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Knowledge

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INCORPORATING

BBC

SCIENCE
WORLD

MISSION TO THE CENTRE OF THE EARTH

Plans to drill deeper than ever will
uncover clues to our planet's past *p48*



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CONTENTS



COVER STORY

48 Mission To The Centre Of The Earth

Does the answer to the origin of life lie in the Earth's core?

FEATURES

28 Driving Into The Future

Five cars that are going to change your expectation from cars

36 Mystery Messages From Space

Signals from outer space that have scientists scratching their heads for an answer

42 Dressed For Success

Feathers and plumes – the new dinosaur description that has the paleontology community excited

62 The Tiger Mum's Handbook

The early years of a tiger cub is a perilous journey for the tiger mum

68 The World's Worst Smell

Hold your nose as we list the most vilest of smells from across the world

70 Origins Of Hinduism

We trace the history of one of the world's oldest religion – Hinduism

REGULARS

6 Q&A

Our panel of experts answer the questions you've always wanted to ask

14 Snapshot

Outstanding photographs to inform and engage

20 Discoveries

Scientists unveil the surest clue to the origins of life, breaking down the Mars Rover 2020 and the latest from the world of science

54 Portfolio: Marine Conservation

Spectacular images that show the triumph of sea creatures over humans

74 How Do We Know: How To Make X-ray Images

From its discovery to its advanced use, we scan the origins of how X-rays entered our lives

78 Ye Olde Travel Guide: Seville 1670

A bustling port in Spain, Seville is a city bursting with exotic foods from the New World



28



62



36



68

80 Edu Talk

Acclaimed story teller Geeta Ramanujam tells how storytelling is helping children learn

81 Games Review

We review Middle Earth: Shadow of Mordor and bring you nuggets of gaming news from across the industry

82 Puzzle Pit

A veritable buffet of brain teasers guaranteed to test your mind

86 Gadgets

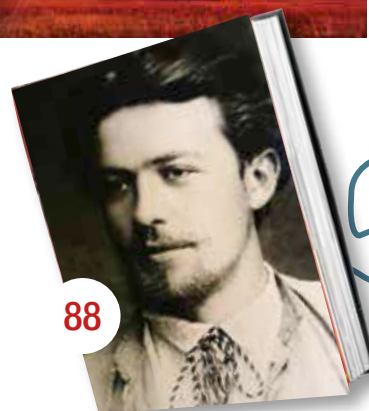
The new year deserves new gadgets. Take your pick from our pages

88 Inside The Pages

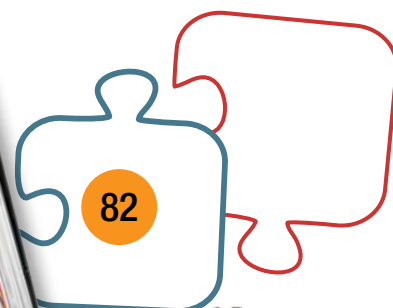
A story about friendship gone wrong, the steadfast literary sidekicks, and our readers review their favourite books

90 In Focus

Dr Joseph Ignance Guillotin didn't invent the guillotine, then why was it named after him?



88



82



42

FROM THE EDITOR



Albert Einstein said it already, “The more I learn, the more I realise how much I don't know.” And that's the thing about the pursuit of knowledge or anything extraordinary. It is never ending, and so addictive. Scientists, academics, innovators and other creative people of the world find an entire lifetime too to really ‘understand and explore’. For all the parents out there who are worried for their children's future (and that includes me), and what professions they are going to

pursue, maybe Einstein's epiphany holds the answer – help your children find a passion that can engulf them and engage them; professions and careers will follow.

So let's start the New Year with this thought. And welcome and celebrate many new beginnings and opportunities, and hope that they find the ‘one’ worth pursuing through a lifetime.

Continuing with this thought, in this issue we bring you up-to-date with the exciting mysteries of our world, which has had generations in a pursuit for an answer – what is at the centre of the Earth, evolution, is there life beyond our planet and much more. All are a must read.

And congratulations to the regional winners of the all-India BRAINIAC Quiz (pg 26) who made it to the finals. The rounds were tough but they kept their wits. The D-day is in Chennai on 10 January where they compete for the grand title. But a bigger thanks to all the participants that came in overwhelming numbers to participate in the regionals in Delhi, Mumbai and Kolkata over these past two months. You all simply swept us away with your enthusiasm.

Good luck and have a great year.

Pooja Singh

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EXPERTS THIS ISSUE



John Pickrell is the editor of *Australian Geographic*. A proficient blogger, he is also a science writer, author, nature lover. In this issue, he ruminates on the topic of how feathers and plumage might play an important role in understanding dinosaurs better. **See page 42**



Jheni Osman is a science writer and author of the book *100 Ideas That Changed The World*. In this issue, she highlights the answer to the origin of how Earth evolved.

See page 48



Michel Danino has been living in India since 1977. He lectures on Indian civilization IIT Gandhinagar and his recent book is on *Indian Culture and India's Future* (DK Printworld, 2011). In this issue he writes about the origins of Hinduism. **See page 70**



Geeta Ramanujam is an internationally renowned storyteller, educator and academician. She set up Kathalaya in 1998 to promote a storytelling as an effective educative and cultural tool. In this issue, she talks about how storytelling can improve a student's learning.

See page 80



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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Q&A

YOUR QUESTIONS ANSWERED

Why don't moths fly towards the Sun? *p8* Why do you feel wasabi on your nose and chili on your tongue? *p9* What are the most popular smartphone apps in the world? *p10* Are there rainbows on other planets? *p11*

EXPERT PANEL

Susan Blackmore (SB)

A visiting professor at the University of Plymouth, UK, Susan is an expert on psychology and evolution.

Alastair Gunn

Alastair is a radio astronomer at Jodrell Bank Centre for Astrophysics at the University of Manchester, UK.

Robert Matthews

Robert is a writer and researcher. He is a Visiting Reader in Science at Aston University, UK.

Gareth Mitchell

As well as lecturing at Imperial College London, Gareth is a presenter of *Click* on the BBC World Service.

Luis Villazon

Luis has a BSc in computing and an MSc in zoology from Oxford. His works include *How Cows Reach The Ground*.

ASK THE EXPERTS?

Email our panel at bbcknowledge@wrm.co.in
We're sorry, but we cannot reply to questions individually.

KNOW SPOT



The biggest ever lasagne was made in June 2012. It weighed 4,865kg and was divided into 10,000 portions.

Brushing your teeth can be a confusing business

What's the best way to brush your teeth?

A recent study by Prof Aubrey Sheiham and colleagues at University College London found an "unacceptably inconsistent array of advice" from dental associations, dentists and toothbrush companies.

Sheiham recommends brushing from side to side, with the brush at a 45-degree angle and held lightly. He suggests focusing on where plaque is most likely to collect, which is biting surfaces and where teeth meet gums. RM



Why, uniquely among primates, does our head hair keep growing?

Other primates have long head hair too – lion tamarins, for example – the contrast is just more striking against our relatively hairless bodies. Long hair isn't a universal trait either. The races that never left Africa have shorter, curlier hair.

Exactly why the humans that migrated to colder climates evolved long hair is still debated. One possibility is that in hot climates, the disadvantage of lots of head hair outweighed its sexual desirability, but as soon as our ancestors moved north, they were free to choose mates based on the appearance of their hair. It could also be that once we started wearing clothes, the head was the only thing that still needed long hair to keep it warm. LV

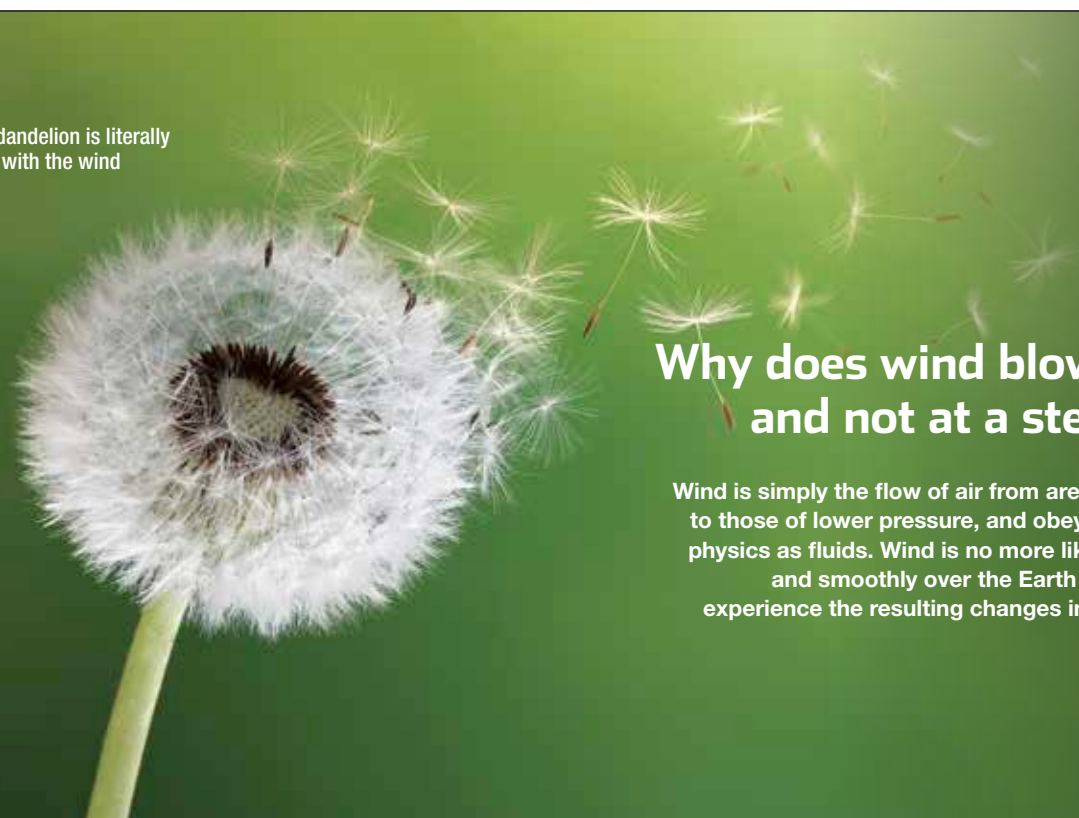
Condition your hair regularly to have shiny locks like this tamarin

VITAL STATS

\$600m

Estimated cost of fighting the Ebola outbreak in western Africa, according to figures from the World Health Organization

This dandelion is literally gone with the wind



Why does wind blow in gusts and not at a steady rate?

Wind is simply the flow of air from areas of high pressure to those of lower pressure, and obeys the same laws of physics as fluids. Wind is no more likely to flow steadily and smoothly over the Earth than water, and we experience the resulting changes in flow as gusts. RM

Can you hear a meteor?

Meteors are able to create sound waves. As they tear their way through the atmosphere they can create a sonic boom in the same way a fast-moving aeroplane does. However, since meteors are generally 100km or more in altitude and sound travels much more slowly than light, such sonic booms would not be heard until many minutes after the meteor appeared to viewers on Earth. Furthermore, the sound may not be loud enough to be heard at all. Some people

claim to have heard hissing or buzzing noises simultaneously with seeing a meteor. These may be caused by the very low frequency radio waves that are generated by meteors, which will arrive at the same time as the observer sees the meteor passing overhead. It has been demonstrated that these waves can cause things like glasses, plant foliage, pine needles and even hair to vibrate. This goes some way to explaining the hissing noises. AG

Meteors look pretty, but do they make a noise as they streak through the sky?



KNOW SPOT

The most heavily cratered moon is Callisto, in orbit around Jupiter. Its surface is 100 per cent covered in craters.



Moths seem to be confused by artificial light

Why don't moths fly towards the Sun?

Most moths are nocturnal, so during the day they keep still to avoid detection from predators. Moths don't fly towards the Moon, either; the idea that moths are trying to navigate by the Moon has been disproved. Exactly why moths fly towards artificial lights still isn't understood – all we know is that artificial lights confuse them in some way. LV

Why is garlic so sticky when you cut it?

Fresh garlic gets its smell from a chemical called allyl mercaptan. At one end of this molecule there is a sulphur atom and a hydrogen atom, which together form a sulphydryl group. When two sulphydryl groups come together, they form a relatively strong bond, called a disulphide bridge. These bonds are what hold together the complex 3D structure of protein molecules. When you get allyl mercaptan on your fingers, the sulphydryl groups form disulphide bridges with the proteins in your skin. The stickiness is the resistance you feel when you try to break the bonds. LV

Stinky and sticky, but oh-so delicious





VITAL STATS

2,743m

The height at which scientists have flown unmanned 'octocopters' to gather samples of the atmosphere above the South Atlantic

Why do caterpillars make webs?

Several moths have web-spinning caterpillars, including the lackey moth, brown-tail moth and small ermine moth. Instead of using camouflage to remain inconspicuous, these moths synchronise their development. The eggs all hatch at once and the caterpillars emerge in huge numbers. They form feeding colonies on a tree or hedge, and spin a silk canopy above their heads as they go. This makes it harder for birds and parasitic wasps to get to them. Webs of the bird cherry ermine moth (shown here) can cover entire trees in May and June. LV



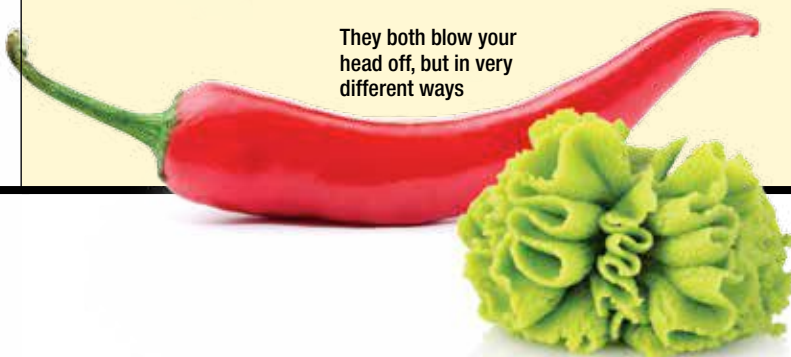
Caused by tiredness or a round with Mike Tyson?

Can you train yourself to get by on little sleep?

Yes, but you'll be unhappy. Psychologists have long studied sleep deprivation by keeping people awake. A surprising finding was how well people cope after very little sleep. However, they lose concentration, make more mistakes and become grumpy and miserable. Occasional deprivation does little harm and we recover after a good night's rest. But continued lack of sleep has long-term effects including obesity, diabetes, heart disease and shortened life expectancy. The immune system is put under strain, hormone levels are compromised, sex drive can fall and depression and anxiety are common. If you think you'll get more work done or have more fun by sleeping less, think again. SB

Why do you feel wasabi on your nose and chilli on your tongue?

They both blow your head off, but in very different ways



The active ingredient in chilli is capsaicin, which is a waxy substance that is solid at room temperature. It dissolves in fats but not water, so it tends to stay put, coating your tongue and the roof of your mouth. Wasabi, on the other hand, contains allyl isothiocyanate, which is a much lighter molecule with a freezing point below -100°C . Although it is still liquid at body temperature, it's much more volatile and some of the allyl isothiocyanate will always evaporate and make its way up into your nasal passages. LV

Q&A

What are the most popular smartphone apps in the world?

The most recent figures are from 2013 by the analysts Global Web Index. At the time, there were 970 million smartphone users worldwide. Google Maps is the most popular app of all, followed by Facebook. At number five is Wei Xin. Never heard of it? It's a free instant voice messaging app and it's massive in China. Dominating in such a large smartphone market, Wei Xin is in the global top five despite only being used in China, Malaysia and Hong Kong. GM

Outside China, Wei Xin is known as WeChat



How did Earth get its name?

Each language has its own name for our planet but they all have one thing in common. Each is derived from a word meaning 'ground' or 'soil' (or sometimes 'universe' or 'creation'). For example, the modern English word 'Earth' derives from the Germanic 'erde', meaning 'ground'. The roots of such words all date from a time when humankind was unaware that Earth is actually a planet. They merely signified the ground beneath our feet, and were adopted for the planet later on. AG

Our planet shares its name with the ground we walk on in nearly all languages



The human population is expanding, but it won't necessarily continue to do so indefinitely

Is there a limit to the human population on Earth?

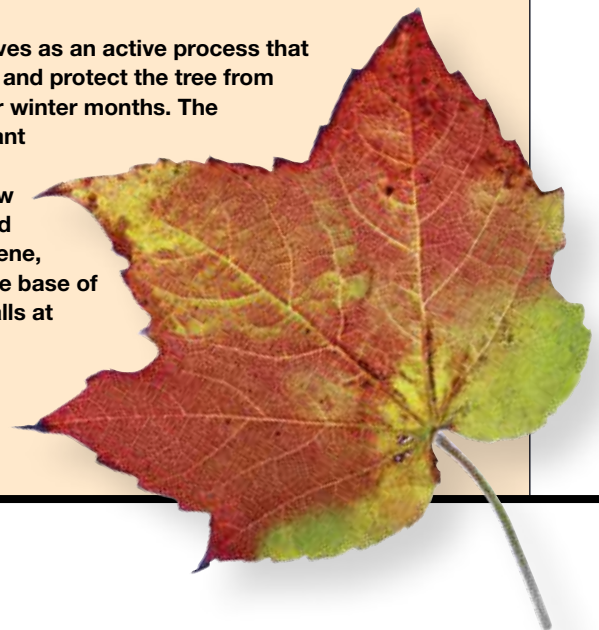
In 2002, Harvard University sociobiologist Edward Wilson estimated that the amount of available arable land in the world would be enough to feed a maximum of 10 billion people. This assumed that they were all vegetarians. However, if everyone on the planet had the same eating habits as the average American, then there would need to be four Earths to support them. Drinking water may be more of a constraint since only 3 per cent of the Earth's water is freshwater and

most of that is locked in ice caps or other inaccessible places.

But this assumes that our species will multiply indefinitely, and that isn't borne out by current trends. According to the United Nations Population Division, the rate of growth of the human population has been falling since 1963. By 2050, the population is predicted to stabilise at between 8 and 10.5 billion. The limit to human population may be our own desire to reproduce, rather than the Earth's capacity to support us. LV

What makes deciduous plants start to lose their leaves in autumn?

Deciduous trees shed their leaves as an active process that evolved to conserve resources and protect the tree from being blown over in the windier winter months. The process is controlled by the plant hormone auxin. As light levels and temperatures drop, the flow of auxin to the leaves slows and levels of another hormone, ethene, rise. This signals the cells at the base of the leaf to weaken their cell walls at the same time as other cells expand to break the connections between the weakened cells, like tearing perforated paper. LV



Are there rainbows on other planets?



The beautiful 'glory' of the planet Venus

The ingredients required to make a rainbow are sunlight and raindrops. Currently, there is no other planet known to have liquid water on its surface or in sufficient quantities in the atmosphere to make rain. However, other liquid droplets could refract sunlight and spread it out into its component colours, just as water droplets do on Earth. On Saturn's moon Titan, for example, the atmosphere is rich in liquid methane droplets that almost certainly form rain. Titan's atmosphere is extremely hazy, meaning that direct sunlight is probably uncommon, but there is still a chance that methane rainbows could form. If they do exist, they would look very similar to terrestrial rainbows, but would be somewhat broader due to the different refractive index of methane compared to water. Another similar phenomenon, called a 'glory', occurs on Venus and is caused by droplets of sulphuric acid that are present in the planet's atmosphere. AG

Is the amount of matter in the Universe infinite?

Only if the Universe itself is infinite. Whether it is or not depends on the average density of matter in the Universe. If the density of matter is less than the so-called 'critical density', the Universe is infinite. If the density is greater than the critical density, then the Universe is finite. While the average density is not yet known, it appears to be annoyingly close to the critical density; so close that we cannot distinguish between the two possibilities. AG

There's a lot of matter out there, but is it infinite?

VITAL STATS

5.5km

Is the height of Martian mountain Aeolis Mons. NASA's Curiosity rover reached the mountain – its primary destination – on 11 September 2014

TOP TEN BIGGEST SPIDERS BY LEG SPAN

1. Giant Huntsman
Length: Up to 30cm
Distribution: Caves in Laos. Other huntsman species are found worldwide

2. Goliath Birdeater
Length: Up to 28cm
Distribution: Upland rainforest regions of northern South America

3. Brazilian Giant Tawny Red
Length: Up to 26cm
Distribution: Tropical South America

4. Brazilian Salmon Pink Birdeater
Length: Up to 25cm
Distribution: Atlantic Forest, Brazil

5. Purple Bloom Birdeater
Length: Up to 22cm
Distribution: Moist forest areas of Colombia

6. Poecilotheria rajaei
Length: Up to 20cm
Distribution: Sri Lanka and parts of India

7. King Baboon Spider
Length: Up to 20cm
Distribution: Most of east Africa, especially Kenya and Tanzania

8. Golden Silk Orb-weavers
Length: Up to 16cm
Distribution: Australia, Asia, Africa, the Americas

9. Brazilian Wandering Spider
Length: Up to 15cm
Distribution: Forests of Central and South America

10. Cerbalus arvensis
Length: Up to 14cm
Distribution: Sand dunes in Israel and Jordan





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AWARDS & RECOGNITIONS

Students attaining top ranks at school level, state level, and at international level will be recognised.



SCHEDULE OF EXAMS:

EXAM	DATE 1	DATE 2
17TH NSO	Wednesday, 12th Nov '14	Tuesday, 25th Nov '14
8TH IMO	Thursday, 4th Dec '14	Thursday, 18th Dec '14
5TH IEO	Tuesday, 20th Jan '15	Thursday, 29th Jan '15

INTERNATIONAL AWARDS - CLASS 1-12

RANK	AWARD	NO. OF AWARDS
1	₹50,000 each + Gold Medal* + Gifts Worth ₹1,000 + Merit Certificate	47
2	₹25,000 each + Silver Medal* + Gifts Worth ₹1,000 + Merit Certificate	47
3	₹10,000 each + Bronze Medal* + Gifts Worth ₹1,000 + Merit Certificate	47

STATE AWARDS - CLASS 1-12

RANK	AWARD	NO. OF AWARDS
1	₹5000 each + Gold Medal* + Gifts Worth ₹1,000 + Merit Certificate	940
2	₹2,500 each + Silver Medal* + Gifts Worth ₹1,000 + Merit Certificate	940
3	₹1,000/ each + Bronze Medal* + Gifts Worth ₹1,000 + Merit Certificate	940
4-25	25 Gifts Worth ₹1,000 + Merit Certificate	20,680

(NEW) STATE AWARDS – FOR LEVEL ONE WINNERS

Class wise →

Top ten rank holders from each of 20 states / zones, who qualify for the 2nd level exam will be awarded a Certificate of Merit and a gold medal each. This will be applicable for NCO, NSO, and IMO.

SCHOOL TOPPER AWARDS

Medals will be awarded to toppers from each class as under:

- If 10 or more students from one class write an exam - gold, silver, and bronze medals will be awarded to top three rank holders.
- If between five to nine students from a class write an exam - a gold medal will be awarded to the topper.
- Participation Certificates will be awarded to every student and Merit Certificates to all 2nd level qualifiers.
- Performance Analysis Report for each participating student will be provided.

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NATURE | SNAPSHOT

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Slow grower

The Atacama desert in South America is peppered with odd, cushion-like plants known as the llareta, a spongy cousin of parsley. Despite the harsh weather conditions they have to endure, some of these plants are up to 3,000 years old.

Despite looking like a rock blanketed by moss, the plant has a tightly packed structure of branches, each adorned with clusters of tiny leaves. The resulting plant is so strong that you could comfortably stand on top of it. However, this hardiness comes at a price: the plants are thought to grow just 1.5cm a year.

“I suspect that the llareta became so strong because of a combination of environmental stressors (cold at night and hot in the day) and grazing pressures,” says Catherine Kleier, a researcher from Regis University, Colorado, who studies the peculiar plant. “The plant is compact to trap heat and decaying leaves, but the more compact the plant, the more successfully it protects itself against grazing from the native viscacha, a long-tailed, rabbit-like rodent.”



Cosmic cab

This is the future of manned spaceflight: SpaceX's Dragon V2. The vessel acts like a space taxi and will be used to deliver up to seven astronauts to the International Space Station, and Mars if SpaceX's CEO Elon Musk's plans come off. The plush interior was shown off in May, with a launchpad test due next month.

Dragon V2 will ride to space on a SpaceX rocket, but can then touch down almost anywhere on the planet with thrust from its eight boosters. It can land with the precision of a helicopter before being refuelled for another journey. This sets it apart from other crewed vehicles like Russia's Soyuz, which relies on a parachute to bring it down. "You can just reload and fly again," says Musk. "This is extremely important for revolutionising access to space because as long as we continue to throw away rockets and spacecraft, we will never truly have access to space."







The hills are alive

Located in the John Day river basin in eastern Oregon, USA, the colourful layers of the Painted Hills formed back in the days when the area was a floodplain – some 20 million years ago.

“The Painted Hills aren’t actually painted, except by the brush of deep geological time,” says Dr Matt Genge, a senior lecturer in Earth and Planetary Science at Imperial College London.

Instead, the colours of the different layers give clues to their origins. The black layers were formed from the decayed remains of vegetation that grew along the side of the floodplain. The grey rocks are mud and silt drawn from the water when the plains flooded, and the red layers are laterite, a soil formed when warm water saturates the ground over long periods of time.

“Within the colourful layers are some surprising fossil remains. Bones of early horses, dogs, cats and saber-toothed cats are present together with camels and rhinoceroses,” explains Dr Genge.

DISCOVERIES

THE LATEST FROM THE
FIELD OF SCIENCE

MOLECULE DISCOVERY SUGGESTS LIFE COULD HAVE STARTED IN SPACE

Study of gas clouds where stars are forming could be
the key to solving the mystery of where life began

The ALMA telescope
in Chile has found
organic material in an
interstellar gas cloud

The largest and most complex organic molecule ever seen in interstellar space has been detected by the Atacama Large Millimeter/submillimeter Array. The molecule, isopropyl cyanide, was spotted 27,000 light-years (10 trillion kilometres) from Earth, inside a star-forming giant gas cloud named Sagittarius B2.

As stars are born in the cloud, they heat up microscopic grains of dust. Chemical reactions on the surface of this dust can result in the formation of complex molecules. Various types of molecule have previously been detected in space. But hydrogen-rich organic molecules – such as those most closely related to the ones necessary for life on Earth – appear to be most plentiful in the gas clouds from which new stars are being formed. The discovery of isopropyl cyanide in interstellar space suggests that the building blocks of life may be widespread throughout our Galaxy.

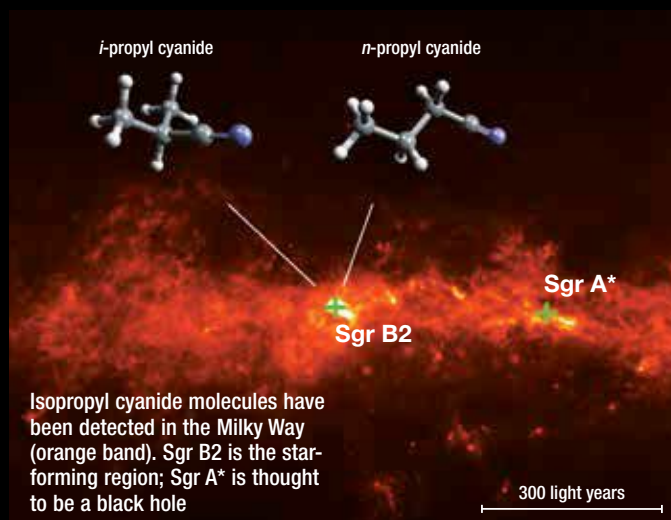
Since the search for molecules in interstellar space began in the 1960s, around 180 kinds have been discovered. Each molecule emits light at particular wavelengths, giving it a unique pattern of electromagnetic radiation that acts as its 'signature'. These signatures can then be detected using a radio telescope, allowing researchers to determine the composition of interstellar space.

"Understanding the production of organic material at the early stages of star formation is critical to piecing together the gradual progression from simple molecules to potentially life-bearing chemistry," says lead author Arnaud Belloche.

The discovery could mean that more complex organic molecules, such as amino acids, may also be present in interstellar

gas clouds. Amino acids are the key ingredients of proteins, which played an important role in the evolution of life on Earth.

"Amino acids identified in meteorites have a composition that suggests they originate in the interstellar medium," adds Belloche. "Although no interstellar amino acids have yet been found, chemistry may be responsible for the production of a wide range of complex molecules that eventually find their way to planetary surfaces."



PSYCHOLOGY

Marching in step gives you powerful feeling

Men feel more powerful marching in unison than when they walk in no particular formation. A study at UCLA College in California found that when men walk in step with other men, as military personnel often do, they perceive a potential enemy to be smaller and less intimidating. This has the effect of making them feel less vulnerable.

Researchers Daniel Fessler and Colin Holbrook had a theory that we've evolved to think that walking in unison signifies the strength of a group of people. To test it, they recruited male volunteers and put them in pairs. Some of the pairs marched in unison along a 250m route on the UCLA campus. Other pairs walked the same route, but not in lockstep.

Afterwards, the participants were then shown photographs of men with angry expressions on their faces and asked to judge their height. Those who had walked in unison thought the angry men were shorter and less threatening. On average they guessed the men to be an inch shorter than those who had walked out of unison.



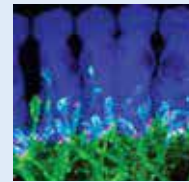
Left, right, left. Join a march to feel powerful

"Experiencing moving in unison with another person appears to make us paint a less threatening picture of a potential assailant," said lead author Fessler, a professor of anthropology in the UCLA College. "They loom less large and formidable in the mind's eye. Simply walking in sync may make men more likely to think, 'Yeah, we could take that guy!'"

The scientists believe that the behaviour could explain why riot police, who often march in lockstep, sometimes use excessive force: "We theorise that it also makes them more likely to use violence than they otherwise would be," says Fessler.

GOOD MONTH/ BAD MONTH

It's been good for: THE HARD OF HEARING



Scientists at Harvard University have improved the hearing of partially deaf mice by boosting NT3 levels in the inner ear (pictured). This

protein is used in brain-ear communication. The findings could lead to therapies to restore hearing loss in humans.

GAMERS

Psychologists at the University of Toronto have found that people who play videogames seem to learn new 'sensorimotor skills', such as riding a bicycle or typing, more quickly than non-gamers. They set a group of 18 gamers and 18 non-gamers the task of tracking an icon on a computer screen with a mouse. Gamers improved more quickly than non-gamers.

It's been bad for:

THE GUNA PEOPLE



The indigenous people of Panama's Guna Yala islands are being forced out of their land thanks to rising

sea levels and extreme weather caused by climate change. "The situation in Guna Yala is the first case we are aware of in Latin America of large-scale climate displacement," said Scott Leckie, of international NGO Displacement Solutions.

SHIFT WORKERS

A team from the Weizmann Institute of Science in Israel has discovered that gut microbes have circadian rhythms that are controlled by the biological clock of their host. Disruption of the host's body clock due to jet lag or shift work can alter the rhythms and composition of the microbes, potentially leading to metabolic problems and obesity.

These South Korean soldiers are experiencing a collective sense of strength through marching



DISCOVERIES

THE LATEST FROM THE FIELD OF SCIENCE

GRAPHIC SCIENCE MARS 2020 ROVER

Seeing research differently

SuperCam is an instrument to perform chemical composition analysis and search for organic compounds in rocks

Planetary Instrument for X-ray Lithochemistry (PIXL) is an X-ray fluorescence spectrometer and imager that will determine the chemical make-up of the Martian surface

Mastcam-Z is a panoramic and stereoscopic imaging camera that will investigate the Martian rock

Scanning Habitable Environments with Raman & Luminescence for Organics and Chemicals (SHERLOC) is a spectrometer that uses an ultraviolet laser to detect organic compounds

The Radar Imager for Mars Subsurface Exploration (RIMFAX) is a ground-penetrating radar that will survey the subsurface

The Mars Oxygen ISRU Experiment (MOXIE) will attempt to create oxygen from CO_2 in the Martian atmosphere

Mars Environmental Dynamics Analyzer (MEDA) will measure temperature, wind speed, pressure, humidity, and dust size and shape

Six years from now, NASA will be sending another robot to join Opportunity and Curiosity in exploring the Red Planet. To kit out the Mars 2020 rover, the agency has chosen seven high-tech instruments from 58 proposals received from researchers worldwide. These instruments, detailed above, will be used to identify and select a collection of rock

and soil samples that will be stored for potential return to Earth by a future mission.

NASA administrator Charles Bolden said of the project: "Mars exploration will be this generation's legacy, and the Mars 2020 rover will be another critical step on humans' journey to the Red Planet."

TIMELINE

A history of organic compounds in space

1937

Methylidyne, a gas made up of a single carbon atom and a single hydrogen atom, becomes the first organic molecule to be observed in interstellar space.

1953

Stanley Miller and Harold Urey carry out an experiment in which amino acids are created by mixing water, ammonia, methane and hydrogen and subjecting them to strikes from simulated lightning.

1969

The Murchison meteorite lands near Murchison, Victoria, in Australia. When analysed, the space rock is found to harbour at least 15 different amino acids.

2005

NASA's Spitzer Space Telescope finds polycyclic aromatic hydrocarbons, molecules critical to all known forms of life, in the spiral galaxy M81.





Why Dr R K Pachauri likes *BBC Knowledge* magazine

BBC Knowledge magazine is a comprehensive read on various aspects of science – art, nature, history and even philosophy. In my opinion the content is fairly intellectual and it would not do any justice if I do not pay my compliments to the photographs that are published in the magazine. It is impressive to see that landmark events of the past are celebrated in a literarical way with equal gusto with which future advancements in science are highlighted.

I personally believe that *BBC Knowledge* does provide necessary exposure and trivia, which makes learning fulfilling. I enjoy reading the **Portfolio** section and the information provided under the **Updates – The Latest Intelligence** section is the best.



Dr Rajendra Kumar Pachauri is the Chairman of the Intergovernmental Panel on Climate Change (IPCC), which was awarded the Nobel Peace Prize in 2007 for its work on climate change. He is the Director General of TERI, India and is the founding director of Yale's Climate and Energy Institute (YCEI).

FOR THE CURIOUS MIND • SCIENCE • HISTORY • NATURE

SATHYABAMA UNIVERSITY presents

BRAINiAC

IN ASSOCIATION WITH



Knowledge

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MUSEUM OF ART

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Quiz Managed by



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ENTER THE DEFINITIVE ALL-INDIA SCHOOL QUIZ

Who can participate: Students from standard 9 - 11

Regional Rounds: Chennai 10 January, 2015

Timing: 10 a.m. onwards

Nationale Finale: Chennai 10 January, 2015

Timing: 3 p.m. onwards

***Prizes:** A cash prize of ₹1 lakh and a trophy to the national winner and gift hampers to all finalists

* Terms and conditions apply. Dates subject to change.

To participate, speak to your teacher co-ordinator or
log onto www.knowledgmagazine.in/brainiac

SATHYABAMA UNIVERSITY presents

BRAIN•AC

IN ASSOCIATION WITH

 **Knowledge**

POWERED BY

 **KIRAN NADAR
MUSEUM OF ART**

Sathyabama University presents the BRAINIAC powered by BBC Knowledge in association with Kiran Nadar Museum of Art; the search for India's smartest student. A multi-level quiz to test knowledge and quick thinking amongst the students, it is the country's largest single participant quiz – meaning students participate individually and not as a team.

Regional rounds were held in the cities of Delhi (North Zone), Mumbai (West Zone), and Kolkata (East Zone) where over 200 students from each zone participated in a cut-throat competition making the contest a tremendous success.

The regional round in Chennai (South Zone) and the national finale of BRAINIAC will take place on 10 January 2015 at the Sathyabhama University campus in Chennai, where the national winner will take home a trophy and cash prize of ₹1lakh.



BRAINIAC Regional
Zone Trophy



1



2



3



4

5



6



7



8



9



10



11



Sathyabama University formerly known as Sathyabama Engineering is a pioneer institute imparting knowledge in the areas of engineering, science, technology and education. The University offers 21 courses at the UG level and 33 courses at PG level in addition to Sciences, MBA, MCA and Ph.D. programmes in all disciplines.

The Kiran Nadar Museum of Art (KNMA) was established at the initiative of the avid collector Kiran Nadar. It opened its doors to the public in January 2010, as the first private museum of Art exhibiting Modern and Contemporary works from India and the subcontinent.

Prizes for the contest are sponsored by Cremica, Hachette and Popular Prakashan. The quiz is conducted by Nexus Consulting.

01: North Zone regional winners Joydeep Sen Gupta (2nd runner-up), Ashim Kumar Dubey (winner), Ayaan Gupta (1st runner-up) with chief guest musician Ayaan Ali Khan, director & chief curator Roobina Karode of KNMA and the professor from Sathyabama University 02: Chief guest Ayaan Ali Khan at the event in Delhi 03 & 04: The participants answering the preliminary written round of the West Zone regional round in Mumbai 05: The three East Zone regional winners - (l-r) Ritabrata Chowdhury (2nd runner-up), Ekata Lahiri (winner) and Trivikram Choudhury (1st runner-up) 06: Gift hampers for the winners 07: Quiz master Venkateshan Srinivasan interacts with the crowds during the audience quiz segment of the event 08: Participants registering at the North Zone finals 09: Participants being taken around the Kiran Nadar Museum, our venue for the North Zone finals 10: The participants at the East Zone finals in Kolkata 11: The West Zone final winners - (l-r) Rahul Santosh Shinde (2nd runner-up), Poojan Sarvaiya (winner) and R Siddarth (1st runner-up)



A futuristic cityscape at night, with glowing blue light trails and a dark car in the foreground. The car is a Mercedes-Benz, with its distinctive star emblem visible on the wheel. The background is a dense, glowing network of light trails, suggesting a high-tech, digital environment.

DRIVING INTO THE FUTURE

What technology will you find in your next car? Daniel Bennett test-drives the world's smartest motors to find out

Want to know what features your next car might have? Then you don't need to look much further than the flagship models of today. Like a shop window, manufacturers pack their smartest wares into these machines to showcase the technology and design they intend to endow the rest of their cars with. From automated driving to 360-degree cameras to night vision mode, we test the five most high-tech cars on the road today to find out what you might be driving tomorrow... ▶

BMW M4

Price: ₹1.5 crores (on road)
www.bmw.in



These days, A good measure of whether something's 'modern' or not is whether it has its own app. The M4 has two. Between them they can access your social networks, podcasts and show you where you parked your car (though we'd hope not to need that feature too often). The most useful thing of all they can do is pick apart the telemetry from your car's engine to tell you how you've been driving and precisely what to do to start saving some money on petrol. Following the app's instructions, we gained an extra 5mpg.

The computer onboard the car itself was easily the most intuitive to use. It blinked between menu screens instantly, with all the options oriented around a single dial while keeping the sat-nav displayed on the right-hand side of the screen at all times. There was hardly any waiting around when we used Google maps data to find us the nearest petrol pump.

There's a built-in web browser too, which is less snappy, but a welcome addition should you need to look something up. Once your destination is primed, the directions also pop up on your windscreen via a Heads-Up Display (HUD), along with a progress bar that fills up as you close in on the next turn. This means you rarely have to take your eyes off the road.

While you drive, the cameras are also busy reading the nearest road signs to project the current speed limit alongside your actual speed on the HUD. These cameras also work with radar detectors on the nose and rear end of the M4 to help you park. They actually highlight obstacles as you approach them, going from green to red as you get nearer.

BMW's offering might not be as pioneering as the Mercedes, but it pulls off everything it does offer supremely well.



FASTER SOUNDS

The M4 will let you stream music from an ever-growing number of online stores and internet radio stations

ENGINE SIZE	2,979 CC
HORSEPOWER	431HP @ 5,500 RPM
MPG*	32.1 MPG
0-60MPH*	4.3 seconds
DIMENSIONS	4.7 X 1.9 X 1.4M, 1,612KG

*Manufacturer's quoted figures





AUDI A8

Price: ₹1.3 crores (on road)
www.audi.in



TRACKING TRAFFIC

Future Audis will include a system that tells the driver how fast to travel to avoid stopping at the next set of lights

ENGINE SIZE	2,967 CC
HORSEPOWER	255 HP @ 4,000RPM
MPG*	47.1 MPG
0-60MPH*	6.1 seconds
DIMENSIONS	5.3 X 1.9 X 1.5M, 2,585KG

The A8 is elegant and understated. Inside, the ergonomics of every button, stick and switch have carefully thought out. For example, since the gear lever is flat like a boat's throttle, it's where you'll naturally rest your left hand. Knowing this, Audi has placed all the most used controls a finger's stretch away from this spot.

The same design ethos runs into the intuitive Audi Connect system, which manages the car's settings, sat-nav and multimedia. For instance, you can input addresses and postcodes by drawing them out with your finger on the central touchpad. It's much quicker than relying on the car's central 'jogwheel', and it successfully translated our crude chicken scratching into letters. Once the car pulls away, the touchpad displays the numbers 1-6 so you can select your favourite radio stations quickly. Your sat-nav directions are then

beamed onto the windscreen by the car's HUD, along with safety warnings if you start getting too close to the car in front. There's even an update coming, which will be able to tell you what speed to maintain to avoid having to stop at the next traffic light – thus saving you fuel. And the 360-degree camera, which takes radar images from around the car and compiles them into a top-down view, means parking will never be difficult again.

Unlike the other cars, the A8 drinks diesel. It's also a relatively small three-litre engine block, but Audi has clearly taken the lessons it's learned beating petrol cars in 24-hour races and put them to good use. It can be frugal and quiet one second, ferociously fast the next, while the four-wheel drive system makes you feel glued to the road at all times, and forget you're in something the size of a yacht.



LEXUS LS 600H



Price: From £99,995 (Not yet sold in India) • www.lexus.co.uk

Panelled with walnut and draped in leather, the LS 600h has all the opulence of a stately home. But beneath the old-fashioned demeanour is a strikingly modern petrol-electric hybrid engine – similar in a sense to what you'd find in a Toyota Prius.

Tacking an electric motor onto a five-litre V8 might seem futile ecologically speaking (though we did average around 28mpg), but it's not there to save the planet. What it is there to do is move quickly and silently. Unlike a petrol engine, the battery-powered motor, which is charged from the wheels when the car coasts, can deliver all of its power the second you stamp your foot on the pedal. This means if you need to move all 2.8 tonnes of the car in a hurry, you don't need to wait for the petrol engine to reach its peak rev range. And since this is a bit of a limousine it doesn't hurt that it'll do all this silently, too.

Most of the technology throughout is channelled to do that

very job – keep everything serene. The LS 600h was the car in which we felt most isolated from the outside world. Even on the noisy, potholed road, the inside of the cabin was relatively sedate.

Again, the car is always casting a watchful eye over the road. Radar that is sensitive enough to pick up individual pedestrians monitors the adjacent lanes and sends out a warning if you start to switch lanes without checking your blind spot – all the while monitoring the car in front in case it needs to ready the brakes and safety systems for a crash.

Unfortunately, the on-board computer isn't as smart or as relaxing to use as the rest of the car. It's controlled via a small joystick, which more often than not causes you to glide over the option you wanted. Generally speaking it slows everything down, and puts you off using the clever features packed behind its 12-inch display.



ACQUIRING APPS

The LS 600h can be improved with apps that give you access to local information and radio from around the world

ENGINE SIZE	4,696 CC
HORSEPOWER	389HP @ 6,400 RPM
MPG*	32.8 MPG
0-60MPH*	6.2 seconds
DIMENSIONS	5.2 X 1.9 X 1.5M, 2,815KG





****Price: ₹1.72 crores approx (on road) • www.mercedes-benz.co.in**

MERCEDES S500 AMG L



PRECISION PARKING

The S500 uses cameras around the car to display your exact position from above, as well as the view from the rear camera

ENGINE SIZE	2,967 CC
HORSEPOWER	255 HP @ 4,000RPM
MPG*	47.1 MPG
0-60MPH*	6.1 seconds
DIMENSIONS	5.3 X 1.9 X 1.5M, 2,585KG

****As per current currency exchange**

This is easily one of the most advanced machines I've ever experienced. On the surface, the luxuries are easy to spot. A vaporiser diffuses perfume, the chairs give hot stone massages and the sound system pumps out pin-sharp music. But strip away these extravagances, and the S500 is still miles ahead of its rivals.

Intelligence seems to be wired into the very chassis of the S500. A pair of cameras behind the rear view mirror scan the road ahead, scouting for bumps and potholes. When they find one, the whole body leans over to one side to reduce the impact – the car genuinely seemed to glide over speed bumps. These cameras also keep an eye on the car in front: the S500's computer will spot an accident before you can, and ready the brakes in anticipation. Fail to react and the car will sound warnings before hitting the brakes for you. Thankfully we didn't have to test this out!

After dark, an infrared camera behind the radiator keeps watch. You can monitor this from the dash, but the car is always looking for animals or people in the road. If a person steps out the car flashes its headlights, but if the car detects an animal on the tarmac, it only warns you, for fear of startling the animal.

The S500 will even do the driving for you. On motorways, we engaged the DISTRONIC Plus system – a kind of robotic chauffeur – which steered the S500 between the white lines at a constant speed, only slowing when the car in front got closer. We kept our hands on the wheel, but otherwise just sat back and enjoyed the ride – for several hundred miles.

In truth, we'd need a few more pages to fit in all the tech found inside the S500, like the blind spot warnings, the 360-degree parking camera and more. For now all we can say is that we hope this is where car technology is heading.





From the outside, it seems that Tesla wants to convince us that battery power is the way forward by making a car that's as similar as possible to what we're used to. Apart from the missing exhaust – eagle-eyed observers might notice there's no front radiator, either – there's little that gives away what's under the Model S's shell. That's not to say it looks dull. The bodywork is handsome from every angle, but the part of me that's still impressed by futuristic-looking concept cars is a little disappointed that Tesla hasn't opted for a more exotic design.

The interior, however, is a different story. Where you'd normally find a jumble of buttons that control the air-con and radio, there's a 17-inch touchscreen. From this command centre, the Model S can be customised to an almost absurd level. A slider selects what percentage to open the sunroof by. And you can drag a crosshair across the screen to pinpoint exactly where you want the Dolby Surround Sound system to aim the audio – letting you have a conversation in the front while the kids listen to music in the back.

Options, then, are one thing you will never be short of, and unlike most cars where fiddling with knobs and switches is a hassle, the responsive touchscreen makes everything intuitive and direct. There are some serious features in there too. You can see the picture from the rear-view camera, turn the whole screen into a Google Maps-powered sat-nav, or browse the web. You can even decide whether the car crawls forward when your foot's not on the brake pedal.

Like an iPhone, this is all based around an operating system (OS) that's simple to use – no manual required. And also just like a smartphone, the Model S needs its own SIM card. Getting a phone contract for your car might seem like just another cost, but the OS and SIM together make this unlike anything else on wheels. On the third day of testing, a little message popped up on the screen letting me know an update was available for the car. I scheduled it for midnight, not wanting to be the first person that turned a computer crash into a car crash, and parked the car. The next

TESLA MODEL S

Price: From £49,990 (Not yet sold in India)
teslamotors.com/en-gb



APP CONTROL

The Tesla app lets you control the car remotely. You could, for example, defrost the windscreen on a chilly morning

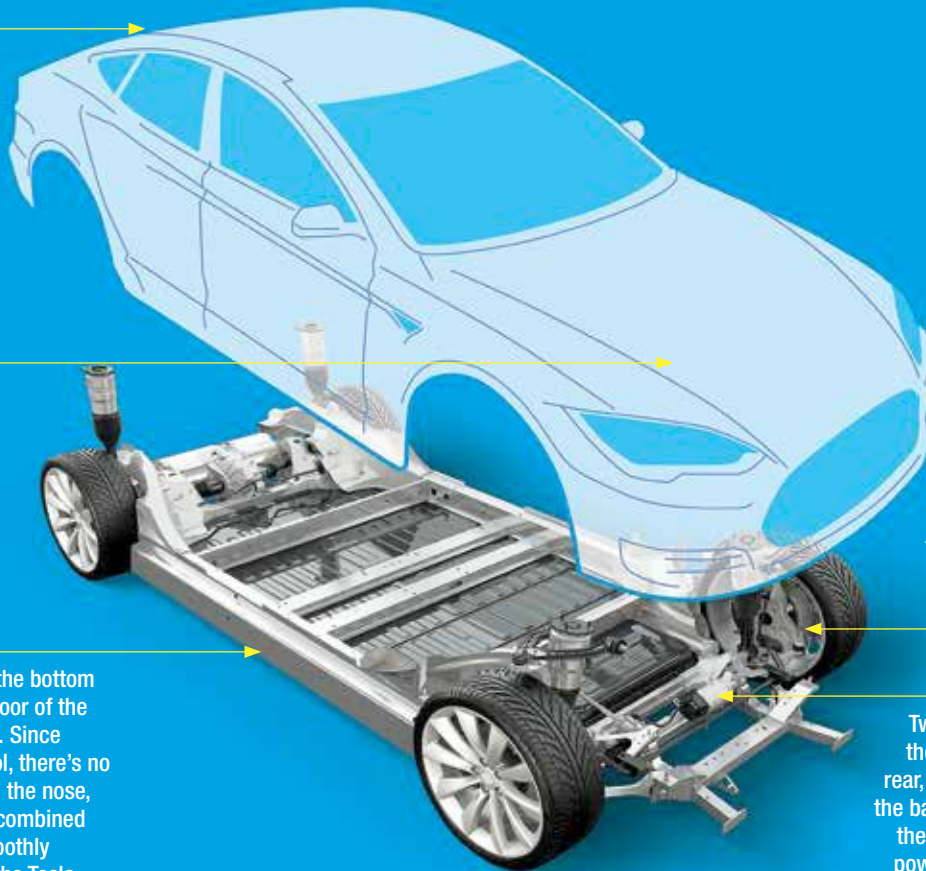
ENGINE SIZE	4,696 CC
HORSEPOWER	389HP @ 6,400 RPM
MPG*	32.8 MPG
0-60MPH*	6.2 seconds
DIMENSIONS	5.2 X 1.9 X 1.5M, 2,815KG



UNDER THE HOOD

A closer look at some of the clever engineering that makes the Tesla Model S one of the most advanced cars money can buy

The rear window is awkward to see out of, so there's an HD camera fitted on the rear bumper. Inside the car you can see a live view from this camera as you drive, which is a big help with parking.



The battery tray sits at the bottom of the car, making the floor of the Model S completely flat. Since there's no engine to cool, there's no need for an air intake in the nose, either. These two facts combined mean that air flows smoothly around the car. In fact, the Tesla offers the lowest air resistance of any car available today.

The brakes are hooked up to the batteries. Each time you slow down the car puts the excess energy into charging the battery – just like the KERS technology used in Formula 1.

Two drive trains, one at the front and one at the rear, translate power from the batteries into motion in the wheels. Since all the power is available all the time there's no gearing, and having fewer moving parts means there's less chance of anything going wrong.

morning the Tesla had gained a set of new features. Among other things, the powers-that-be had added hill starts – where the car holds itself in place on a gradient – and tweaked the throttle response, following feedback from customers. This is the first car we've ever known that actually improves with age.

Furthermore, if something does go wrong, a Tesla engineer is able to access the car's diagnostic systems remotely, with the possibility of getting you back on the road digitally.

Driving the Tesla is a similarly futuristic experience. Inside, it's soundless. The only noise the car's motors make is a space-age whine when your foot hits the floor. The speed is astronomical, too. A petrol or diesel car has to hit a certain rev range before it's generating its max power output, but batteries can send all their power to the wheels at once – and when you put your foot down, that's exactly what happens. There are few road-going vehicles that can get to 30mph as quickly: as one colleague put it, "It's like

falling off a cliff".

Boisterous driving will sap your batteries, though. The 'distance remaining' indicator was reading 260 miles at the start of our tests; by the time we'd driven around 80 miles or so, that figure had been reduced to a mere 100 miles. That was due to our 'exuberant' driving style. For a start, we'd turned off the regenerative braking mode, which charges the car each time you lift your foot off the pedal. With careful driving, a range of 200 miles would probably be a reasonable expectation – though

we're not sure we'd want to rely on batteries alone for a trip that was quite that long.

Since most journeys comfortably fit inside that range, however, that didn't alarm us too much. What was more worrying was how tricky charging can be. Of course, if you bought a Model S, you'd get the special power outlet installed. Once plugged in, it would take six hours to get a full charge. 🍷

Daniel Bennett is the review editor for UK based *BBC Focus* magazine.



MYSTERY MESSAGES FROM SPACE

Strange signals from outside our Galaxy have scientists baffled. But are they of alien origin? **Hazel Muir** investigates ►



Scientists revisiting archived observations made by the Parkes Observatory in New South Wales, Australia in 2007 noticed something odd. They saw a brief, yet extremely bright burst of radio waves that lasted just five milliseconds. Nothing like it had ever been seen before. But in April this year, a similar signal was reported on the other side of the world at Puerto Rico's Arecibo radio telescope.

Researchers now think there's good evidence that these 'fast radio bursts' (FRBs) are not only real, but very common – and they come from vast distances far beyond our own Galaxy. Nobody knows what causes them, but could they possibly be evidence of intelligent aliens trying to get our attention?

The Parkes Observatory has a vast 64m-diameter radio dish, which is one of the world's oldest large movable dishes. It recorded an FRB in 2001, although it wasn't until several years later that astronomers noticed the strange signal. Since 2007, they have shown that the Parkes radio dish has spotted at least half a dozen FRBs, all of them lasting just a few

The Arecibo Observatory in Puerto Rico has detected an FRB similar to those picked up by Parkes

Signal from Aliens?

In 1967, a possible alien signal appeared in the constellation Vulpecula. Jocelyn Bell of Cambridge University (now Dame Jocelyn Bell Burnell) picked up regular radio 'beeps' that occurred every 1.3 seconds. They looked artificial, so her team named the source LGM-1 (for 'little green men'). However, LGM-1 turned out to be a rotating neutron star – the first one ever discovered.



Jocelyn Bell, discoverer of pulsars, in 1968

Face on Mars

In 1976, NASA's Viking 1 spacecraft spotted a shadowy feature on Mars that looked uncannily like a human face. Many people jumped to the conclusion that it was an alien monument, possibly designed to send a message that a civilisation once existed on the planet.

But the excitement was brief. Later images showed it was simply a Martian mesa (a high plateau with steep sides) that was casting peculiar shadows, making it look like a human visage.



This 'face' on Mars (above) turned out to be a natural rock formation (below)

thousandths of a second. They have all come from different directions on the sky.

All the Parkes observations suggest that the FRBs come from sources that are very far away, according to Prof Benjamin Stappers from the University of Manchester, whose team has analysed the bursts. "Radio waves are dispersed by electrons in interstellar and intergalactic space, like light shining through a prism to give you the different colours," he says. "This causes low-frequency radio waves to arrive at the telescope later than high-frequency waves."

The amount of dispersion the team measured in the FRBs suggests that the radio bursts came from sources millions or even billions of light-years away. "They must be outside our Galaxy," says Stappers.

Until now, the findings have been controversial, because no other radio telescope had seen the peculiar short

"Our result is important because it eliminates any doubt that these bursts are truly of cosmic origin"

bursts. There was always the possibility that the Parkes dish had just picked up some local interference – maybe from a satellite or radar station – or that there was some kind of glitch with its electronics.

Another signal

Earlier this year, however, the plot thickened. Analysis of observations by the giant 305m-diameter Arecibo radio telescope in Puerto Rico have shown that it has also spotted a fast radio burst. It occurred on 2 November 2012 and had the same hallmarks as the Parkes FRBs, suggesting it came from far beyond the Milky Way.

"Our result is important because it eliminates any doubt that these radio bursts are truly of cosmic origin," says Professor Victoria Kaspi from McGill ►

University in Montreal, Canada, who headed the Arecibo survey that detected this FRB. “The radio waves show every sign of having come from far outside our Galaxy, which is a really exciting prospect.”

Dr Laura Spitler from the Max Planck Institute for Radio Astronomy in Bonn, Germany, who led the

“The radio waves show every sign of having come from outside our Galaxy, which is a really exciting prospect”

analysis of the Arecibo signal, adds that the observations now look extremely compelling. “The brightness and duration of this event, and the inferred rate at which these bursts occur, are all consistent with the properties of the bursts previously detected by the Parkes telescope in Australia,” she explains.

Possible causes

So what causes these extremely bright radio bursts? So far they’re a complete enigma, says Stappers. Possibilities include a range of exotic astrophysical objects, such as evaporating black holes or mergers between neutron stars. Neutron stars are the collapsed remains of the cores of massive stars that imploded during supernova explosions.

“Another possibility is that they are bursts much brighter than the giant pulses seen from some pulsars,” adds Professor James Cordes from Cornell University in Ithaca, New York. Pulsars are rapidly spinning neutron stars that emit radio beams from their poles, and these can appear as radio pulses as they sweep across Earth like lighthouse beams.

But is there any chance that the fast radio bursts are messages from extraterrestrials trying to contact us? It seems unlikely. One reason is that

Could FRBs come from a previously unknown type of pulsar? It’s one of several possibilities

False Alarms

At the Arecibo Observatory in Puerto Rico, false alarms of alien communications happen regularly. Often, the dish picks up a narrowband signal that doesn’t look like anything natural.

But it usually takes just minutes to rule out alien communications because the signal persists even when the telescope monitors a different patch of sky. This suggests that the message is coming from a satellite or one of Puerto Rico’s many radar and telecoms installations – a bugbear for SETI researchers.



The Alien Hunter

Douglas Vakoch is Director of Interstellar Message Composition at the SETI Institute in California



What would convince you that a signal was potentially alien?

We'd get excited if the signal looked different from anything that nature can make and if it came from a specific point in outer space, like a nearby star. Also, the signal would need to repeat.

How would you decode it?

First we'd look for patterns in the signal, like simple counting. And then we'd look for ways to connect those patterns to the real world. We can use counting, for example, to organise the chemical elements into the periodic table, and we'd hope scientists on other planets would recognise this pattern in nature, too.

What would you expect the message to say?

A message from extraterrestrials won't be in English or Chinese or Swahili.

But if we get a message from aliens, we know they can build

radio transmitters. They'd need to know basic maths and science, like ' $1 + 2 = 3$ ', so that's how a message might start.

But if they only told us about things we already know, then what's the point? I hope they'd also tell us something about their culture, like their art or music.

What would convince you that you'd cracked an alien code?

I'd be convinced that we understood the message if it showed us something new – something we could later confirm with our own science. Then we'd know we weren't just projecting our own hopes and desires onto this alien message.

After decoding, what would you do about it and who would you tell?

Decoding a message could take decades. Long before then, we'd have told the whole world about it. But then we'd face the most critical questions: should we reply, and if we do, what should we say?

the bursts are probably very common and seem to come from random directions on the sky. Scientists have only detected a handful of them so far, but they think that if huge radio telescopes were monitoring all of the sky all the time, they'd see roughly 10,000 of the bursts each day. It seems odd that aliens on thousands of planets in different parts of the cosmos would all contact us in the same manner.

The natural-looking patterns of the FRBs are further evidence that they are not of alien origin. Light emissions from natural astronomical sources are usually broadband, and smeared out over a wide band of wavelengths. Narrowband signals with a waveband spanning only a few Hertz wide or less are typical from a purpose-built transmitter. That doesn't fit with the FRBs, which have multiple wavelengths.

According to researchers involved in the search for extraterrestrial intelligence (SETI), another problem is repetition. No one has seen any

FRBs repeat in the same patch of sky. However, it's impossible to rule out the idea that they never repeat. Maybe the repetition just takes a very long time, and repeats could be detected in future.

For now, interpreting the bursts is just too difficult. Telescopes under construction in Australia and South Africa have the potential to detect more FRBs, and this could clarify the nature of these odd events.

Another observatory that should pick them up is CHIME (Canadian Hydrogen Intensity Mapping Experiment) in British Columbia. CHIME is an innovative new radio telescope that will have five cylindrical reflectors with the approximate dimensions of snowboarding half-pipes, with radio receivers along each one's focus. The reflectors won't actually move, but they'll detect radio signals from half the sky each day as the Earth rotates.

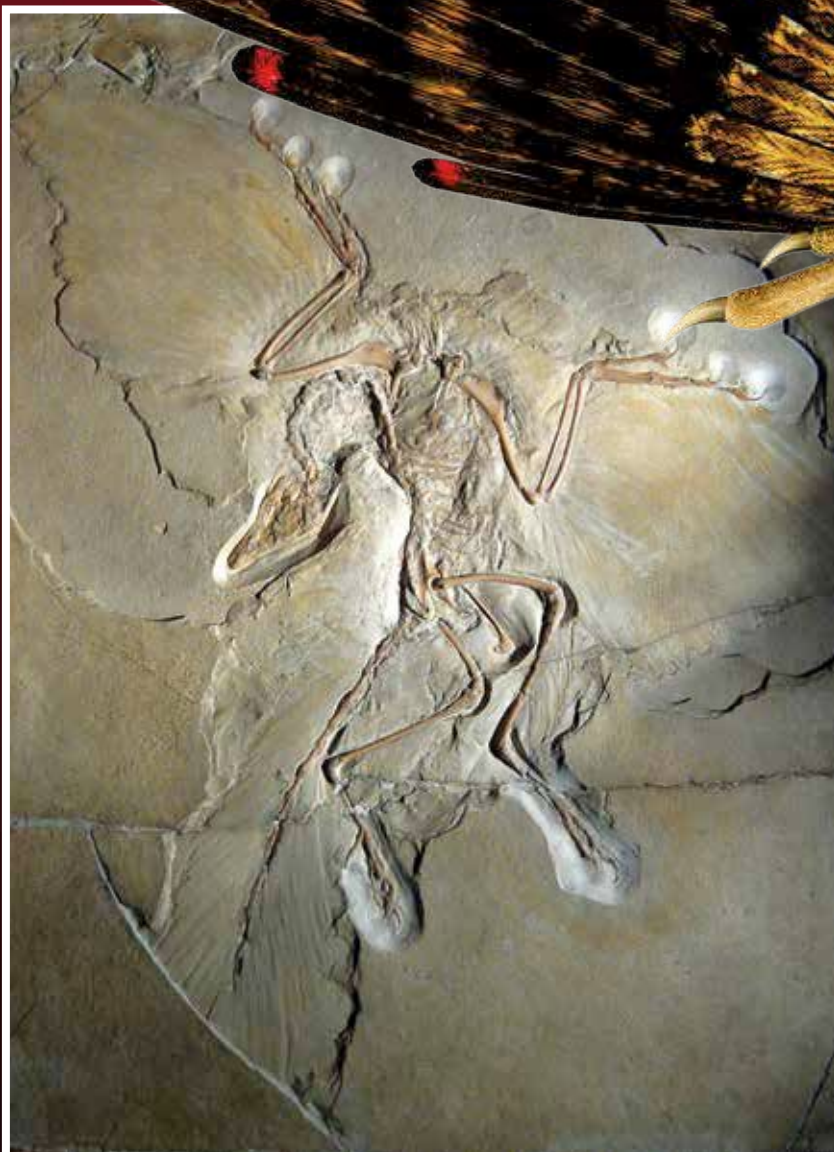
Ongoing mystery

Stappers says he has no personal hunch about what the sources of FRBs are, but he hopes that detecting more will resolve the issue. "We are working very hard to find more of them, and also to pinpoint them in the sky more accurately to try and find their host location," he says. "Are they in galaxies? And if so, where in the galaxy – in the centre?"

Until then, FRBs will have to be filed among unsolved mysteries, alongside the 'Wow! signal'. This strong, narrowband radio burst lasted more than a minute and was detected by Ohio's Big Ear radio telescope in 1977. Jerry Ehman, the astronomer who spotted it, wrote 'Wow!' on a printout of the signal. The Wow! name has stuck, but the signal has never been seen again.

The chances are that the fast radio bursts are something natural, rather than signals from little green men. But what causes them will no doubt baffle astronomers for some time. 🍌

Hazel Muir studied astrophysics before becoming a science journalist and author.



The world-famous fossil of *Archaeopteryx*, 'the first bird', housed at the Museum für Naturkunde in Berlin, and an artist's impression (above)



DRESSED FOR SUCCESS

The discovery of more than 40 species of feathered dinosaur has revealed some remarkable details about the evolution of feathers and flight, reveals **John Pickrell**

One hundred and twenty million years ago, in the part of the world we now know as northeastern China, strange creatures shared the swampy forests with early birds and large ground-dwelling dinosaurs. In the dusky light, as the Sun starts to dip below the horizon and nocturnal insects hum to life, an animal the size of an eagle spreads its wings and leaps from a high branch. It's covered in thick grey plumage and at first glance appears to be a bird – but several features

pick it out as something else entirely. Incredibly, it has four wings – feathered hindlimbs as well as forelimbs – and a long tail replete with flight feathers, which it spreads out to provide the largest possible surface area for gliding.

Changyuraptor yangi – described in *Nature Communications* in July – is the largest of a growing group of known feathered dinosaurs that could glide. Its long tail was tipped by 30cm feathers, which may have helped this hefty 4kg flyer control its speed of descent.

The discovery of feathered dinosaurs, such as *Changyuraptor*, are coming thick and fast these days. Others announced to the world in 2014 ►

include the small Siberian herbivore *Kulindadromeus zabaikalicus*, and *Anzu wyliei* – labelled a ‘cross between an emu and a lizard’ by its discoverers and only the second feathered dinosaur known from North America. More recent finds have included a new fossil specimen of the ‘first bird’ *Archaeopteryx*, and a study which showed how dinosaurs shrank 12-fold over a period of 50 million years in the lineage that led to modern birds.

There is now good evidence that many carnivorous dinosaurs, even fearsome and well-known types – such as *Allosaurus*, *Velociraptor* and *Tyrannosaurus* – had feathers, and that they used them for a variety of functions. Feathers are so intimately entwined in our minds with flight that this idea takes some getting used to. Nevertheless, complex flight feathers can’t have appeared from nowhere, so it makes sense that the earliest feathers had another purpose entirely.

Since the discovery of the first feathered dinosaur, *Sinosauropteryx* (see p47), in 1996, a great flock of 40 or so feathered species has flapped or scurried to the fore. These fossilised creatures have been found with feather impressions, or with circumstantial evidence in the form of either ‘quill knobs’ (pits in the bones where the ligaments of feathers attach) or a ‘pygostyle’ (the bony tail

structure to which a fan of feathers attaches in birds).

Nearly all of these species are carnivorous theropods, and the majority are exceptionally preserved specimens from Liaoning Province in northeastern China, although some hail from Mongolia, Germany, North America and Madagascar. In the years following the discovery of *Sinosauropteryx*, it became clear that most wouldn’t have been

“The creature retained traces of four, long, ribbon-like feathers, which it could have flicked to woo mates”

able to fly – they didn’t have fully formed wings or they weren’t the right kind of shape. Palaeontologists began to realise that feathers evolved for another purpose entirely and were only later co-opted for flight.

The feathers of many of these animals were simpler in structure than anything

we’d recognise as feathers today, and it’s likely they were used like the downy fuzz of chicks for insulation. “To start with, feather structures are not all that complicated – they are a coat of simple filaments,” says Dr Paul Barrett, a palaeontologist at the Natural History Museum in London. “These animals are small and quite active, they have elevated metabolic rates... And this is a way of retaining heat.”

Dino displays

After feathers first found a use in insulation, they developed another purpose. In 2007, in Inner Mongolia, Chinese Academy of Science experts unearthed the finely preserved fossil of a bird-of-paradise-sized dinosaur, which they called *Epidexipteryx*, Greek for ‘display feather’. These scientists noted in a 2008 *Nature* article: ‘Ornamental plumage is used to send signals essential to a wide range of avian behaviour patterns, particularly relating to courtship... It is highly probable that the [tail feathers] of *Epidexipteryx* similarly had display as their primary function.’

The fossilised creature retained traces of four, long, ribbon-like feathers, which it could have flicked and wafted as it danced to woo mates, as birds of paradise do today. This weird dinosaur was a compelling piece

Fossils of *Epidexipteryx* show that it may have used its feathers as a display to attract mates





Recent studies have shown that the four-winged *Microraptor* had iridescent plumage

“Until recently, the consensus was that *T. rex* and other large theropods probably only had feathers as juveniles, if at all”



Microraptor is thought to have had feathers like this

of evidence that early feathers were used for display too.

Other groups of dinosaurs had big ‘pennaceous’ feathers (the typical modern shape, with a central vane and interlocking barbs running off to either side) on their forearms and tails, which were more obviously used for showing off.

A 2013 study by experts including Phil Currie and Scott Persons at the University of Alberta, and Mark Norell at the American Museum of Natural History, provides perhaps the best evidence yet that dinosaurs used feathers for elaborate displays. Oviraptorids are parrot-beaked omnivorous theropods, that had a ‘pygostyle’ tail, where the final few vertebrae are fused to form a ridged, blade-like structure. The researchers found marks on the bones of five different species of oviraptorids, which suggested large muscles that would have allowed the stumpy tail to be flexed and posed in a number of ways. The conclusion was that male oviraptorids likely indulged in tail-

shaking mating displays, much as turkeys and peacocks do today.

So there’s good evidence of early feathers being used for insulation and display, but how did they come to find a function in flight? Eventually, the extra surface area of feathers on the tail and forearms used for display would have offered some lift when jumping or gliding. Then evolution would have started to select for the running or flying functions of feathers, eventually leading to four-winged dinosaurs such as *Changyuraptor* and *Microraptor* that lived in the trees.

Most known feathered dinosaurs are close relatives of birds in the carnivorous theropod group of dinosaurs. Although feathers are only known from a smattering of species across the whole group, the fact that some are early and primitive members and that feathered species are found on many different branches of the family tree, suggests that all theropods were feathered.

Despite this, until recently, the consensus ►



DID TRICERATOPS HAVE FEATHERS?

It's often portrayed with a thick, scaly hide, but the beast may have been covered in bristles

There are some hints that 8m-long, crested herbivore *Triceratops* may have had a bristly covering related to feathers. *Psittacosaurus* is a 1.5m-long, Early Cretaceous member of the parrot-beaked ceratopsian lineage that eventually led to *Triceratops*. Some *Psittacosaurus* specimens discovered in China have revealed plumes of bristles around the tail.

The only skin-impression fossil found for *Triceratops* (which lived in North America near the end of the dinosaur era in the Late Cretaceous) appears to reveal it had bristles, not purely scaly skin as has been long supposed. The remarkable fossil was found by palaeontologist Dr Bob Bakker and is held at the Houston Museum of Natural Sciences in Texas, where he is a curator. We know that *Psittacosaurus* had bristles, so given it is an early member of the lineage that led to *Triceratops*, it seems reasonable to assume that these were passed down.

was that *T. rex* and other large theropods probably only had feathers as juveniles, if at all. The idea was that huge animals don't need insulation, as they lose heat to the environment very slowly. But the discovery of a series of feathered relatives of *Tyrannosaurus* has turned this idea on its head. The first, *Dilong paradoxus*, was



Kulindadromeus zabaikalicus has provided the best evidence yet that feathers were widespread in dinosaurs

discovered by legendary dinosaur hunter Professor Xing Xu in Liaoning in 2004. As this lightly built, 125-million-year-old predator was relatively small, at 2m in length, its downy covering was not wholly unexpected.

Much more surprising, though, was 9m *Yutyrannus huali* (pictured on p47) discovered in 2012. Also from the Early Cretaceous deposits of Liaoning, this shaggy predator was closer in size to *T. rex* itself. It showed that downy feathers were probably much more widespread among dinosaurs than anyone had expected. *Yutyrannus* is the largest feathered animal ever known to have lived.

A few of the new fossils, however, hint that feathers might have originated much deeper in the dinosaur family tree, not close

to the ancestors of modern birds. For example, *Tianyulong confuciusi* was a small bipedal herbivore with a fuzzy covering of fluff. Nothing unusual in that, except it's in the ornithischian group of herbivorous dinosaurs, which are very distant cousins to the carnivorous theropods. Another ornithischian – *Psittacosaurus*, a small and early relative of *Triceratops* – also had bristle-like structures, which may have been a form of feather.

The new Siberian species, *Kulindadromeus zabaikalicus*, described in July, is the best evidence so far that feathers may have been very widespread across all dinosaur groups. This 1.5m-long ornithischian herbivore may have had three different types of feathery filament, as well as scales on different parts of its body.

KNOWN TYPES OF DINOSAUR FEATHER



Sinosauropteryx



Caudipteryx



Anchiornis



Archaeopteryx



Confuciusornis

PREHISTORIC PALETTE

Once a mystery, the power of science is starting to reveal the remarkable colours of dinosaurs

As recently as five years ago, experts thought we'd never be able to tell anything about the colour of dinosaurs. Most were painted in greens and browns similar to lizards and crocodiles. Since the discovery of feathered dinosaurs in 1996, the assumption had been that they might have had some of the same variation in plumage that birds do, but few believed this would ever be confirmed. That was until January 2010, when a study led by Professor Mike Benton at the University of Bristol suggested that *Sinosauropteryx* – the first feathered dinosaur discovered – had ginger and white stripes around its tail, something like a ring-tailed lemur. Similar work has now revealed the true colours of *Archaeopteryx* and four-winged flyers *Anchiornis* and *Microraptor*.

Tiny clues as to the colour of the feathers was found in the structural details of the well preserved fossils of some dinosaurs and early birds. In hair and feathers there are miniscule pigment packages called melanosomes. The way these are stacked or bunched, and whether they are round or oblong, correlates to some of the colours. This has given experts clues as to whether the feathers in fossils were black, brown or red, for example. Iridescent colour is also created by structural features and we can find these in fossil feathers too.



Early birds (*Longirostravis*) perch on one of their large dinosaur relatives (*Yutyrannus*); both species lived in the Cretaceous period

Flying reptiles

There's even the tantalising possibility that feathers originated in the ancestors of animals that gave rise to dinosaurs and their sister group of flying reptiles, the pterosaurs. "Even the filaments of pterosaurs are likely to be a kind of primitive feather," argues Xu, a world expert on feathered dinosaurs at the Institute for Vertebrate Paleontology and Paleoanthropology in Beijing. Experts have known for some years that many pterosaurs had a fur-like covering, which perhaps helped them maintain a high metabolic rate for flight, but it's not yet clear if this is related to feathers or evolved independently.

Others aren't so sure that feathers were common across all dinosaur groups. There's no evidence of feathers in most other ornithischians, according to a 2013 study by Paul Barrett of the Natural History Museum and David Evans of the Royal Ontario Museum. "We have lots of skin impressions from duck-billed and horned dinosaurs, and none of them show anything that looks like feathers," says Barrett. This could be because the ancestors of these dinosaurs started off with feathers and lost them, or it could just be that dinosaurs have within their genes the mechanism to easily evolve skin-related structures, he says. "They also have lots of armour and spikes that form in the skin too." It could explain why some groups have feathers, frills or armour and others don't.

The question now is did all dinosaurs and pterosaurs inherit feathers from the same common ancestor, or is it just that the group had a remarkable plasticity to play around with different structures like bristles, quills, fuzz, fluff, ribbons and, eventually, complex and beautiful feathers sculpted for the purpose of flight. 🟡

The striking ginger and white striped tail of *Sinosauropteryx*



John Pickrell is the author of *Flying Dinosaurs: How Fearsome Reptiles Became Birds*.

MISSION TO THE CENTRE OF THE EARTH

**The goal: to discover how our planet evolved, and hunt for subterranean life.
Jheni Osman looks down...**

ILLUSTRATOR: MAGICTORCH



Riding on a wave of liquid iron, a grapefruit-sized probe is on a journey to the centre of the Earth. The immense weight of the 110,000 tonnes of liquid iron tears apart rock, forging a channel running deep into the very bowels of our planet. Inside the unmanned probe are all sorts of instruments to measure Earth's core – and discover what really lies beneath.

Just like Jules Verne's classic 1864 novel *Journey To The Centre Of The Earth*, this is a work of fiction. But the concept wasn't just dreamt up by some science fiction nut: the brain behind it is physicist David Stevenson from the California Institute of Technology (Caltech). Stevenson came up with the idea after producers of the science fiction movie *The Core* contacted him for feedback on whether the science in the script added up. It didn't. But this nudged Stevenson to investigate

whether we really could reach Earth's core, publishing a letter in the journal *Nature*.

"My letter was tongue-in-cheek," says Stevenson. "The physics is sound, but the idea is unlikely to work in practice, as cracks aren't controllable. Temperatures at Earth's core are as hot as on the Sun's surface. And pressure tends to close off any drill hole, unless it's filled with material of the same density as the surrounding rock. You can't have open spaces inside Earth, even at a mere 10km in depth. And the work you have to do just getting through the material is immense. A journey to the centre of the Earth would be more difficult than a mission to interstellar space, because space is empty." But on the 150th anniversary of the publication of Verne's novel, scientists are once more planning a subterranean mission – but with a closer target in mind. ►

Project mohole

Back in the '50s, while the Space Race was in full swing, a motley crew of scientists came up with an equally ambitious project. Instead of going up to the Moon, they planned to go down – deep underground. In April 1957, over a boozy breakfast, the aptly named American Miscellaneous Society dreamt up Project Mohole. The aim: to go where no drill had ever gone before. The target: Earth's mantle – or more specifically, the Mohorovičić discontinuity, nicknamed the Moho.

In 1909, Croatian geologist Andrija Mohorovičić discovered the boundary between our planet's crust and mantle – the Moho. He noticed that around 30km down, seismic waves caused by earthquakes sped up, suggesting that the rocks down there were completely different in composition from the ones higher up. We now know that the mantle lies 30–60km below continental crust, yet only around 5km below oceanic crust – within reach of drills.

But before Project Mohole could start drilling, funding had to be found and the technology developed to keep a drill ship stable in swelling seas – no deep sea oil rigs existed at that time. Funding was secured in 1961, and the team developed a clever new system called 'dynamic positioning' to keep the ship in place (see *Know The Drill* on p53).

The first drilling mission was a success – boring to a depth of 183m. But then politics played a lethal hand: funding was cut and Project Mohole was canned.

Mission mohole

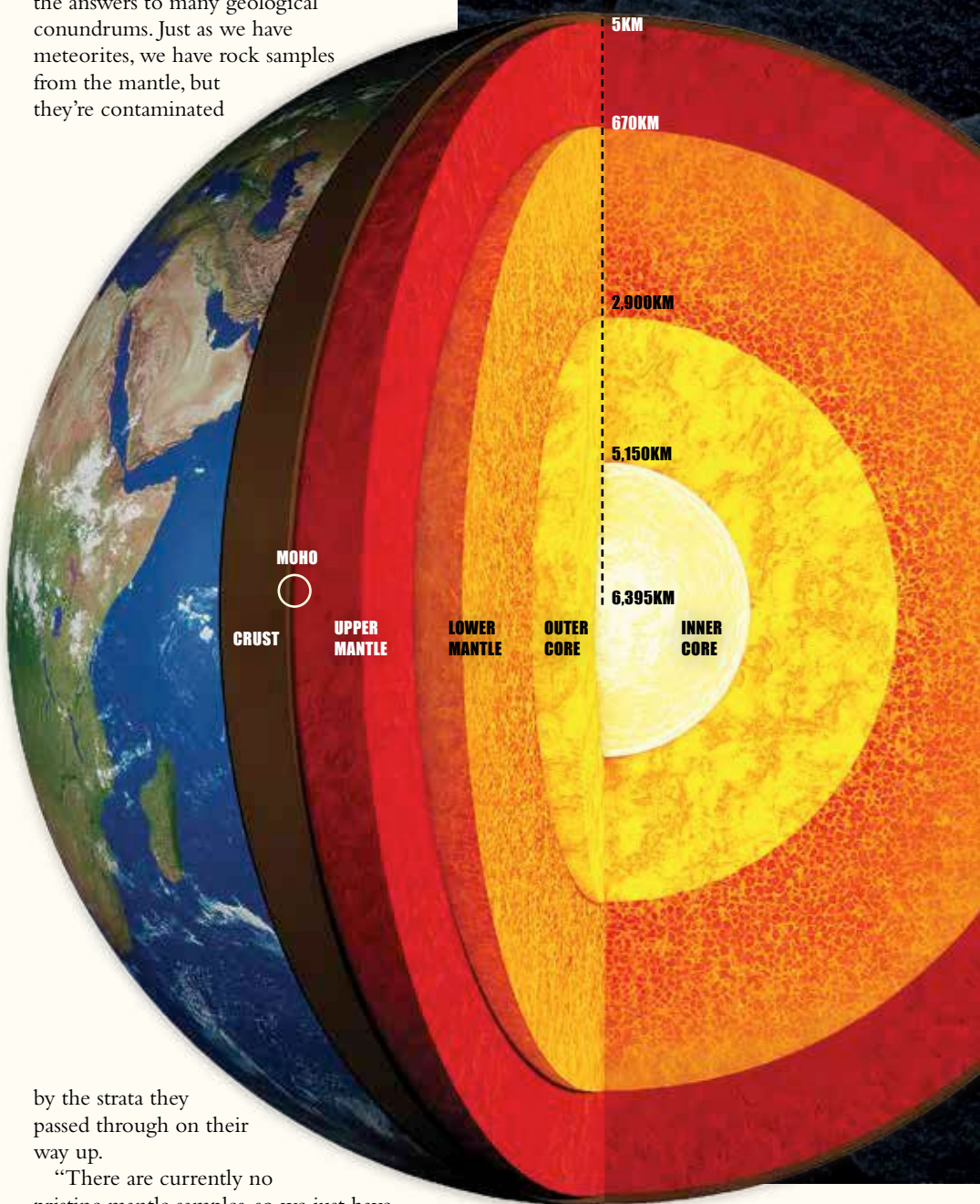
Picking up where Project Mohole left off is a new project called Mission Mohole. The International Ocean Discovery Program (IODP), made up of scientists from the UK, US, Japan and Germany, plans to drill all the way to the Moho. But first the perfect site has to be found. As oceanic crust is much

thinner than continental crust, the team has identified three potential sites at sea, all in the Pacific Ocean. But what's the point of spending years and millions of pounds trying to drill to the mantle?

Think of it like a moonshot – until we actually go there, we'll never really have the answers to many geological conundrums. Just as we have meteorites, we have rock samples from the mantle, but they're contaminated

PEELING BACK THE LAYERS

Getting under Earth's skin



“It’s as demanding to explore the ‘innerspace’ of our planet as it is to explore other planets”

Assistant Professor Matt Schrenk, Michigan State University

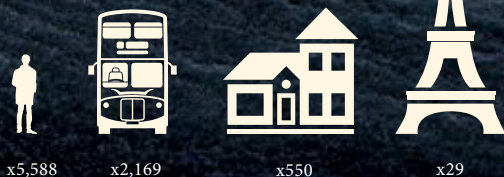
by the strata they passed through on their way up.

“There are currently no pristine mantle samples, so we just have hints of what’s going on,” says Prof Damon Teagle from the UK’s National Oceanography Centre in Southampton. Teagle is part of the international team behind Mission Mohole. “A pristine mantle

sample would be a geochemical treasure trove, like bringing back the Apollo lunar rocks.”

Meteorites give us some clues as to the composition of the mantle, as these

HOW DEEP IS THE MOHO?



CRUST

The outer layer of our planet is relatively thin, between 0-60km thick. Sediments at the surface lie on top of lavas, which sit above gabbros – igneous rocks. Continental crust is much thicker than oceanic crust, which can be only around 5km deep in places.

MOHOROVİČIĆ DISCONTINUITY (MOHO)

This boundary between the crust and the mantle lies about 5km below the sea bed. At the Moho, it's thought rocks change in composition from crustal rocks to mantle ones.

MANTLE

The mantle makes up 68 per cent of Earth's mass, making it the largest component of our planet. The upper mantle is composed of hard rocks, while the lower mantle rocks are softer and beginning to melt.

OUTER CORE

Made of iron and nickel, we know the outer core is liquid, as seismic waves travel through it more slowly than through solid parts of our planet. The dynamo theory suggests that heat radiating from the inner core, combined with Earth's rotation, causes the liquid iron to rotate, creating weak magnetic forces.

INNER CORE

Also made of iron and nickel, the inner core is solid. With temperatures reaching up to 5,500°C, it's the engine room of Earth.

ROCKS

Some of the rocks that are likely to be encountered during the Moho attempt



Basaltic lava



Dykes



Gabbro



Peridotite

Metres below sea level

CHIKYU

JOIDES RESOLUTION

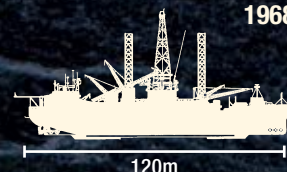
DRILLING SHIPS

CUSS 1
1957



The first deep-sea drilling ship, built by oil companies and used in the first attempt to drill into the Moho in 1961

GLOMAR CHALLENGER
1968



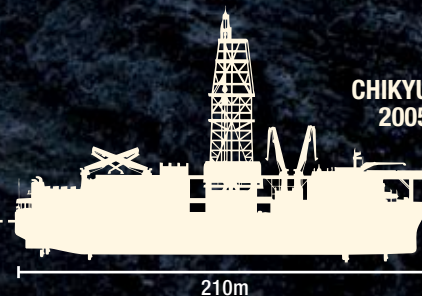
Glomar Challenger provided the first definitive proof of plate tectonics, as well as some key insights into the nature of Earth's crust

JOIDES RESOLUTION
1985



Since launching in 1985, JOIDES Resolution has sailed on 132 scientific expeditions and recovered over 251kg of core samples

CHIKYU
2005



Currently the world's most advanced drilling vessel, Chikyu displaces 56,752 tonnes and can drill at depths of up to 10km

10,000+

PERIDOTITE

extraterrestrial rocks were born from the same cosmic material as mantle rocks. Meanwhile, we have a rough idea of the layers in our planet (see above) through tracking the speed of seismic waves, or by

studying subatomic particles from space called neutrinos that pass through Earth. But it's all still a bit of a guesstimate.

The other big draw for drilling

to the mantle is the possibility of subterranean life. While we won't find the giant prehistoric monsters from *Journey To The Centre Of The Earth*, we might well find life on a much smaller scale. ►

Extreme extremophiles

The deepest anyone has ever drilled is over 12km. Life has been found 5.3km down in a borehole in Sweden. At that depth, pressure is immense and temperatures are searingly hot. Forget superhumans, supermicrobes known as ‘extremophiles’ have impressive arsenals to survive in these unbelievably challenging conditions.

Take *Geogemma barossii*. This single-celled microbe is found at hydrothermal vents on the sea floor, surviving and reproducing at a toasty 121°C. In the lab, *Methanopyrus kandleri* can withstand temperatures of 122°C. Then there’s *Spinoloricus cinzia* that doesn’t need oxygen to survive, while *Picrophilus oshimae* and *Picrophilus torridus* can grow at pH 0 – far more concentrated than battery acid.

“My favourite subterranean organism is a bacterium that feeds off sulphate and hydrogen,” says astrobiologist Dr Lewis Dartnell. “The hydrogen is produced by the splitting of water from radioactivity in the

rocks, and so it feeds indirectly on radiation. But one of the most impressive of all is a polyextremophile called *Deinococcus radiodurans*. This superhero organism can survive several different extreme conditions – being dried out, high doses of UV, and doses of ionising radiation thousands of times higher than what would kill one of us.”

For life to exist in the Moho, microbes would need to be able to multi-task in a

“It’ll be like lowering a hair into a two-metre deep swimming pool, and then drilling three metres into the foundations”

Prof Damon Teagle, National Oceanography Centre, Southampton

similar fashion to this polyextremophile.

They would have to withstand extreme pressure and heat, while being on a permanent diet, surviving on virtually no nutrients. With 6km of rock pressing down, you’d think that pressure would be the biggest problem for life at this depth. But in fact, lots of microbes can survive at high pressures. Lab microbes have been found to endure a whopping 1,000 atmospheres, while microbes live perfectly happily under 11km of water at the bottom of the Mariana Trench – and can *only* grow at very high pressures.

A bigger problem is heat. But pressure actually comes in useful when dealing with extreme temperature, as it prevents water from boiling and producing lethal steam. With the hottest temperature any currently known lifeform can survive being 122°C, there’s hope extremophiles could survive in the Moho, where temperatures could be as low as 120°C.

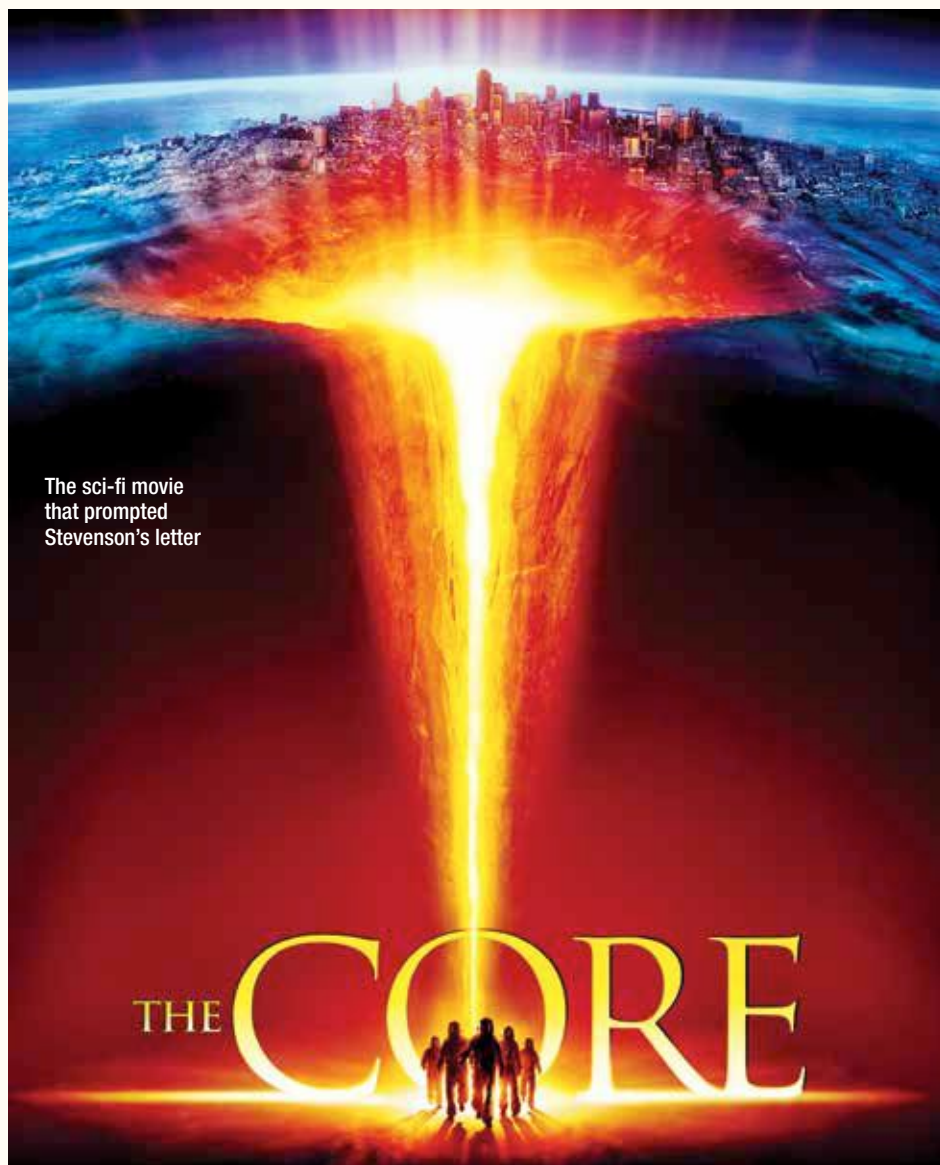
The biotic fringe

Assistant professor Matt Schrenk, from Michigan State University, studies the microbiology of serpentine rocks found on the seabed, similar to those that may be found at the Moho. “The attraction of this project is *not* the prospect of finding life in the mantle, but rather observing the transition between biotic and abiotic – habitable and uninhabitable. Mission Mohole may allow us to observe the ‘biotic fringe’ and understand the physiological limits to life.”

Despite high costs, Schrenk believes that exploring the region could bring benefits to our understanding. He thinks the biggest Moho challenge to extremophiles would be a lack of nutrients, as fluid circulation at that depth is minimal.

“There are so many basic science questions that need answering,” says Schrenk. “How deep is the biosphere? What is there? How related are these deep biosphere organisms to everything else on Earth? It’s as demanding to explore the ‘innerspace’ of our planet as it is to explore other planets.”

“The organisms found may be evolutionarily distinct and retain clues to the ancient Earth, or conduct unique activities and possess unique enzymes that may be of use in biomedicine. And quantifying the extent and activities of the deep biosphere, and its interactions with deep carbon, may be important to finding alternative energy technologies, as



The sci-fi movie that prompted Stevenson's letter

KNOW THE DRILL

Oceanic crust may be a lot thinner than continental crust, but drilling into it presents a whole list of problems...

Drilling on the sea bed is no easy feat. To counteract the rise and fall of the swelling ocean, a system called 'dynamic positioning' is used. Sonar is bounced off six submerged buoys, and the data is fed back to the operations room, which controls the propellers that serve to keep the ship in position.

At the drill site on the sea floor is a cone, with sediment packed around to hold it in place. A large steel tube called 'surface casing' is fitted inside, from which a second layer of casing can be hung. The casing prevents the hole from collapsing inwards. Inside the casing is a drill pipe with an uber-hard drill bit at the end.

In such challenging conditions, all sorts of things can go wrong, from the hole collapsing in

on itself to the drill pipe getting stuck in the hole. And even if nothing goes wrong, the drill bit will simply grind itself down over prolonged use, so it needs replacing regularly.

JOIDES Resolution is the world's most successful research ship to date. As part of the International Ocean Discovery Program (IODP) it's drilled down to the gabbros layer at one of the potential drill sites for Mission Mohole.

New ship on the block, Chikyu, is a step up in terms of technology – it has what's known as a riser system. This works by lubricating mud being pumped down into the borehole, and flushing out chips of rock and other debris from inside. What's needed now is for a 4,000m riser to be developed that could bore even deeper into our planet.

well as strategies to combat global warming."

Core conundrum

Mission Mohole hopes to strike mantle gold sometime in the next decade. The IODP team is currently trying to get the cash together to carry out site surveys, so that there are no big surprises in store, such as large faults running through the rock at depth. Since the recession, getting funding for ambitious science projects has become even harder. The biggest expense will be the cost of running a drill ship – the research vessel Chikyu, which is lined up to carry out the drilling, costs around US\$500,000 a day to run (see left).

While the project waits for funding, there's time to fine-tune the technology needed to drill 5km below the seabed while hovering over one spot as the sea swells and ebbs. "It'll be like lowering a thin hair into a two-metre deep swimming pool, and then drilling three metres into the foundations," says Teagle.

Professor Julian Pearce from Cardiff University knows a thing or two about how tough it is to drill at sea. He's currently onboard another research ship, JOIDES Resolution, which has drilled to a depth of just over 2km. "It's more difficult than drilling on land because the drilling platform can move up and down. So it's not possible to drill 'hard rocks' by diamond coring – the method used to drill deep boreholes on the land. This results in less material being removed and shallower, less stable holes. If you were to drill to the Moho, the deeper you go, the more difficult it is because of increased temperature and reduced hole stability."

So the big question is – if Stevenson's idea of sending an unmanned probe to the core isn't viable, could we ever *drill* to the centre of the Earth? "Getting more than 2,000m into the ocean crust has proved hard enough!" says Teagle. "So 3,000km into the Earth is beyond reality."

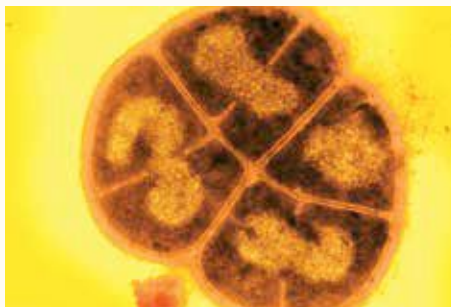
Pearce agrees: "Not a hope, I'm afraid! The drill bit and pipe would melt, and it wouldn't be possible to keep a hole that deep stable and vertical."

Sadly, we'll have to leave that mission to the centre of the Earth to Jules Verne's Professor Von Hardwigg. ☐

The Chikyu deep-sea research vessel



Geomicrobiologist Matt Schrenk is keen to search for microbial life around the Moho boundary

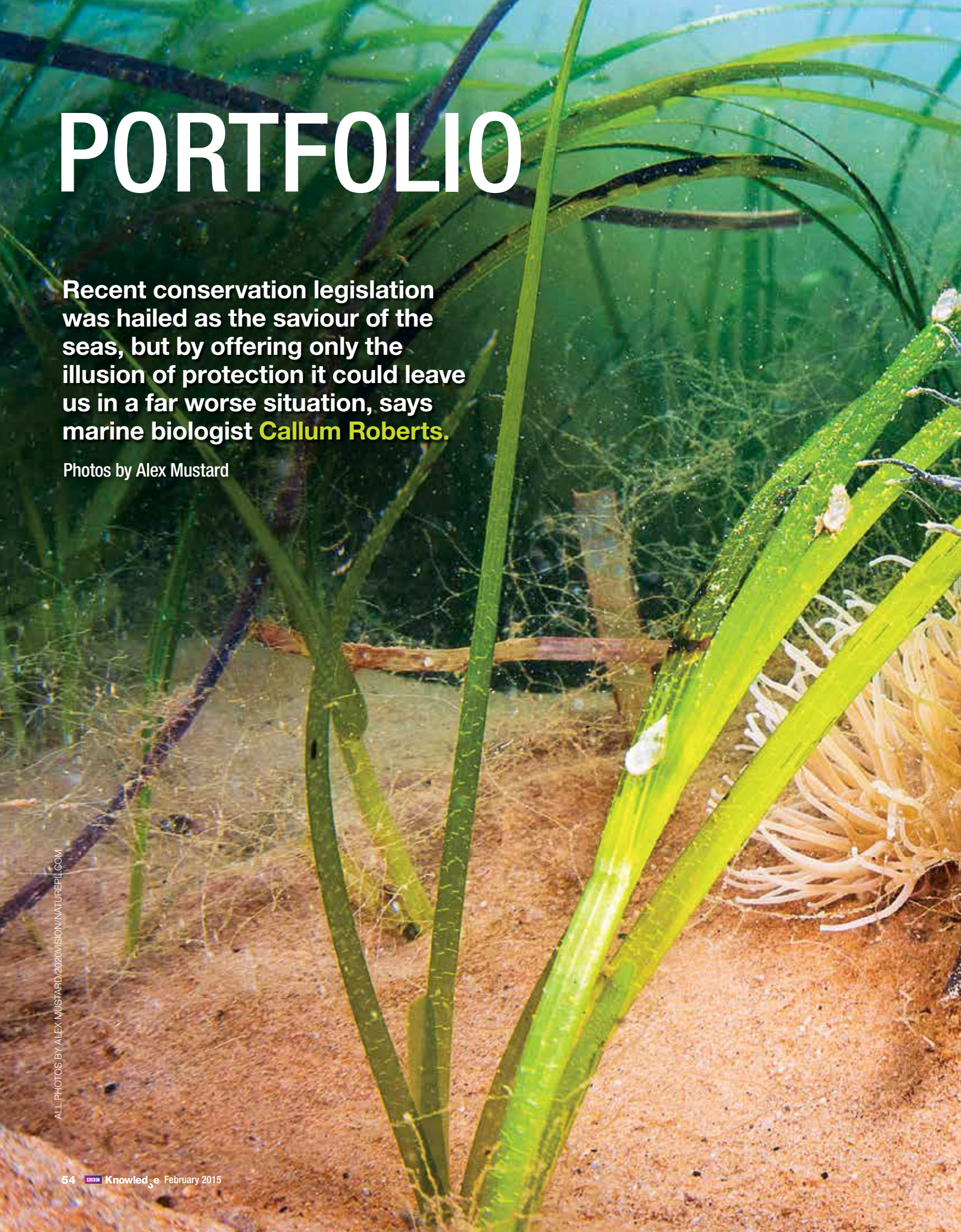


Deinococcus radiodurans is one of the most resilient extremophile life forms known to us today



Jheni Osman is a science writer whose books include *100 Ideas That Changed The World*.

PORTFOLIO

An underwater photograph showing a dense thicket of seagrass. The blades are long, narrow, and green, with some showing signs of wear or damage. A prominent white, irregular patch, likely a biofouling organism, is visible on one of the blades in the foreground. The background is filled with more seagrass and some brown, fibrous material, possibly dead or decaying vegetation. The water is clear, and the lighting is bright, suggesting a shallow depth.

Recent conservation legislation was hailed as the saviour of the seas, but by offering only the illusion of protection it could leave us in a far worse situation, says marine biologist **Callum Roberts**.

Photos by Alex Mustard

ALL PHOTOS BY ALEX MUSTARD/2020VISION/NATUREPI.COM

THE LONE HORSE

This long-snouted seahorse was photographed in Studland Bay, Dorset. Eelgrass beds like this are home to a huge variety of fish and invertebrates, but are easily damaged by anchoring, coastal development, fishing and pollution. Several Marine Conservation Zones contain eelgrass, but high levels of protection are needed to safeguard their extraordinary life.



STRONGER TOGETHER

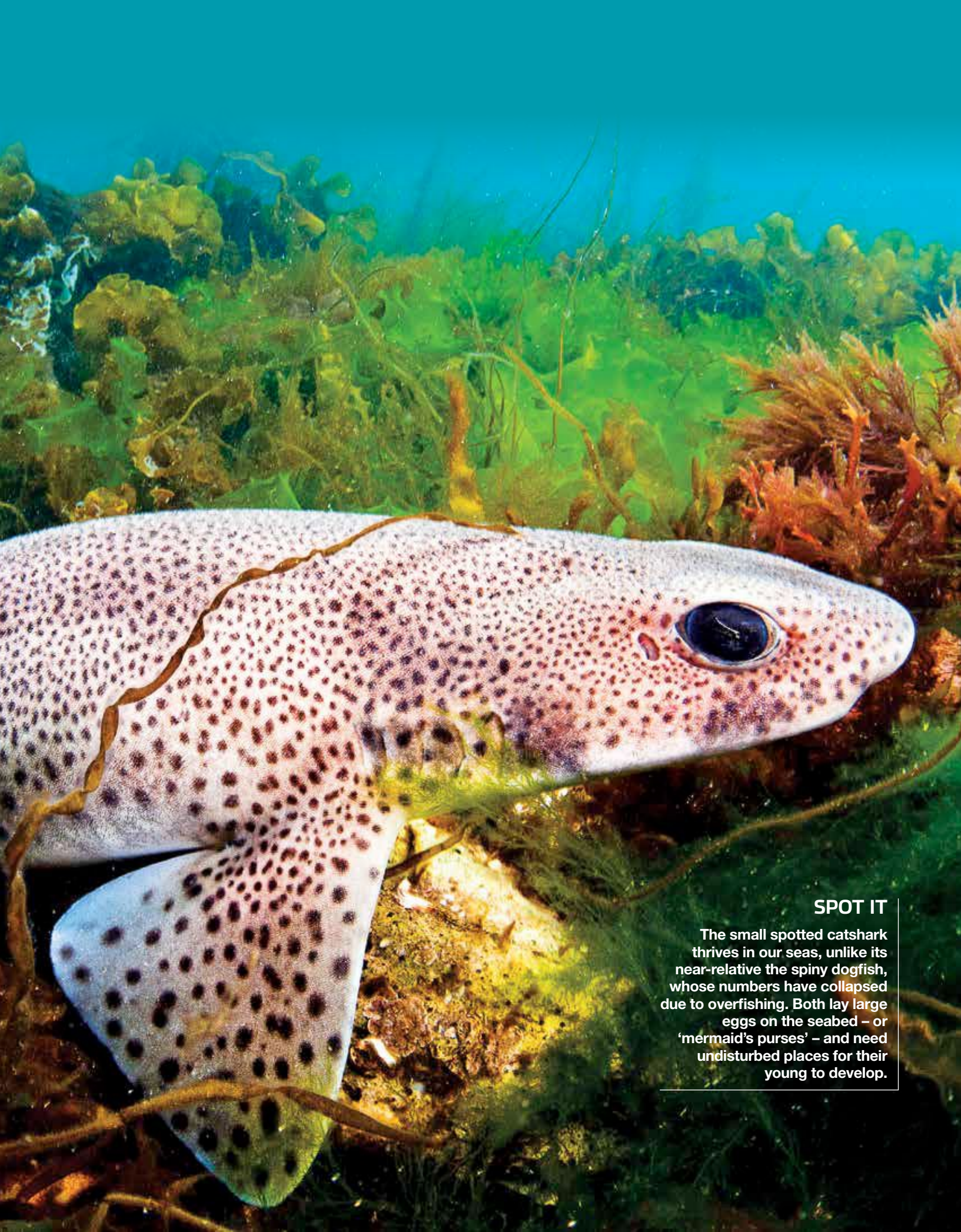
Young spider crabs gather together, behaviour that is thought to be a defensive strategy. But life is safer for the species now because many of its most enthusiastic predators have been fished to scarcity.



JEWELLED FEATHER

Sea pens filter drifting food from the water. This one has found refuge in Scotland's Loch Duich where trawls and dredges are banned. Marine Conservation Zones could restore such species, but only if protected from mobile fishing gear.





SPOT IT

The small spotted catshark thrives in our seas, unlike its near-relative the spiny dogfish, whose numbers have collapsed due to overfishing. Both lay large eggs on the seabed – or ‘mermaid’s purses’ – and need undisturbed places for their young to develop.





CLAWED SCAVENGER

A hermit crab picks detritus from the bed of Loch Long, Argyll and Bute. The crustaceans' catholic tastes make them highly successful scavengers and they readily take fish guts and bycatch discarded by fishermen, or pick over areas of seabed raked by trawls.

▼ JUST KEEP SWIMMING

A tiny amphipod *Iphimedia obesa* crawls through a forest of polyps on a colony of the coral deadman's fingers *Alcyonium digitatum* in Loch Carron, Ross and Cromarty. Cold-water corals like this thrive in places that are too steep, rugged or tide-swept to be reached by trawl or dredge-fishing techniques. Like eelgrass, they suffered heavily from the 19th-Century expansion of trawling, often clogging nets when new areas of seabed were fished for the first time.



◀ "OUT OF MY WAY"

These common cuttlefish communicate through a dermal semaphore of flashing colours and tiger stripes. They prefer rugged seabed where they lay their eggs amid weeds, sponges and coral. They are spreading north as the sea warms due to our changing climate.



WATER BENEATH MY WINGS

Above A puffin 'flies' underwater in the Farne Islands, Northumberland. Breeding is highly dependent on sand-eel numbers. At one time sand-eels were caught to fuel Danish power stations, but thankfully such wasteful use of a precious resource has now been abandoned.

▼ JUST A PEEK

Grey seals have prospered since persecution ceased in the 1970s, so much so that fishermen now complain that they are competing with them for fish. Better management of fisheries and Marine Conservation Zones would produce more fish for people and seals alike.



THE LOCATION

These photographs were taken in a range of locations around the UK including Loch Carron (1), Loch Duich (2) and Loch Long (3) in Scotland; the Farne Islands in Northumberland (4); Studland Bay (5) and Burton Bradstock (6) in Dorset; and Babbacombe Bay in Devon (7). The images show the wide variety of species affected by our impact on the ocean's diverse habitats.



THE PHOTOGRAPHER

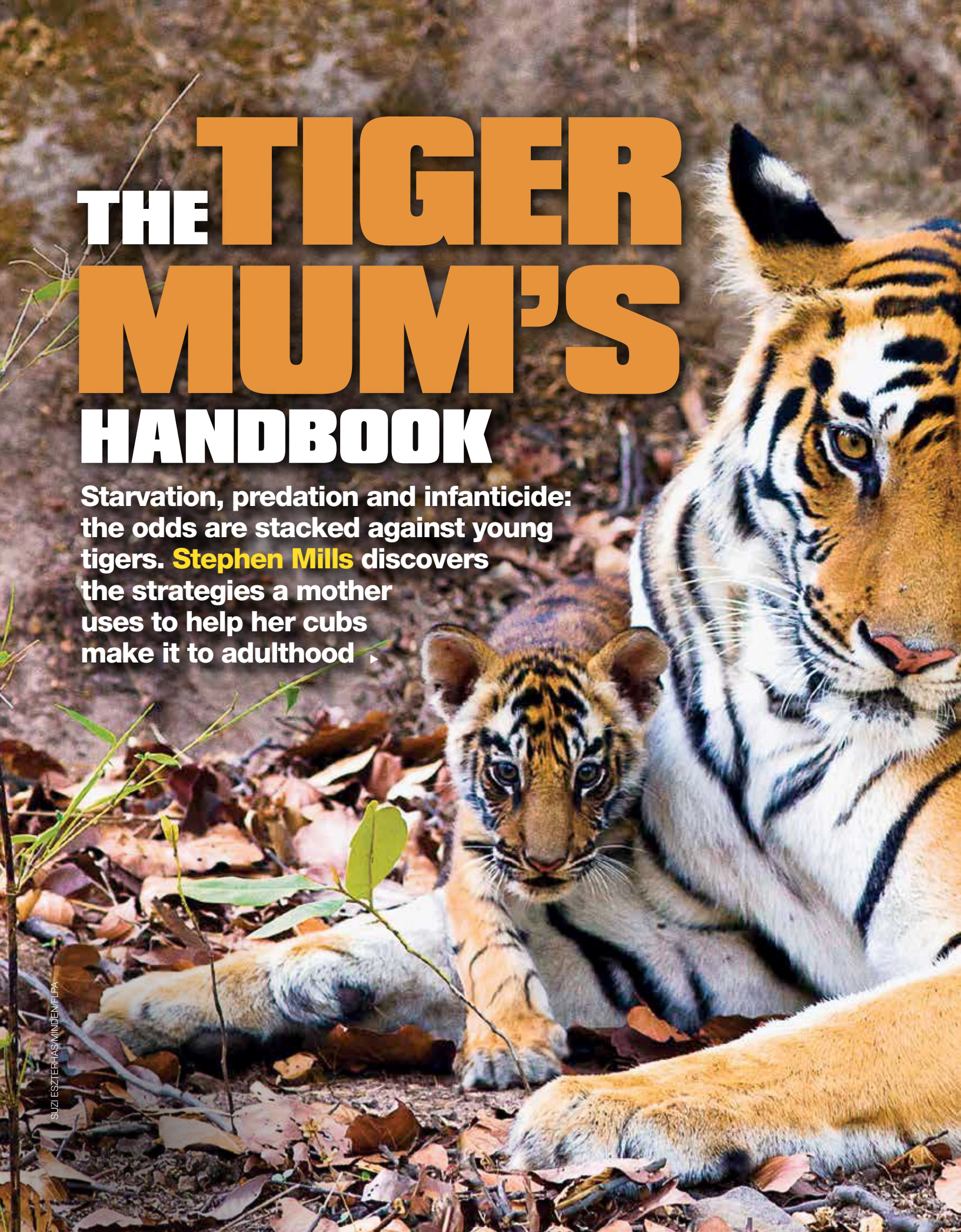


Alex Mustard

Alex is a multi-award-winning photographer and marine biologist who is known for pioneering new techniques. He runs courses and writes for a range of magazines, but here shares some of his favourite images from photography around the UK. You can see more of his work at www.amustard.com

THE TIGER MUM'S HANDBOOK

Starvation, predation and infanticide: the odds are stacked against young tigers. **Stephen Mills** discovers the strategies a mother uses to help her cubs make it to adulthood ▶



A photograph of a tiger mother resting on the ground, surrounded by dry leaves. Two small tiger cubs are perched on her back, using her as a climbing frame. The mother tiger is lying down, looking towards the left. The cubs are standing on her back, one slightly behind the other, both looking towards the left. The background is a natural, rocky, and leafy environment.

A pair of eight-week-old cubs use their mother as a climbing frame as she rests at her lair in India's Bandhavgarh National Park. They will soon join her on brief expeditions away from the den

Madhya Pradesh, India's jungle state: a sunbeam probes between the oval leaves of the sal trees, almost parallel to the strong, straight trunks, catching at last the white spots on the ears of a tiger cub. Nothing moves. Nothing will move again for this baby tiger. The little face peering up from the jungle floor is all that is left of it. Last night a stranger, an alien male tiger, rampaged into its life and ended it.

Such incidents are commonplace in the tiger's world. But, given that according to the International Union for Conservation of Nature there may be as few as 3,000 tigers left in the wild, how can this infanticide possibly be a useful survival strategy? How frequently does it occur, and what are the other threats that young tigers face in their struggle towards adulthood?

At birth, a baby tiger typically weighs just 900g (the known range is 785g–1.6kg). By contrast, the average birthweight for human babies is about

3kg. And, while the human will grow to 25 times its birthweight, the tiger will reach 200 times its original mass. At birth, the tiger cub's ears and eyes are sealed, and it can scarcely move. Its chances of surviving its first year are not much better than 50:50. In fact, its only real asset in life is its mother.

At birth a tiger cub is tiny, its eyes and ears sealed, its chances of surviving the first year just 50:50

A mother tiger is a formidable force of nature. Her protein-rich milk will quadruple the cub's weight within its first month. After two months it will be strong enough to move with her; after six the cub will be 35 times heavier than it was at birth.

A tigress is capable of prodigious

feats of strength, most often displayed when moving a large kill to a secluded place where her cubs can feed safely. Chuck McDougal, who studied the tigers of Chitwan in Nepal for many years, recorded a tigress dragging most of a huge sambar deer over 1km into dense scrub, and another that heaved a buffalo she had killed up a sheer precipice before hauling it several hundred metres into a ravine.

If her cubs survive, a mother will still be doing most of the hunting for them even when they are 18 months old. Until the cubs' canines develop fully, at about 14 months, they are incapable of holding and killing prey. Even then, it will be many more months before they are proficient hunters – and by then they will be as big as their mother.

Ideal homes

The quality of a tigress's home range – how much prey it holds, how amenable the landscape is to hunting – and how skilfully she exploits its



A tiger cub nuzzles its mother, the well-known female known as Noor (T39), in Ranthambore National Park. Females raise their cubs with no input from fathers

features are key factors in the success of her family's life. Her choice of birthing den, for instance, is of vital importance. Whether it's a cave, a hollow tree-bole, a dense grassy tunnel or a deep tangle of bamboo, it must be protected from disturbance, bush fires and flash floods, and defensible against leopards and other predators.

If it's available, a tigress may choose the den in which she herself was born. In the forests of Bandhavgarh, for example, one idyllic cave – cooled by the pools of a permanent stream and fronted by a shingly threshold – has been passed down from mother to daughter for generations.

Essential to a good birthing den is a plentiful supply of prey nearby. For the first two months of the cubs' lives, while the tigress is feeding them solely with her milk, she will be tied to the area – hardly ever hunting farther than 1km from the den. After this most critical period, the cubs follow her as she hunts ever more widely through her range. At six months they are weaned, and – if they survive – they will gradually disperse at about 20 months old, or when her next litter is born.

It's a big 'if'. However efficient the tigress, she cannot transcend the limits prescribed by evolution – limits making young tiger cubs extremely vulnerable to all sorts of threats.

Evolution is like a cost-benefit exercise. It has spawned two broad strategies for many mammals, depending on whether they are destined to kill or be killed – predators or prey.

If you're in the latter category – a deer, antelope, goat or another even-toed ungulate, perhaps – then you produce large, precocious babies, necessitating long pregnancies. The encumbrance of a hefty belly does not interfere with your daily feeding regime since you don't have to chase after grass and leaves to catch them, and the slightly increased risk of being caught while pregnant is far outweighed by the benefit of producing babies that can feed themselves and run away from predators almost as soon as they are born.



If you are a killer, the opposite is true. You cannot hunt if you're burdened by huge foetuses. You risk losing condition and aborting the pregnancy. Better to give birth quickly to the smallest possible young and rely on your own prowess to defend them. You offset this risk by the benefit of a brief gestation – on average for a tigress, just 103 days – enabling you to replace the litter promptly if you lose it.

Many litters are lost. If small tiger cubs are discovered by other carnivores such as leopards, striped hyenas or dholes (wild dogs) while their mother is away, they have no defence. They are also too weak to evade fire or flood. People may kill them, too, even though tigresses can be remarkably restrained in their treatment of human trespassers.

Another threat is disease. Little is known about the susceptibility of

▲ The Ranthambore female Noor (T39) carries her cub. The young start to accompany her on short forays at two months old, but struggle to keep up with her.

▼ A female watches her 17-month-old cubs feast on a sambar deer.



A tigress in Bandhavgarh performs a Flehmen response, tasting the air for the scent of a male – a potential mate or threat

tigers to disease in the wild, but new research suggests that canine distemper virus (CDV) is top of the list of infections afflicting the big cats.

In addition, starvation is an ever-present threat to tiger cubs, particularly in regions where prey becomes seasonally scarce, or where it is widely dispersed – as in the Russian Far East, home of the Amur subspecies. Meanwhile, poaching of deer and other tiger prey deprives the cats of food; conservationists suggest that this is actually a bigger problem than the poaching of tigers themselves. Tiger cubs are dependent on their mothers for such a long period that going hungry is perhaps the biggest killer of all.

But the ultimate threat, the one that attracts the goriest headlines, is infanticide: cubs being killed by a male of their own species. Infanticide can occur when the father of the cubs has died or been chased away, or even if he is merely inattentive. A new male may, if he gets the chance, kill cubs in the hope of mating with their mother. Normally she would not be receptive until her cubs were fully grown, but if the cubs die she comes into oestrus almost straightaway.

Is the situation the same elsewhere? Possibly – though, given the difficulties in observing wild tigers, we can't be certain. Dale Miquelle, director of

8 TOP PLACES TO SEE TIGERS IN INDIA

When Project Tiger – the conservation scheme administered by the National Tiger Conservation Authority – was launched in India in April 1973 it established nine Tiger Reserves. Now there are 47 across the country, with varying levels of access and infrastructure for visitors. These are eight of the most rewarding to explore.

1 BANDHAVGARH NATIONAL PARK

This former hunting forest of the Maharajas of Rewa in Madhya Pradesh is blessed with hills and steep escarpments, making it one of the most beautiful reserves. Porous rocks store monsoon rains, ensuring year-round water – great for tigers. High visitor numbers have to an extent habituated the tigers to jeeps and disturbance, and the prime range, 105km² of sal forest and grassland around Tala Village, is a top area for sightings.

2 KANHA NATIONAL PARK

When Kanha was established, 26 villages were relocated, leaving wide meadows among the grand forests of sal. Famous for its rare dry-land swamp deer, Kanha also hosts other large prey such as gaur and plentiful sambar to support one of the biggest tiger populations in India.

3 TADODA NATIONAL PARK

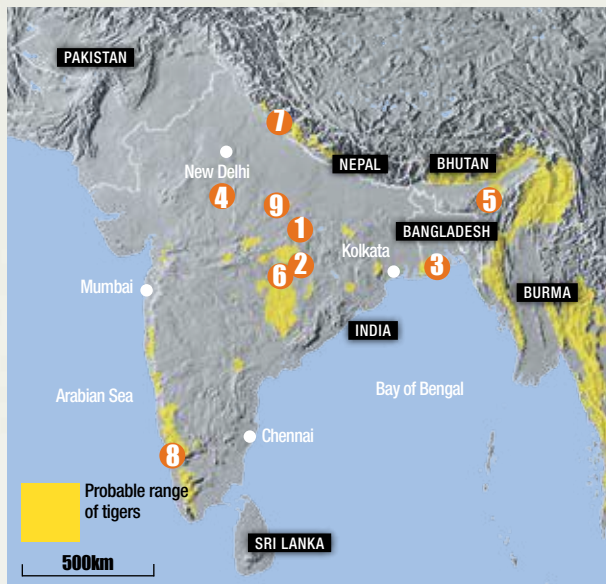
A lesser-known reserve in Maharashtra, Tadoba has limited accommodation and a tarmac road through its centre. Nevertheless tiger encounters have been excellent in recent years, together with regular sightings of dhole, sloth bear and leopard.

4 RANTHAMBORE NATIONAL PARK

Proximity to Delhi can give this reserve the feel of a tourist trap. But its lakes and



With ancient temples and plentiful water, Bandhavgarh is among India's most attractive tiger reserves



red-coloured fort, immortalised in films and books, provide a picturesque backdrop to sightings. Despite incidents of heavy poaching, this lovely patch of Rajasthan still has visible tigers.

5 KAZIRANGA NATIONAL PARK

The vast grasslands and riverine forests of Kaziranga lie in the floodplains of the Brahmaputra in Assam. It holds one of the highest-density tiger populations in the world but, with so much cover, the cats can be hard to spot. Kaziranga is also the stronghold of the greater one-horned rhinoceros, and has good numbers of Indian elephants.

6 PENCH NATIONAL PARK

This reserve in western Madhya Pradesh is only two hours' drive from the large city of Nagpur, so gets busy at weekends, and the visitor experience is over-managed. But the large reservoir at its heart means there is always water and always a chance of seeing tigers and other predators. The BBC made the series *Tiger – Spy in the Jungle* here with a remote-controlled 'log-cam'.

7 CORBETT NATIONAL PARK

Project Tiger was officially launched in Corbett, in what is now Uttarakhand state in the foothills of the Himalaya. With its surrounding forests Corbett still holds probably India's second-biggest tiger population. Though its limited network of forest tracks means sightings are infrequent, Corbett's varied landscape holds Indian elephants and is superb for birdwatching.

8 NAGARAHOLE NATIONAL PARK

Part of the larger Nilgiri Biosphere Reserve, this national park in Karnataka in the foothills of the Western Ghats mostly comprises moist and dry deciduous forests. Visit for sightings of tiger, leopard, otter and Indian elephant.

the Wildlife Conservation Society's Russia Program, reports that in Sikhote-Alin Reserve, the largest reserve in the Amur tiger's range, just one case of infanticide has been documented in the past 20 years. "This one was quite dramatic: the male ate the cubs, which were about six months old, then died – apparently from wounds incurred while fighting with the cubs' mother, or possibly another male in the area."

We currently interpret this behaviour according to the selfish gene theory, which elevates the interests of an individual's gene package over those of the wider species. It does not necessarily seek to ensure the survival of the fittest – only the survival of those particular genes carried by that particular male.

The kids aren't alright

To the female, infanticide represents a massive loss of genetic and nutritional investment. So how, from an evolutionary point of view, can this be 'fair'? The answer lies in what David Smith calls the 'land-tenure' system. He was one of the lead scientists of the long-term Smithsonian Tiger Ecology Project in Chitwan National Park, Nepal.

It's no exaggeration to claim that modern tiger research dates from December 1974, when the Smithsonian team radio-collared its first tiger. The researchers went on to collar dozens more, and discovered a fascinating phenomenon. Tigresses living 'next door' to each other, just 10km apart, were all related – mothers, daughters, aunts and nieces – much like lionesses in a highly dispersed pride.

A daughter would probably be

Conservationists suggest that poaching of deer and other tiger prey is a bigger problem than poaching of tigers



A mother tussles with her 18-month-old cub – a sign that she is ready for her offspring to disperse and establish their own territories

able to land-grab remote parts of her mother's range when they became temporarily unoccupied while the mother was tied to the core den area by a new litter. This ability to settle in a familiar landscape offers a huge survival advantage for females. Intimate knowledge of the lie of the land, of where and when prey is concentrated, and of how tracks, forest clearings and dry riverbeds connect to provide highways and stalking routes – these things can decide whether a predator eats or starves.

All this is denied to male tigers. They must travel far afield to convey their all-important gene package to strangers. Exiled from the familiar hunting grounds of home, the wandering males suffer three times the mortality rate of females of similar age.

The Smithsonian study found that, even if he makes it to the top, an adult male's average period of dominance is a mere 32 months. Furthermore his lifespan is several years shorter than that of a female. No wonder adult male tigers are in such a hurry to mate.

Indeed, the Smithsonian and subsequent studies have shown that mating is about the only thing on an adult male tiger's mind. He doesn't fight over food or notions of territory, but only for access to a female in oestrus. This even affects a male's attitude to hunting.

Raghu Chundawat's study of tigers in the dry forests of Panna National Park in Madhya Pradesh showed that adult tigresses were mostly cautious hunters, avoiding human landscapes and concentrating on natural prey

rather than cattle. Dominant males, on the other hand, always on the move between females, took their meals where they could – nearly 90 per cent of them from domestic livestock.

The selfish gene explanation may favour the opportune, the lucky or the sneaky, but that is not to say there is no role for the fittest. David Smith still inspires listeners with his memories of Tiger 105. Weighing over 225kg, this was the biggest tiger his team ever handled. Dominant for six years in the 1970s, Tiger 105 ranged over 120km², with exclusive access to seven different females. He sired 51 cubs, of which 27 survived to disperse. In the two years following his death there were frequent fights and infanticides, and only five cubs survived in the whole region. Tiger 105, fittest of all, ensured a productive era of stability for the females and he must have made a huge contribution to the gene profile of tigers in Chitwan today.

All this destruction of cubs and expensive production of males doomed to wander and mostly die in the name of sexual reproduction is very wasteful. At present, we can't be sure why this system has evolved. But we can only guess and hope that, somehow, the losses we rue – including that small cub in the sal forest of Madhya Pradesh – are helping to safeguard the genes, and future, of the species. 🟡



Stephen Mills is a writer and film-maker who has been watching and filming tigers for over 25 years. He also leads wildlife tours, and has visited India more than 40 times.

INFANTICIDE IN MAMMALS



This lion and lioness in the Maasai Mara are less than happy to see this cub

COMMON IN...

CARNIVORES

Infanticide has been recorded in leopards, jaguars and bears, but lions provide the best-studied example. Each pride is a community of related females and cubs. Male coalitions of two or three related lions compete for access to the pride; if successful, they defend all cubs born during their tenancy, regardless of paternity. But when a new coalition wins a takeover battle, infanticide often results. Mothers defend their cubs but if the cubs are killed they may eat the carcasses, minimising the nutritional loss.

PRIMATES

Infanticide by males hoping to accelerate access to females has been observed in more than 40 species of primate. Some female primates employ 'paternity confusion' – mating with several males, all of whom are likely to protect ensuing offspring as their own. This is particularly effective among species such as baboons in which numerous males may be attached to each troop.

SMALL MAMMALS

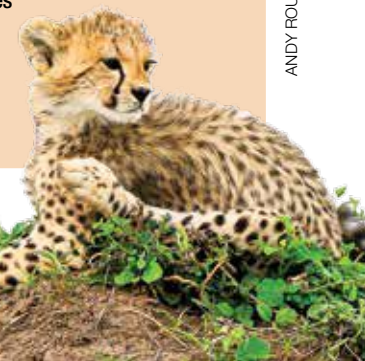
Male meerkats are not known to kill babies. Why would they? Females are ready to mate again as soon as they give birth. But female meerkats, living communally, kill the young even of close relatives to focus the group's efforts on raising their own babies. Young gerbils also kill babies but apparently stop once they have mated themselves. Some male mice are murderous when they have just mated, knowing that extant babies cannot yet be theirs. Female rats kill alien young, for food and to take over nests.

NOT SEEN IN...

CHEETAHS

DNA analysis in the Serengeti revealed that, of litters containing more than one cub, nearly half were sired by multiple males. It seems female cheetahs can ovulate 'to order', so different eggs can be fertilised by different males during a single oestrus. Males form long-lasting, fiercely territorial coalitions, only socialising with females during mating. Females have larger ranges, travelling through the territories of several males, so by 'habitual promiscuity' they may cut the risk of infanticide. Most cubs die anyway, killed by lions, hyenas, leopards or starvation.

A cheetah cub nurses for four months, but doesn't become independent till it is 18 months old.



THE WORLD'S

Our noses can distinguish over a trillion different smells. But what are the most pungent pong? **David Busse** and **Lauren Hoskin** investigate...



THE 'CORPSE FLOWER' INDONESIA

The titan arum plant, *Amorphophallus titanum*, is indigenous to rainforests in Sumatra, Indonesia. It has a humongous 3m-tall (10ft) flower that kicks up an almighty stink when it blooms. Fortunately for those living in the immediate vicinity, titan arum can go for many years without flowering.

The smell of rotting flesh is due to a mixture of sulphur-containing compounds (pungent cheese), trimethylamine (rotting fish) and isovaleric acid (sweaty socks). This repugnant stench is thought to attract pollinating insects such as 'flesh flies' and carrion beetles.



THE DURIAN MALAYSIA



Some describe the durian as the 'king of fruits', but many are put off by its stink, which has been likened to rotting onions, faeces and gym socks. The fruit, native to Malaysia but

now common across southeast Asia, owes its smell to 44 compounds such as methanethiol (rotten cabbage) and ethanethiol (onion). Three of these had previously never been known in nature until researchers analysed the durian.



CENTURY EGG CHINA

This unusual Chinese delicacy consists of an egg preserved for several weeks or even months in a mixture of clay, ash, salt, quicklime and rice hulls. The alkaline preservatives raise the pH of the egg, breaking down many of its proteins and fats.

The result is a grey-green yolk suspended in a dark brown white that reeks of ammonia and hydrogen sulphide – substances whose smell is described, unsurprisingly, as that of 'rotten eggs'.



THE ZORILLA CENTRAL AND SUB-SAHARAN AFRICA

Also known as the Cape polecat or African skunk, this furry fiend produces a nasty stench from its backside that can be readily detected up to half a mile away.

Much like the better-known American skunk, the zorilla has anal glands that release a blend of chemicals to defend against predators by temporarily blinding them. Sulphur-containing compounds make up a large part of these eye-watering fumes – hence the stink.

WORST SMELLS



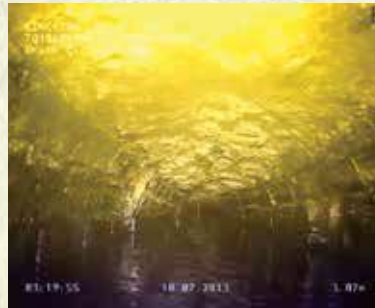
VIEUX BOULOGNE FRANCE

In 2004, scientists labelled Vieux Boulogne the smelliest cheese on the planet after a panel of judges and an 'electronic nose' rated the olfactory strength of 15 cheeses. This pongy fromage even beat Époisses de Bourgogne, another cheese so pungent it's banned on local buses. The rind of the cheese is washed in beer, and the aroma comes from the beer's bacteria reacting with the enzymes in the cheese.



THE FATBERG UK

In 2013, sewer workers removed a 15-tonne ball of fat lodged in London's pipes. "It's a heaving, sick-smelling, rotting mass of filth and faeces. It's gross," said a Thames Water spokesperson. The fatberg, a bus-sized toxic mix of congealed fat, oil, nappies and faeces, took three weeks to clear.



SULPHUR CITY NEW ZEALAND

Rotorua, a city in northern New Zealand, has acquired the nickname of 'Sulphur City' due to its geothermal activity and subsequent aroma. Large numbers of geysers and thermal springs in the nearby countryside pump hydrogen sulphide into the air, resulting in the fragrance of rotten eggs. Since almost 70,000 people live there, though, it would seem that the residents get used to it.



THE STINKBIRD SOUTH AMERICA

Also known as *Opisthocomus hoazin*, this bird from the Amazon Delta is so stinky it is only hunted by humans in dire need. The stinkbird owes its manure-like stench to an aromatic diet of leaves and its unique digestive system, which uses bacterial fermentation to break down food. Its food fermentation chamber is so enlarged to accommodate decomposing plants and stinky gases that its flight muscles and sternum are reduced, making it a weak and clumsy flyer.



SURSTRÖMMING SWEDEN

This Swedish delicacy is made by fermenting raw herring for at least six months. The process relies on the production of lactic acid bacteria and an enzyme in the spine of the fish to convert sugars into acids and alcohols. Species of the bacteria *Haloanaerobium* help ripen the fish, giving it a sour taste, but also cause the production of hydrogen sulphide and butyric acid.



SEAL ISLAND SOUTH AFRICA

Seal Island, a tiny landmass measuring just 50x800m and lying 5.7km off the coast of South Africa, is home to over 60,000 Cape fur seals living in close proximity, and the decomposing fish and putrid faeces of their tight living quarters combine to make a colossal stench. The stink of decaying fish arises when an odourless chemical called trimethylamine oxide in the fish's flesh is exposed to air and broken down by bacteria. This produces trimethylamine, which has a reeking, ammonia-like odour that is found in abundance on Seal Island.



A pictorial representation
of Brahma - the Creator
of the Universe according
to Hindu mythology



ORIGINS OF Hinduism

Indologist **Michel Danino** traces the roots of one of the world's oldest religions - Hinduism

Searching for the origins of Hinduism is a bit like exploring a thick forest: there are so many paths and trails that it is difficult to decide which ones matter. Perhaps that is because Hinduism is itself something of a forest — a disorderly, unregulated, tangled growth. Judaism, Christianity and Islam look so neat in comparison: one god, one founder, one book. Hinduism has not just many gods, founders and books, but as many as you like; in fact, you are free to keep adding to them. You may, if you wish, start worshipping a new god (how about a god of exams, say, Pariksheshwara?) or write a new Upanishad, though you may have to wait for a few centuries for it to be accepted as such.

Defining Hinduism, in the first place, is a challenge, and we have as many definitions as we have scholars. In 'The

Harappan Legacy' (BBC Knowledge, April 2012) archaeologists have agreed to see in the Indus civilization (2600–1900 BCE) some of the roots of Hinduism: tree worship, figures in yogic postures (and the well-known 'Priest-King' in contemplation), symbols like the *swastika*, the *linga* and the *trishula*, three-faced gods, fire altars, sacred proportions and much more. It bears repetition that John Marshall, who directed excavations at Mohenjo-daro, asserted in 1931, 'Taken as a whole, [the Harappan] religion is so characteristically Indian as hardly to be distinguished from still living Hinduism.'

The Early Texts

We must turn to the early texts for its conceptual framework, starting with the *Vedas*, especially the oldest of the four, the *Rig-Veda*. While its date remains ►



unsettled, its 1,028 hymns, which have been faithfully memorised and orally transmitted by generations of students and teachers to the present day, are invocations to gods and goddesses, such as Indra, Agni, Mitra or Sarasvati.

Certain fundamental concepts do emerge clearly from the *Rig-Veda*, especially its insistence on a single divine essence taking many names and forms: “The Existent is One, but sages express It variously; they say Indra, Varuna, Mitra, Agni ...” (1.164.46). These powers, ultimately, are mere aspects of ‘That One’ (*tad ekam*), or ‘that truth’ (*tat satyam*).

Absent from the *Vedas*, however, are notions like *dharma*, *karma* and rebirth, which is what makes the Vedic religion rather different from the Hinduism we know: Hinduism reveres the *Vedas* and claims them as its source, but in practice has little use for them, beyond including some of their mantras in rituals and ceremonies. A few centuries after the *Vedas* were composed, the concepts of *dharma* and rebirth emerged in the Upanishads, texts which also gave expression to the central spiritual principles of Hinduism in a philosophical language: they taught that all is the divine (“you are That”, *tat tvam asi*) and that the microcosm (our small individual scale) and the macrocosm (the cosmos) are essentially correlated, implying that everything in this universe is symbolic. Our body, for instance, is made of the same five elements — earth, water, fire, wind, ether — as the universe, and while its head corresponds to the higher worlds, its feet symbolise the earth. And there are at least five beings in us: the material, the emotional, the mental, the spiritual and the highest self.

These are no mere abstractions, since they are the foundations of Ayurveda and orient the actual treatment of this ancient Indian system of medicine. They also gave rise to many systems of yoga, which ultimately aim at union with our spiritual or divine essence.

Popular Hinduism

Like all religions, Hinduism operated at other levels, those of popular literature, art, worship and ritual.

Popular literature was taken care of by vast collection of heroic or mythological stories (often conveyed by many encyclopaedic texts known as the *Puranas*), legends, parables and ballads. The

best-known examples are of course India’s two great epics, the *Ramayana* and the *Mahabharata*, which travelled to every nook and corner of the subcontinent through countless retellings, translations, and adaptations. The two epics fulfilled several functions: they gave everyone — king or subject, husband or wife, guru or student — role models to be followed. They provided a readily accessible teaching on the intricacies of *dharma*. And they contributed greatly to the land’s cultural unification.

The Borders of Hinduism

While its non-dogmatic and amorphous nature, its apparent polytheism, its refusal to limit itself to one founder and one book, were often criticised or even ridiculed by nineteenth-century Indologists, in practice those features encouraged a plethora of cults, sects, modes of worship, and of course deities. In its long-standing (and, in fact, on-going) interaction with rural and tribal communities, Hinduism generously exchanged deities, rituals and cults. Gods like Jagannath, Ganesha, Narasimha and many aspects of the mother goddess have tribal origins; on the other hand, rural and tribal communities often accepted ‘mainstream’ gods, such as Shiva or Rama, rishis like Agastya, or heroes such as the five Pandava brothers of the *Mahabharata*.

This symbiosis is what has been so disconcerting to many students of Indian religions: on the one hand, a mainstream Hinduism based on texts like the *Upanishads*, the *Bhagavad-Gita* or the *Puranas* and sometimes called *sanatana dharma* or the ‘eternal law’, which has produced manifold teachings and methods of self-exploration and self-realisation; on the other, a popular Hinduism which may appear to be little more than a loose fusion of regional cultures, customs and traditions, absorbing more of them from successive waves of invaders, and yet somehow managed to build up an identity of its own, contributing to the creation of a united and yet multicultural India where spiritual and religious freedom was always highly valued. ☐



Michel Danino has been living in India since 1977. He is a guest professor at IIT Gandhinagar. His recent titles are *The Lost River: On the Trail of the Sarasvati* (Penguin India, 2010) and *Indian Culture and India's Future* (DK Printworld, 2011).

Important Gods of Hinduism

TRIMURTI



Brahma – The Creator

Legend has it that Brahma was born from Vishnu's navel.



Vishnu – The Preserver

He is said to take birth in the form of various avatars to return cosmic order in the Universe. His tenth and final avatar is called Kalki.



Shiva – The Destroyer

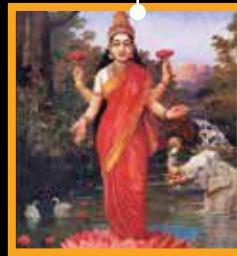
Represents the force of destruction and austerity. His third eye, if opened can destroy the world.

TRIDEVI



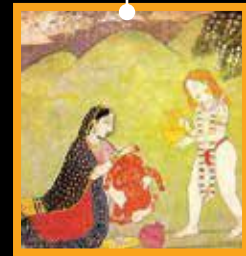
Saraswati – The Goddess of Knowledge, Arts & Music

According to Hindu mythology, she is credited with the invention of writing.



Lakshmi – The Goddess of Wealth

When the Gods were in exile, Lakshmi hid in the ocean. During the churning of the ocean, Lakshmi was reborn and became Vishnu's consort.



Parvati – The Goddess of Strength

Shiva's consort, she is the reincarnated form of Sati, his first wife. She is the source of all powers and weapons.

POPULAR DEITIES



Indra – God of Rain

He is described in the texts as having a thousand eyes.



Varuna – God of Ocean & all Waters

Sits on a throne of diamonds watching over demons arising from the waters.



Vayu – God of Wind/Air

Is the father of Lord Hanuman (through Anjana) and of Bhima (through Kunti).



Yama – God of Death

Legend has it that Yama was the first mortal to die.



Surya – Sun God

The Sun temple in Konark Orissa is built in his honour.



Chandra – Moon God

He is the father of planet Mercury and is said to be descended from Varuna.



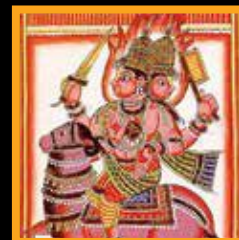
Nataraja – Lord of Dance

An avatar of Shiva, he performs the dance of destruction to destroy an unbalanced Universe.



Prithvi – Goddess of Earth

One of the avatars of the Goddess is that of a white cow. She is also a mother to Indra and Agni.



Agni – God of Fire

He is Indra's twin brother and is the messenger between Gods and mortals.



Kamadeva – God of Pleasure

Kamadeva was reduced to ashes by Shiva, as he interrupted Shiva's meditation.

HOW DO WE KNOW?

HOW TO MAKE X-RAY IMAGES

It was a relatively fast road from the discovery of X-rays to them being put to use in hospitals; their remarkable properties were quickly harnessed by doctors and were a catalyst for ever more advanced scanning technologies

History is littered with examples of discoveries made by accident, but as Louis Pasteur said more than a century ago, “Chance favours only the prepared mind.” When the German scientist Wilhelm Röntgen accidentally found X-rays in 1895, he knew to pursue them. Röntgen wasn’t the first to observe the effects of X-rays, but he is widely credited with their discovery. The Crookes, or cathode ray tube he was experimenting with was common at the time in the labs of physicists interested in how electric charges passed through gases. It had been invented by the English physicist William Crookes in 1875, and it’s likely that some Crookes tubes had been emanating X-rays prior to Röntgen’s discovery. Crookes himself, for example, found that photographic plates placed near the tubes became cloudy – later recognised as an effect of being exposed to X-rays.

Röntgen first noticed X-rays on 8 November 1895, having only been using a Crookes tube for a month. It’s thought that he was investigating cathode rays with the tube (see ‘The key experiment’, p76) when he noticed a screen in the room fluorescing. He realised this must have been caused by a new phenomenon, which he called ‘X’-rays in recognition of their mysterious nature.

It’s not clear why Röntgen pursued X-rays where others hadn’t, but he was known for

his meticulous experimentation. He cast aside his other work and locked himself away for six weeks to investigate the new rays. He found that they could pass through a variety of materials, such as books and paper, but not others, such as lead. A few days before Christmas that year, he made an image of his wife Bertha’s left hand by placing it between the X-ray source and a photographic plate.



Taken in 1895, this X-ray image shows a wedding ring on the left hand of Wilhelm Röntgen's wife Bertha

The image, complete with visible bones and wedding ring, was probably not the first X-ray image, but it may well be the first to have been made deliberately.

Harnessing x-rays

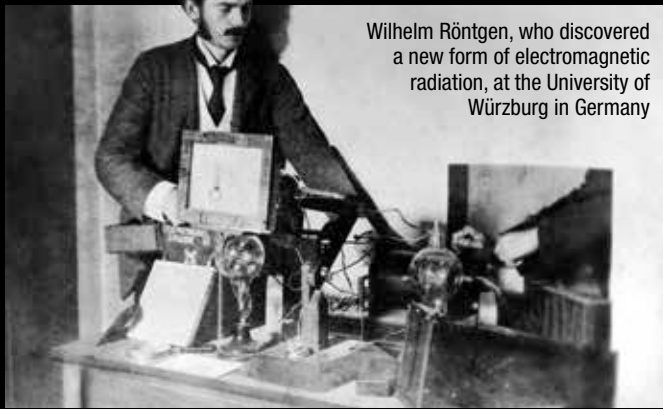
We now know that X-rays are a form of electromagnetic radiation, on the same spectrum as visible and ultraviolet light. They are generated when electrons from the cathode in the X-ray tube collide with the anode – around 1 per cent of the energy generated is emitted as X-rays. While visible light is absorbed by the body, higher frequency X-rays can pass through us. Different materials absorb different amounts of X-rays. Dense material like bone absorbs more, which is why they show up so well in X-ray images. That’s because the film in the shadow of the bones is less exposed to the radiation.

To produce an X-ray image, you need a source of X-rays and a way of capturing the image. In 1913 the US physicist William Coolidge, who was working for General Electric, was inspired by the work of a colleague to develop the first hot-cathode X-ray tubes, where the cathode from which the electrons originate takes the form of a heated filament. This led to a more reliable and focused source of X-rays, and the tube was boxed in with lead, shielding everyone

An X-ray image reveals the structure of the spine; the technology is crucial when it comes to assessing damage to bones

< **IN A NUTSHELL**

From the chance discovery of a strange radiation being emitted in a laboratory to realising its unique properties and finally putting it to medical use, harnessing the power of X-rays has transformed medicine over the last century.



Wilhelm Röntgen, who discovered a new form of electromagnetic radiation, at the University of Würzburg in Germany

THE KEY EXPERIMENT

Wilhelm Röntgen was the first to realise that something else is emitted by a Crookes tube other than cathode rays, a discovery that would transform medicine in the years to come

Röntgen had been studying electricity and gases for a month when he unwittingly performed his key experiment. He was using a Crookes tube to generate streams of electrons called cathode rays. The Crookes tube contained a small amount of gas with an electrode at either end. When a voltage was applied, electrons were released from the negatively charged electrode (the cathode) and directed towards the positively charged anode.

In the darkened room was a screen painted with barium platinocyanide, which releases light (fluoresces) when exposed to

electromagnetic radiation. He had covered the Crookes tube in black cardboard so that visible light would not interfere with his observations. From the corner of his eye he saw a faint glow from the screen, something invisible was emerging from the tube and making it fluoresce. The screen was further away than the distance that cathode rays were known to travel, and the effect was still there when he placed books between the tube and screen. Later, it is thought that when he placed his hand between the tube and the screen, he saw the ghostly image of his fleshless bones.

NEED TO KNOW

Cathode ray / Crookes tube:

A glass tube that has had most of the air removed. The tube has both a negatively charged (cathode) and positively charged electrode (anode). When a voltage is applied, electrons are released from the cathode, and X-rays are generated when they hit the anode.

Computed tomography:

A computer-based technique in which images of slices of the body or brain are captured one at a time and then processed to produce a clear image. The sections can

be digitally stitched together to produce a three-dimensional image.

Fluoroscopy: An imaging technique which uses X-rays and fluorescence to capture moving images of the inside of the body in real-time — the video to standard X-ray imaging's still photographs.

X-ray: A form of electromagnetic radiation with a higher energy and shorter wavelength than visible light. X-rays can pass through materials that visible light cannot, and so are good for medical imaging.

but the patient from the rays. Versions of the Coolidge tube design are still used today.

Glass photographic plates painted with a light-sensitive mixture were used to capture images until 1918, when radiographic film was introduced by the Eastman Kodak company. Today, film has been replaced by digital detectors.

Clinical practice

The first X-ray department, the New Electrical Pavilion at Glasgow Royal Infirmary, was established in 1896 or 1897, and X-ray images soon became part of everyday clinical practice. Around the same time, a French doctor called Antoine Bécclère opened an X-ray department in Paris and coined the term 'radiology'. He is credited with introducing equipment such as lead screens, aprons and gloves for people taking X-ray images.

While early X-rays were useful to surgeons looking to remove foreign bodies or tumours, organs were harder to analyse. Even as techniques improved, soft tissue visualisation proved a challenge. This was addressed by the use of contrast agents — liquids that are opaque to X-rays and therefore make whichever organ they are in show up. In 1906 Bécclère pioneered imaging of the digestive tract with the 'barium meal'. It was barium sulphate mixed with water and swallowed to outline the oesophagus and stomach, which he used to diagnose a child's appendicitis. It is still used today to visualise blockages and tumours. Later, iodine-based contrast mediums were developed for the imaging of the circulatory system and the kidneys.

In parallel with traditional X-ray imaging, fluoroscopy was developed. This technique uses the same principle as X-ray imaging but instead of producing still images, doctors can see inside the body in real-time. The earliest fluoroscopes, produced in the months after Röntgen's discovery,

were funnel-shaped. The user would look through a gap in the thinnest end, and the wider end was covered with a thin piece of cardboard painted with a metal salt called barium platinocyanide, which fluoresces when X-rays hit it. The patient was placed between an X-ray source and the fluoroscope, and the user was able to see an image of them on the cardboard.

Inventor Thomas Edison produced the first commercial fluoroscope in the early 1900s, in which the barium platinocyanide had been replaced with calcium tungstate, which fluoresces more brightly. Today fluoroscopy is used to guide surgery in real-time — in pinning broken bones, for example.

Computer power

Computers have revolutionised many areas of healthcare, and this is no less true for X-ray imaging. In 1967 the British engineer Godfrey Hounsfield invented 'computed tomography' (CT or sometimes CAT) scanning — essentially a computerised version of Vallebona's tomography. CT scanning takes far more detailed pictures than conventional X-rays, and these are processed by a computer before they're used for diagnosis. Crucially, the series of two-dimensional slices that CT scanning produces can also be digitally stitched together to create a 3D image.

He tested his prototype scanner on a preserved human brain, animal brains (ferried across London on public transport) and later himself. In 1971, the first clinical CT scan of a patient with a suspected brain tumour took place, and the scanner was introduced into hospitals from 1972. A full-body scanner became available in 1975. The X-ray has come a long way, and despite newer imaging techniques being developed, it seems there'll be a place for successors to current x-rays images for a while yet. 📍

Designed by Godfrey Hounsfield, this brain scanner was the first production model and went into service in 1971. It established computed tomography (CT) as a key imaging technology



CAST OF CHARACTERS

The minds that turned a harmful form of radiation into a life-saving medical technology

1832-1919



▲ **William Crookes** was a British researcher and later spiritualist who worked in physics and chemistry. Inventor of the Crookes tube, he was an early investigator of cathode rays.

1845-1923

▼ **Wilhelm Röntgen** discovered X-rays in 1895. The German physicist won the Nobel prize for his discovery in 1901. He died of a carcinoma, not believed to be related to his work, and all his papers were burned upon his death.



1856-1939



▲ **Antoine Bécère** was a French doctor and researcher who had already established himself in the field of immunology when he became fascinated with X-rays. He pioneered the use of barium for imaging the digestive tract and is credited with both naming and professionalising the field of radiology.

1873-1975

▼ **William Coolidge** is best known for his work carried out at the General Electric Research Laboratories. The American physicist invented the much-improved X-ray 'Coolidge tube' and made important contributions to light bulb technology.



1919-2004



▲ **Godfrey Hounsfield** was a British electrical engineer who produced the first CT scanner for routine use in hospitals in 1972 when he worked at EMI. He won the Nobel Prize in 1979, and spent some of his prize money on a home laboratory.

TIMELINE

Being able to peer inside the body revolutionised medicine, and took just under a hundred years to develop

1895

Wilhelm Röntgen discovers X-rays while experimenting with cathode ray tubes. Within weeks of publication, scientists and the public alike are excited by the possibilities.



1900



Thomas Edison invents the first commercial fluoroscope, a device with which one can view the inside of the body in real-time.

1906

French immunologist-turned-radiologist Antoine Bécère uses a contrast agent for the first time, giving a young girl a barium meal to diagnose her appendicitis using X-rays.



1913

General Electric's William Coolidge invents the hot-cathode X-ray tube, improving the reliability and safety of X-ray sources.

1918



Kodak introduces radiographic film, replacing photosensitive glass plates.

1971

Godfrey Hounsfield's prototype CT scanner is used on a patient for the first time and reveals that the 41-year-old woman has a brain tumour.



Katherine Nightingale is a science writer with a degree in molecular biology.

HISTORICAL HOLIDAYS: GUIDEBOOKS FROM THE PAST

Seville 1670

In the latest instalment of our historical holidays series, in which experts imagine they're writing a travel guide in the past, **Brendan Sainsbury** proposes a visit to a mighty port city groaning with the riches of New World exploitation

Rich with the spoils of Spain's American empire, Seville is one of the most cosmopolitan cities in Europe. But wealth is unequally distributed, the once-great river port is silting up, and thieves, floods and public executions can turn the streets into dangerous obstacle courses.

When to go

The best time to visit is when a transatlantic fleet is in port. The weighty Veracruz and Cartagena convoys meet up in Havana and normally arrive in Seville in early September, although larger vessels are increasingly docking in the deeper waters of Cádiz.

Heaving with exotic cargo from the New World, the ships pull into Seville's Arenal quarter where the whole city gathers to celebrate. Expect music, commerce, gossip, festivities and a diverse multitude of people. It is a truly incredible spectacle.

What to Take With You

A wide-brimmed hat is essential to mitigate the debilitating effects of the strong Spanish sun. Gentlemen are also advised to pack a good pair of stout boots. Although Seville experiences very little rainfall, the Guadalquivir river regularly bursts its banks, an event that turns the streets into muddy and barely navigable quagmires.

Costs and Money

Spain's finances are weak, and wild fluctuations in food prices can be triggered by natural disasters such as flooding. Many locals rely on charitable handouts.

The Spanish currency is the much-sought-after escudo. Gold escudo coins come in several denominations and are used only by the wealthy. The wider populace uses silver reales.

Sights and Activities

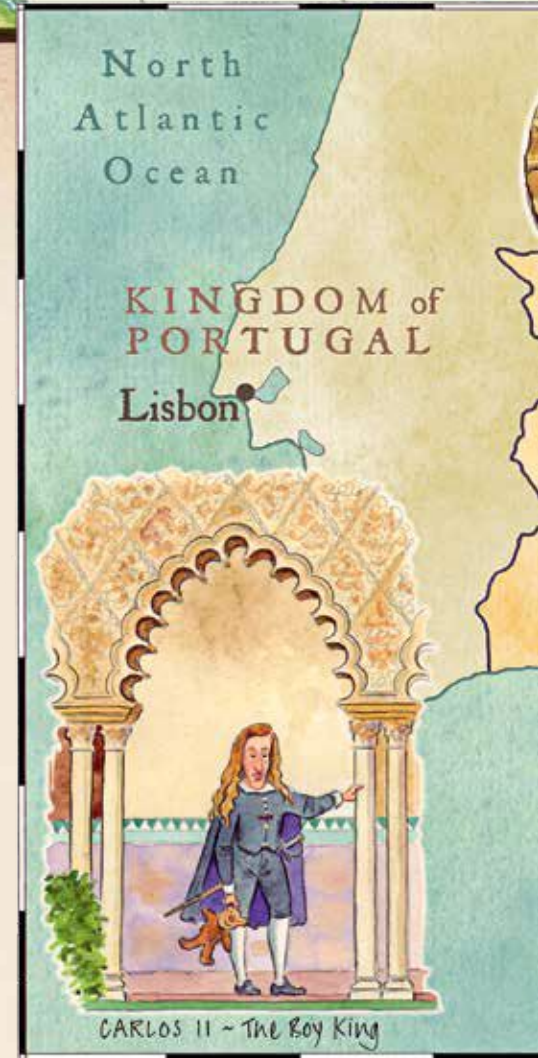
Any visit should start in Seville Cathedral, a magnificent Gothic structure originally conceived in 1401 but still busy with sculptors, architects and artists adding embellishments to its ornate interior.

Unless you're a visiting Habsburg, it's unlikely you'll be invited inside the Alcázar (royal palace) where the boy king, Carlos II, often lodges, but you can admire its unusual Mudéjar architecture from the outside.

The golden age of Sevillian art shows no sign of abating. The mantle of the late master Velázquez has passed to another Sevillano artist, Bartolomé Murillo. Señor Murillo has been busy since the 1650s, opening an art academy to nurture new talent, and working on a brilliant canvas of Saint Anthony inside Seville Cathedral. With luck you may get to admire his latest project, a series of six paintings on the subject of 'Mercy', in the recently inaugurated Iglesia de la Caridad.

Dangers and Annoyances

The gulf between rich and poor is



huge. The back streets, particularly around the port, teem with vagabonds, thieves and rogues known as pícaros.

Refrain from commenting on matters of religion. The Inquisition Court, based since 1481 in Seville's Castillo de San Jorge, is not known for its religious tolerance; *autos-da-fé* (public penances) are sometimes meted out. Avoid public executions, especially burnings at the stake, when an unpleasant mob mentality takes over.

Prepare to flee the city should you hear any reports of infectious disease.

“Strange foodstuffs are offloaded from ships freshly arrived from the new world”



Seville today

Though no longer wealthy in colonial spoils, Seville remains one of the world's great treasures. The Andalusian capital is bathed in sunshine and rich in historical highlights. Two of the city's stand-outs – the **cathedral** and mighty **Alcázar** – are, if anything, even more impressive than they were in 1670 when they towered over the city; they're especially eye-catching at night, when they are illuminated. In the summer, the great palace hosts nocturnal concerts.

But you can still be entranced by Seville having seen neither of these places. Simply walk the streets of the medieval judería (Jewish quarter), today the **Barrio de Santa Cruz**, and take in the atmosphere of the tiny lanes and flower-strewn plazas.

Seville also has a lovely waterfront, busy shopping centre and, of course, the parades and parties of **Semana Santa** (Holy Week). The stalls and socialising of the **Feria de Abril** make that another excellent time to be in town. You could do as locals did in 1670 and flock to **El Rinconcillo**, then the newest bar in town, today the oldest – but still as much fun.

If you like this...

For another Andalusian gem, head to the old city of **Cádiz**, thought to be the oldest continuously inhabited settlement in Europe.

The last plague to hit Seville, in 1649, wiped out a large proportion of the city's population – an estimated 60,000 citizens.

Entertainment

Seville's Roma inhabit the rambunctious Triana quarter on the less-desirable side of the Guadalquivir. Their esoteric folk music involves much yodelling, foot-stamping and clapping of hands. The curious and brave can cross the city's wobbly pontoon bridge to seek it out.

Drinking

The fine local wine is much sought after, especially by the British who refer to it as 'sherris sack'. Rumour has it that Francis Drake made off with several thousand barrels of the stuff when he 'singd the King of Spain's beard' at Cádiz in 1587.

Seville's newest bar, El Rinconcillo, opened earlier this year and is causing quite a stir. Inside, one can barely move

for the crowds. Regulars are confident it has staying power.

Eating

Strange foodstuffs are offloaded quayside from ships freshly arrived from the New World. Visitors are advised to view them with suspicion. The small red fruit that the Spanish call a tomate is sometimes eaten in restaurants, but is more commonly used as a table decoration. So-called chilli peppers are best left to monks, who grow them in their monasteries as scientific curiosities. Safer for European palates are excellent local dry-cured hams and fresh seafood.

Getting Around

Hire a horse. Andalusian horses are, without question, the noblest and most elegant mounts in the world. 🐾

Brendan Sainsbury has written *Lonely Planet* country guides to Cuba, Italy, Spain, the US, Peru and Mexico.



The Alcázar is even more impressive than it was in 1670

EDU TALK

Geeta Ramanujam, co-founder of Kathalaya – House of Stories, in an interview with **Moshita Prajapati**, extols the virtues of storytelling as an effective educative learning tool



Why did you focus on oral storytelling as a tool for learning?

You see there is a kind of energy that one transmits when you directly address children with words, and that is of emotions.

The main reason why I started Kathalaya in 1998 was to revive an interest for children and teachers in lessons and concepts in subjects, which were being taught in a monotonous manner. When I was a teacher (I would teach the subjects of History and English), I would tell my students a story related to that day's lesson plan. I would then stop halfway and they would ask, "What happened next?" My reply was to tell them to turn to page 34 and read further to know what happened next in the story. For children, to start a book maybe boring, but if you give them a prod, they would continue to finish reading the book.

How beneficial is storytelling in the learning process?

What we do at Kathalaya is that our lesson plan is drawn on two aspects; language development of listening, reading and writing and the second

I think if we can help students unlearn it would be lovely

one is the oral tradition of listening, retelling and recalling. 10 years ago we introduced storytelling into the curriculum of schools in Bangalore and we conducted a study in four of those schools - Kumaran Children's Home, Sishu Graha Montessori School, Mahatma Montessori School and the Valley School. We divided the students into two groups; one where one batch of students were taught through the method of storytelling and others weren't. We found that the children listening to stories learnt better and were able to apply wisdom and common sense to their course work. And more importantly, they were interested in reading more upon the subject/concept. Whereas those who were taught via rote method just scored the necessary marks in

the subjects and moved on ahead.

Did you face any hurdles whilst implementing your learning plan?

I still face challenges. Despite years of telling stories to children, it is still looked upon as a childish thing. When you tell them about story telling, the first thing school administrators ask is – "Oh so you are going to do puppetry? Are you going to use masks, enact and do drama?" The thing is we have fixed notions. Acting out stories is the most primitive form in which you tell a story as it is. You don't have to raise your voice. It just involves speaking to the student. So I have had to break down barriers people had about storytelling and tell them the focus of storytelling is – it is a spoken word and a spoken word when spoken well does not require props to make a child listen.

At a TED Talk event, you said that the current Indian education system lacks perceiving power and wisdom. What made you say that?

Wisdom is a bridge between learning and knowledge. What happens is we are not able to perceive because learning now has become very rote. We are bombarding our students with information from all sides and I believe they are not able to handle and decipher all this information. See learning should be applicable for life. So if there is learning or education, which does not help one manage their own lives then what is the point in learning itself. So the wisdom to perceive is missing.

What according to you is good education?

I think practical learning, which is pedagogically sound is good education. Just because a man lands on Mars we don't have to increase the syllabus for children in schools. Why do we have to bring telescopes and study of science for students who are four-years-old. They don't need to know so much. What they need to know is to know how to comprehend it. I think that it is a great thing we need to equip them with rather than stuff with knowledge. I think if we can help students unlearn it would be lovely.

GAMES REVIEW

MIDDLE EARTH: SHADOW OF MORDOR



Middle Earth: Shadow of Mordor's frenetic combat and riveting storyline will keep players hooked

PC, ₹999; PS4, Xbox One, ₹3,499; PS3, Xbox 360, ₹2,999

If the battle sequences in director Peter Jackson's *The Lord of the Rings* movie series got your adrenaline pumping, **Middle Earth: Shadow of Mordor** will be a rush you've long dreamed about. Brisk, entertaining and gloriously referential, this Role Playing Game (RPG) proves that the best games are the ones that set out to deliver unadulterated fun.

Players assume the role of Talion, a Ranger who shares his body with the wraith of powerful, long dead Elf. This setup lays the foundation for two skill sets, with the Ranger's abilities improving speed and combat abilities and the wraith's skills furthering your character's mastery of magic and mind control. The story is rooted in the canon of Tolkien's massive legendarium, and is set between the events of the two most popular story arcs: *The Hobbit* and *The Lord of the Rings*. The look and feel of the game stays true to the Middle Earth fans know

and love, and players will often feel as if they are playing through scenes in one of Jackson's films.

The game borrows elements from other popular franchises as well, with free running that clearly has **Assassins Creed** inspirations and a combat system modelled heavily on the **Arkham** series of Batman games. What's new is the Nemesis System, wherein in-game opponents recognise and adapt their behaviour based on past encounters with the player. This keeps things fresh and dynamic as the game's AI keeps evolving.

Middle Earth: Shadow of Mordor makes no pretenses at being anything other than a notoriously enjoyable hack and slash game. The familiar setting and epic scale make it appealing to casual gamers as well, and it's Nemesis System gives you new avenues to explore every time you play. This is easily one of the best linear RPGs released this year, and definitely the best Lord of the Rings game to date.

GAMES PREVIEW

GTA goes next-gen

Fans of the **Grand Theft Auto** series have something to look forward to this holiday season as the Sony Playstation 4's GTA V Bundle will be made available in India. For ₹41,490 you can gift yourself the next-gen console as well as get the franchise's latest instalment, GTA V, in its most eye-popping avatar yet.



Lights, Camera, Action!

When March 11, 2016 was announced as the release date for the upcoming *Warcraft* movie, fans were overwrought with anticipation. Now, the announcement of the cast for the movie at Blizzcon 2014, the annual Blizzard Entertainment convention, has sent excitement levels soaring even higher. Let's see if the game's immense popularity translates into success at the cinema.



Win or die

The hugely popular *Game of Thrones* books and TV series is being brought to life by Telltale Games in their trademark episodic format. The series is made up of six playable episodes, each containing 90 – 120 minutes of gameplay. The game will see players control the fortune of a fledgling noble House in Westeros, as depicted in the books and TV show.



- Dushyant Shekhawat

PUZZLE PIT

Questions and challenges guaranteed to give your brain a workout

SEND IN YOUR
ENTRIES
AND
WIN EXCITING
PRIZES

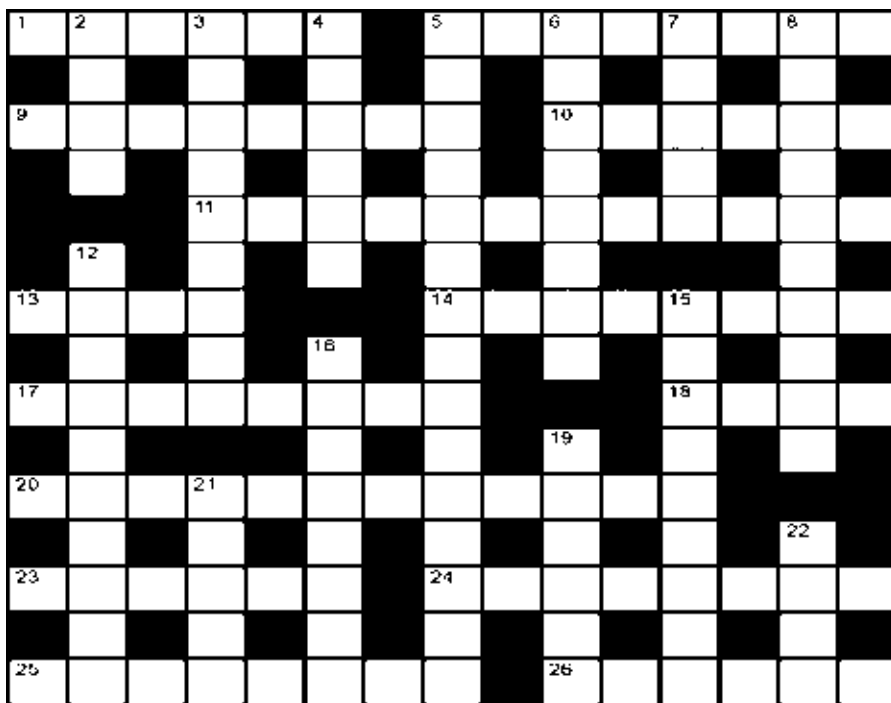
Crossword No.24

ACROSS

- 1 Oman's capital (6)
- 5 Most affable and gracious; most calm and collected (8)
- 9 Central Pacific republic (8)
- 10 The top of the mountain? (6)
- 11 Not now, some other time afterwards? (2,1,5,4)
- 13 Son of Lord Rama and Sita (4)
- 14 Staggered, swayed or tossed about (8)
- 17 What the employees do when they go on strike? (4,4)
- 18 Flat and regular (4)
- 20 ___ Day: August 15th for us (12)
- 23 Popular tourist destination in Himachal Pradesh (6)
- 24 Shivaji and his descendants? (8)
- 25 Capital of Finland (8)
- 26 Screamed or shouted (6)

DOWN

- 2 Exodus author Leon ___ (4)
- 3 Like a bull in a ___: like a person who causes damage in situations that require careful thinking (5,4)
- 4 With no exception? (2,1,3)
- 5 He recently became the first Indian badminton player to win a Super Series Premier Men's title (8,7)
- 6 Thinks highly of others' attributes (8)
- 7 Accused or identified (5)
- 8 Evade capture (4,3,3)
- 12 As a precaution? (4,2,4)
- 15 Fundamental or rudimentary (9)
- 16 An amusing performer (8)
- 19 Vigour, zeal or spirit (6)
- 21 In short, they may be written or oral? (5)
- 22 Wished? (4)



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.24 Worldwide Media, The Times of India Bldg, 4th floor, Dr Dadabhai Navroji Road, Mumbai 400001 or email bbcknowledge@wmm.co.in by **10 February 2015**. 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.



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.



COBREZDQKXFDL
KFLASKAREG TR
ZSNAEJPMBE GA
YTI YVEEXREGC
GJFP UNTSQMRTG
TCIJRGQATAWNU
C WZKHNUPNHRE
KPRAHWNEOYEUT
CFBOVESRPPETG
FLSJ FMRZLLAR
JQUPIGEONLASP
GJWGMCI EVCNC
ICSZ DALTGKBT

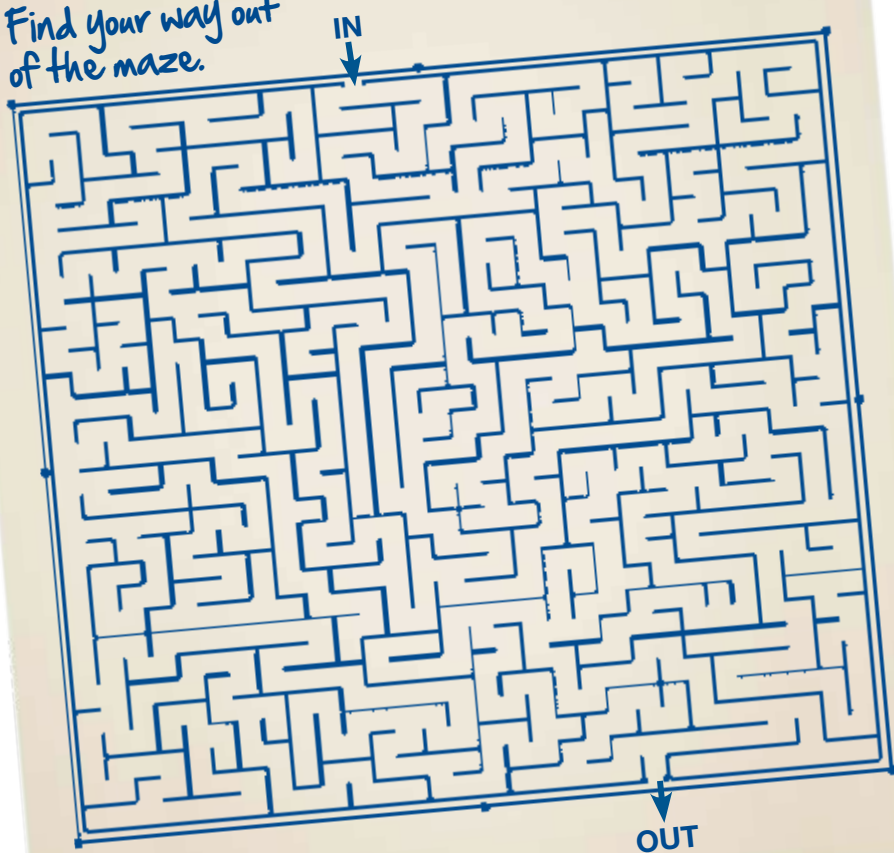


Q2 HEAD AND TAIL

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

Official witness	Notary	
Community book building		
A form of identification		
Bridge or rummy		
___ chance (poker, eg.)		
In the nick ___		
Interval, extent		period

Find your way out of the maze.



Q3 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.

LRTAI			*	*	
AIONN		*			*
AEMRYM			*		
EEFRUG				*	

The precision of ___ takes away from the uniqueness of seeing. - Pierre Bonnard (6)

MINDGAMES

Test your knowledge with our Big Quiz set by James Lloyd

- 1** A cave engraving found in Gibraltar may be the best evidence yet for Neanderthal art. What symbol does the etching resemble?
- a) A hashtag
 - b) A question mark
 - c) An asterisk

- 2** Complete the recent headline: '_____ -powered battery could charge your phone'
- a) Urine
 - b) Sweat
 - c) Saliva

- 3** Which fictional character was recently sent into space aboard a Japanese micro-satellite?
- a) Hello Kitty
 - b) Godzilla
 - c) Mario

- 4** This odd-looking critter is a baby aye-aye lemur being weighed at North Carolina's Duke Lemur Center. To which island are lemurs endemic?
- a) Mauritius
 - b) Majorca
 - c) Madagascar



This fella is endangered on its home island of...

- 5** According to psychologists at King's College London, what could predict a child's future intelligence?
- a) Their drawings
 - b) The length of their earlobes
 - c) Their parents' jobs

- 6** This otherworldly image is a close-up of which creepy-crawly?
- a) Bed bug
 - b) Human flea
 - c) Deer tick



- 7** Recent research at the University of Exeter has refuted what commonly held belief?
- a) That magpies steal shiny objects
 - b) That bulls are enraged by the colour red
 - c) That goldfish have a three-second memory

- 8** Astronomers have mapped the huge supercluster of galaxies to which the Milky Way belongs. They've dubbed it 'Laniakea', but what does this mean in Hawaiian?
- a) Exquisite sky
 - b) Celestial sphere
 - c) Immeasurable heaven

- 9** Computer scientists from Birmingham University have developed a robot capable of what?
- a) Polishing your car
 - b) Loading your dishwasher
 - c) Taking out your rubbish and sorting your recycling

- 10** Complete the recent headline: 'Spending less time _____ could be the key to living longer'
- a) Sitting down
 - b) Phoning friends
 - c) Watching TV

- 11** The world's last known passenger pigeon died 100 years ago. What was her name?
- a) Mabel
 - b) Maggie
 - c) Martha

- 12** Scientists have discovered the most complete giant sauropod dinosaur skeleton yet. Roughly how much did the *Dreadnoughtus* weigh?
- a) 20 tonnes
 - b) 40 tonnes
 - c) 60 tonnes

- 13** This snazzy Soviet dog spacesuit recently went up for auction. What was the name of the Soviet dog who in 1957 became the first animal to orbit Earth?
- a) Lisichka
 - b) Laika
 - c) Lenin

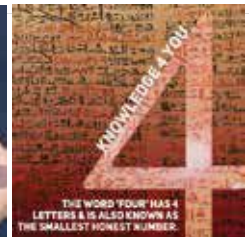
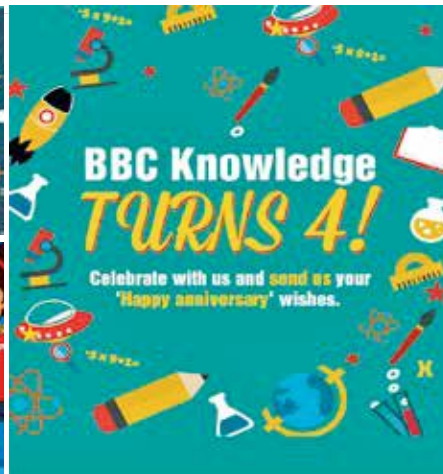


11c, 12c, 13b

4 Mindgames: 1a, 2b, 3a, 4c, 5a, 6b, 7a, 8c, 9b, 10a, 11c, 12c, 13b
Answer: The precision of naming takes away from the uniqueness of seeing. - Pierre Bonnard
03 Scramble: Words: trail/trail, anion, yammer, refuge
02 Head & Tail: Notary-public-library-card-game-of-time-period.

01 Picture Search: Bone, flask, Germany, grapes, harp, jeans, notepad, nutmeg, penguin, pigeon, plant, racquet, saturn, tiger, wheel, Wifi.

SOLUTIONS:



Knowledge Magazine India BBC Knowledge Turns 4!

In October 2014 BBC Knowledge completed four years and as part of our extended celebrations we ran a delightful campaign on our Facebook page. Designed around the number 4, the posts highlighted the importance of the number from the worlds of Science, History and Nature. Here is a peek at the celebration activities the many congratulatory messages from our fans. And a shout out of thanks to our readers for their wishes!

BBC Knowledge India retweeted



Piyusha Pilonia @piyusha13 · Oct 27

'Happy Anniversary' @KnowledgeMagIND best combination of fun & knowledge.



[View conversation](#)



Sarabjit Kaur Congrats on being 4 #BBC #KNOWLEDGE !!! Its great work from you all. Get to read amazing material designed by experts..awesome style..kudos!!

Like · Reply · October 28 at 1:35am



Children's Day Contest

On the occasion of Children's Day on 14 November, 2014, BBC Knowledge magazine, normally the purveyor of concrete facts, indulged in whimsical nostalgia as readers shared their most outlandish childhood beliefs on our social media platforms. Under the hashtag #SilliestChildhoodBeliefs, the contest had participants remembering the times when they thought the moon followed them around at night, and other equally quirky childhood superstitions. This contest led to some fun revelations, and brought back fond memories for the readers. Chandramani & Priyaforu were declared winners.

GADGETS

NEW GADGETS FOR THE NEW YEAR

THE MICRO 3D

Billed as the world's first truly consumer 3D printer, the Micro 3D aims to make 3D printing technology accessible and enjoyable for professionals and beginners alike! The trademarked Micro Motion Technology provides auto-levelling and auto-calibration for the printer head, ensuring precision on projects. Its simple cubed design houses Micro Filaments, special 3D printing material that can change colour in response to the environment.

Price: ₹21,577

• www.printm3d.com



POLAROID CUBE

While it may look tiny and cute, the Polaroid Cube camera packs a wallop. The 35mm cube is simple to look at and even simpler to use, with just one button on its exterior. This neat portable camera can record video, capture stills and boasts a 124 degree wide angle lens. The rubber-coated body is tough enough to withstand some rough handling and is also waterproof.

Price: ₹6,120

• www.polaroidcube.com



PHONEBLOKS

A modular cellphone that you can tailor exactly to your specifications, Phonebloks is an ingenious concept that allows users to upgrade their phone in increments, switching out component pieces (or Bloks) rather than replacing the entire handset. With strategic partnerships with Google and Motorola, Phonebloks seems ready to revolutionise the mobile industry! A launch date set for early 2015 will make this alternative to smart phones a viable option for users next year.

Price: TBA • www.phonebloks.com



IMPOSSIBLE BICYCLE

The portable bike just got a whole lot more portable. Developed by Beijing-based design team Impossible Technology, The Impossible is an electric bicycle compact enough to fit comfortably in a backpack. A disc motor powered by ten rechargeable batteries provides locomotion at speeds of up to 12.4 miles per hour. **Price: ₹26,585 • www.getimpossiblebike.com**



OCULUS RIFT

With the Oculus Rift headset, virtual reality will soon be an accessible entertainment option for mainstream audiences. The headset, with its equipped goggles replaces the TV screen. Low-latency head tracking technology allows the wearer to look around and fluidly explore the virtual environment. The Oculus Rift also immerses its user in stereoscopic 3D, making the gaming experience more interactive than it ever has been.

Price: ₹21,638 • www.oculus.com



HENDO HOVERBOARD

Hendo Hoverboard floats an inch above the surface of the ground, allowing the user to glide on thin air. Four hover engines on the bottom provide stability and propulsion, while its sleek design lends itself to aerodynamic performance. Skateboards beware, your days are numbered.

Price: ₹6,18,350 • www.hendohover.com



INSIDE THE PAGES

THIS MONTH'S READ

Fat and Thin

by Anton Chekhov

Two friends—one a fat man and the other a thin man—met at the Nikolaevsky station. The fat man had just dined in the station and his greasy lips shone like ripe cherries. He smelt of sherry and fleur d'orange. The thin man had just slipped out of the train and was laden with portmanteaus, bundles, and bandboxes. He smelt of ham and coffee grounds. A thin woman with a long chin, his wife, and a tall schoolboy with one eye screwed up came into view behind his back.

"Porfiry," cried the fat man on seeing the thin man. "Is it you? My dear fellow! How many summers, how many winters!"

"Holy saints!" cried the thin man in amazement. "Misha! The friend of my childhood! Where have you dropped from?"

The friends kissed each other three times, and gazed at each other with eyes full of tears. Both were agreeably astounded.

"My dear boy!" began the thin man after the kissing. "This is unexpected! This is a

Come, come! The fat man frowned. What's this tone for? You and I were friends as boys...

surprise! Come have a good look at me! Just as handsome as I used to be! Just as great a darling and a dandy! Good gracious me! Well, and how are you? Made your fortune? Married? I am married as you see. ... This is my wife Luise, her maiden name was Vantsenbach ... of the Lutheran persuasion. ... And this is my son Nafanail, a schoolboy in the third class. This is the friend of my childhood, Nafanya. We were boys at school together!"

Nafanail thought a little and took off his cap.

"We were boys at school together," the thin man went on. "Do you remember how they used to tease you? You were nicknamed Herostratus because you burned a hole in a schoolbook with a cigarette, and I was nicknamed Ephialtes because I was fond of telling tales. Ho-ho! ... we were children! ... Don't be shy, Nafanya. Go nearer to him.... And this is my wife, her maiden name was Vantsenbach, of the Lutheran persuasion...."

Nafanail thought a little and took refuge behind his father's back.

"Well, how are you doing my friend?" the fat man asked, looking enthusiastically at his friend. "Are you in the service? What grade have you reached?"

"I am, dear boy! I have been a collegiate assessor for the last two years and I have the Stanislav. The salary is poor, but that's no great matter! The wife gives music lessons, and I go in for carving wooden cigarette cases in a private way. Capital cigarette cases! I sell them for a rouble each. If any one takes

ten or more I make a reduction of course. We get along somehow. I served as a clerk, you know, and now I have been transferred here as a head clerk in the same department. I am going to serve here. And what about you? I bet you are a civil councillor by now? Eh?"

"No dear boy, go higher than that," said the fat man. "I have risen to privy councillor already ... I have two stars."

The thin man turned pale and rigid all at once, but soon his face twisted in all directions in the broadest smile; it seemed as though sparks were flashing from his face and eyes. He squirmed, he doubled together, crumpled up. ... His portmanteaus, bundles and cardboard boxes seemed to shrink and crumple up too. ... His wife's long chin grew longer still; Nafanail drew himself up to attention and fastened all the buttons of his uniform.

"Your Excellency, I ... delighted!"

The friend, one may say, of childhood and to have turned into such a great man! He-he!"

"Come, come!" the fat man frowned.

"What's this tone for? You and I were friends as boys, and there is no need of this official obsequiousness!"

"Merciful heavens, your Excellency! What are you saying ...?" sniggered the thin man, wriggling more than ever. "Your Excellency's gracious attention is like refreshing manna. ... This, your Excellency, is my son Nafanail, ... my wife Luise, a Lutheran in a certain sense."

The fat man was about to make some protest, but the face of the thin man wore an expression of such reverence, sugariness, and mawkish respectfulness that the privy councillor was sickened. He turned away from the thin man, giving him his hand at parting.

The thin man pressed three fingers, bowed his whole body and sniggered like a Chinaman: "He-he-he!" His wife smiled. Nafanail scraped with his foot and dropped his cap. All three were agreeably overwhelmed. ■



LITERARY SIDEKICKS WHO



WATSON – THE ADVENTURES OF SHERLOCK HOLMES

Sidekick to SHERLOCK HOLMES

Watson is a doctor, one of the few individuals who are not cowed down by Sherlock's overbearing personality. He is Sherlock's voice of reason, even if it means punching Sherlock to see the reason. He is the sounding board to the literary world's greatest detective.



SAMWISE GAMGEE – LORD OF THE RINGS (TRILOGY)

Sidekick to FRODO BAGGINS

Ridiculously loyal, this gardener became the unexpected hero when he accompanied his best friend from the Shire on the journey. Which other sidekick do you know of that have saved the skin of the main character so many times? His unwavering friendship is one of the main traits of the most epic journey traced in the books.



RONALD WEASLEY AND HERMIONE GRANGER – HARRY POTTER SERIES

Sidekick to HARRY POTTER

Calling them sidekicks seems a bit unfair considering they were strong characters in their own way – Hermione despite being a muggle born is a brilliant wizard and gets the trio out of all kinds of scraps, and Ron is courageous and loyal to the fault. These two are proof that sometimes friends just get better as the year goes by.



BESS MARVIN AND GEORGE FAYNE – NANCY DREW SERIES

Sidekick to NANCY DREW

Nancy's two friends are poles apart - Bess is the more feminine one amongst the three and George is a complete tomboy. Both help teenage detective Nancy see different points of view from the same story. They are willing to run around, follow villains, question suspects, look for clues and even bail Nancy out of jail because that's what friends do.



REGINALD JEEVES – JEEVES SERIES

Sidekick to BERTRAM WOOSTER

Jeeves is not just a butler. He is the screw that holds Bertie's life together. His unrivalled dexterity in extracting his master from every sticky situation, makes him a valuable companion to have by one's side. Bertie's neediness and cluelessness are matched by Jeeves's resourcefulness elevating their relationship to an iconic literary friendship.

QUESTION OF THE MONTH

Which is your favourite book and why?



In 2008, I had graduated from school and was applying for admission in professional courses for further studies, which would help me chart my career graph. I was disappointed as I hadn't heard a positive reply from any. It was during this period, I happened to read *Wings of Fire* by Dr Abdul Kalam. I came upon a part in the book whilst reading where he writes his unsuccessful attempt to join the Indian Air Force to Swami Sivananda. His reply to Kalam, "Our destiny is predetermined and the failures we face are essential to lead us to our destined path." His response changed my perspective on life. I waited for my destiny to reveal itself and today, unlike my friends who talk about the career they chose, I love my job as a content writer. Since date, no other book has inspired me and it remains my favourite by no competition.

- Karthika Mohanan, age 24



DID HE SAY THAT!?

As far as I'm concerned the entire reason for becoming a writer is not having to get up in the morning.

- Neil Gaiman

READER'S REVIEWS



I Am Malala is the autobiography of a courageous Pakistani girl called Malala Yousafzai, who at 17 years old is the youngest Nobel Peace Prize winner. She won the prize for efforts as an educationist activist in ensuring education for girls in the Taliban controlled region of her home in Pakistan.

Malala was only ten-years-old when the Taliban took control of her region and laid down a decree stating that women weren't allowed to go to the market and the girls shouldn't go to school. Malala's father Ziauddin Yousafzai who raised her with all the attention he lavished on his sons, taught her to stand up for what she

believed in. She fought for her right to education and on October 9, 2012, she nearly lost her life for the cause. The Taliban shot her point-blank on her way home from school. She survived the fatal wound and lived to tell her tale.

This is the remarkable story of a girl who knew from a young age that she wanted to change the world and she did. It influences a person in a right and a good way. Her struggle and fight open your eyes to another world and will make you believe in hope, miracles and the determination of one person to inspire change.

- Devika Rajasekar, age 12

IN FOCUS



Dr Joseph Ignace Guillotin

“Now, with my machine, I cut off your head in the twinkling of an eye, and you never feel it!”

- Despite being opposed to the death penalty, Dr Joseph Ignace Guillotin was responsible for the widespread use of the guillotine during the French Revolution

LEGACY

Dr Joseph Ignace Guillotin (28 May, 1738 - 26 March, 1814) was a French physician who wished to put an end to the system of capital punishment. In December 1788, during the simmering unrest that marked the oncoming French Revolution, Guillotin authored a political pamphlet, *Petition of the Citizens Living in Paris*. He was appointed as one of the 10 Paris deputies of the Estates General as part of the National Constituent Assembly.

During his time with the Assembly, Guillotin desired to abolish capital punishment. He proposed the use of a 'simple mechanism' as an alternative to the public beheadings and hangings. He felt that swift decapitation by the machine and that painless executions were the first step to their abolishment.

In an ironic twist of fate, his name would be forever linked to one of the most grisly execution devices in history, the guillotine. Due to his pacifist beliefs, this association caused him terrible embarrassment, so much that his family requested the French government to rename the device, but were refused. Guillotin was imprisoned during the political upheaval of the Revolution, and upon his release returned to medicine. Guillotin died in Paris in 1814 of natural causes.



The execution of Robespierre

DID YOU KNOW

- Dr Guillotin was not the inventor of the guillotine, merely its most vocal advocate. Its real inventor was the physician Antoine Louis.
- The guillotine was not favoured by only the French; over 16,000 people were said to have been executed by guillotine in Nazi Germany.
- The guillotine was France's official method of judicial execution for 189 years, until the abolishment of capital punishment in 1981



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