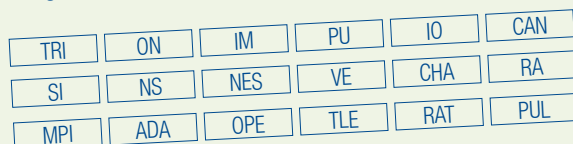
2. Snuggle (2)

3. Surgeries (4)

4. USA's neighbour (2)

5. Rash or impetuous (4)

6. Agartala is its capital (3)



BBC KNOWLEDGE QUIZ

See how you fare in the general knowledge quiz given below.

Ratings: 1-3 Poor, 4-5 Fair, 6-7 Excellent

- How many medals did India win at the 2016 Summer Paralympics?
a) One
b) Four
c) Three
- What is the capital of Tanzania?
a) Dodoma
b) Ukraine
c) Dar es Salaam
- ISRO recently launched a PSLV. For which of these countries did it also carry a payload?
a) France
b) Greece
c) Algeria
- Which former Israeli president and Nobel Peace prize winner passed away recently?
a) Golda Meir
b) Shimon Peres
c) Yitzhak Rabin
- What is the base of a hexadecimal number system?
a) 16
b) 6
c) 7
- Who wrote the recently-released *It's All In The Planets*?
a) Arvind Adiga
b) Chetan Bhagat
c) Preeti Shenoy
- In which century were the Wars of The Roses fought?
a) 17th
b) 13th
c) 15th

SOLUTIONS:

Q1 Picture Search: Apricot, atom, cardigan, clamnet, cocker sun, table, tepee, throne.
Q2 Scramble: Words: Opera, snore, knight, ramify
 Answer: I got into science fiction by being interested in astronomy first. - Terry Pratchett
Q3 Head & Tail: Break-Fast-Buck-Ram-Down-Beat-About-Time.
Q4 Enigma Code: Mangle, Legman, Lament, Magnet, Mental, Monger, Normal
Q5 Double - Barrelled: Nose
Q6 Brain Teasers: 1 Simply remove 'SEVEN LETTERS' and you are left with FIVE and FOUR. - F - - - • 1 - - V - • - E - F - - 0 - U R. 2 21 runs. 3 A golf ball. 4 Keep up with the times!
Q7 Pick and choose: 1 Nestle, 3 Operations, 4 Canada, 5 Impulsive, 6 Tripura
BBC Knowledge Quiz: 1 b) Four, 2 a) Dodoma, 3 c) Algeria, 4 b) Shimon Peres, 5 a) 16, 6 c) Preeti Shenoy, 7 c) 15th



IN FOCUS

Indians in Space



Rakesh Sharma

“Saare jahaan se accha!”

was Rakesh Sharma’s reply when asked by then Prime Minister Indira Gandhi how India looked from space.

Rakesh Sharma is a true icon of Indian space exploration, who made history when he became the first Indian to go into space.

Sharma always had high-flying inclinations. Born on 13 January 1949, he enrolled in the National Defence Academy at the age of 18. By 1970, after completing his training, he joined the Indian Air Force as a fighter pilot, climbing through the ranks to be Squadron Leader in 1984.

During this time, the erstwhile Soviet Union was conducting its Interkosmos programme. Its goal was to assist the Soviet Union’s allies with manned and unmanned space missions. In 1982, as part of

a joint mission between the Indian Space Research Organisation (ISRO) and Interkosmos, Sharma was selected to be the first Indian to go to space.

Sharma flew into space in a Soyuz T-11 rocket as part of a three-man crew with Yury Malyshev and Gennadi Strekalov. He spent almost eight days in space aboard the Salyut 7 Orbital Station, conducting experiments and studies, before returning to Earth. His landmark achievement made India the 14th nation in the world to send a person into space. Upon his return, he was awarded the Ashoka Chakra by the Government of India as well as the honour of Hero of the Soviet Union.

“Looking down at Earth, we could not see borders or people with different nationalities,”

said Sunita Williams, describing the perspective she gained from her time in space.

Sunita Williams is a NASA astronaut who holds the women’s records for most completed spacewalks and for the longest space walk time. Born to an Indian-American father and Slovene-American mother in 1965, in Ohio, she was selected by NASA for its astronaut programme in 1998.

In 2006, Williams was launched to the International Space Station (ISS) as part of Expedition 14/15. In her time at the ISS, Williams completed three spacewalks, and also ran the first marathon in space when she

participated in the Boston Marathon, running on a treadmill in the ISS physical fitness centre.

In 2012, Williams launched into space again as a part of Expedition 32/33. During Expedition 33, Williams served as Commander of the ISS, becoming the second woman to do so.

Although a US citizen, Williams treasures her link with India. On her first space mission, she proudly declared that, along with a Ganesha idol and a copy of the *Bhagavad Gita*, she was also carrying *samosas*!



Sunita Williams

“You are not just from any particular piece of land, but from the solar system.”

That was Kalpana Chawla’s statement to the world upon her return from her first space mission for NASA.

Chawla was born in Karnal, now part of Haryana, in 1962. Even as a child, she was fascinated with flying. At the age of 20, in 1982, Chawla moved to the United States of America. Once she became a naturalised US citizen in 1991, she was eligible to join NASA’s Astronaut Corps.

Her first mission was on the Space Shuttle Columbia as part of the STS-87 flight in 1997. On this mission, Chawla logged over 372 hours in space, and travelled a distance equivalent to 252 orbits of the Earth.

Chawla was to return to space in 2000 as part of the STS-107 flight. During Space Shuttle Columbia’s

launch, a piece of the foam insulation from the external tank broke off and damaged the left wing. It was this damage that allowed atmospheric gases to penetrate the wing structure during the doomed spacecraft’s re-entry to Earth. This caused the shuttle to become unstable and break apart only 16 minutes away from its scheduled landing, killing all seven crew members.

After the tragedy, Chawla was posthumously awarded the Congressional Medal of Honour, the NASA Space Flight Medal and the NASA Distinguished Service Medal.



Kalpana Chawla

WIKIMEDIACOMMONS X3



Knowledge  **e**
