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Knowledge

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

INCORPORATING BBC SCIENCE WORLD

SURVIVING SPACE

+

READY FOR DRIVERLESS CARS?

IS SOCIAL MEDIA MAKING YOU ANTI-SOCIAL?

SHOULD WE LET PANDAS GO EXTINCT?

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From the editor

ARE WE READY TO BE SPACED OUT?

It's happening. Everything we're doing Out There seems to have one objective: to boldly go where not many men have gone before... and check out whether many men can live there!

What are your thoughts on living someplace other than Earth? Have you ever thought about what would be required from our bodies, from our minds, from our diets? I hadn't really thought about it – till I read **Surviving Space**, our cover story this issue. And it really made me wonder…

Our Knowledge Community gave us some interesting cues in what they would take to Mars if they were to be space colonists. Take a look at pg 8.

We have other great stories this issue too: There are the **robots who learn**; how far will they go? There are **driverless cars**; are you ready to turn the steering wheel over to them? All this **social media**; is it doing the opposite of what it was conceived for? That **King Arthur**; did he really exist?

Enough with the questions! We have beautiful photographs of the **Rann of Kutch** in Gujarat, and a celebration of **Harry Potter being 20 magical years** in our lives…

Because, when it comes down to it, some of us are certainly not going to be on the first ship to Mars, or the Moon… and hey, that's okay! There's so much, anyway, to celebrate here on Earth!

Primrose Monteiro-D'Souza
Editor & Chief Community Officer,
BBC Knowledge

EXPERTS THIS ISSUE

Dr. Lewis Ryan Dartnell is an author, presenter and professor of science communication at the University of Westminster. He is best known as a popular science writer, especially for *The Knowledge: How to Rebuild our World from Scratch.* In this issue, he explores the possibilities of how our bodies do and can behave in space and whether humans can lead a life among the stars – a la *Star Trek*.

Robert Banino is a journalist and editor who contributes to *BBC Focus* magazine. This issue, he sheds light on the future of driverless cars and how they might create as many as problems as they would solve.

Dr Peter John Bentley is a British author and computer scientist based at University College London. In this issue, he details the growth and development of AI, and how robots can be evolved into machines with emotions, instead of terminators.

Padma Shri Urvashi Bhutalia is a prominent Indian author and publisher, In this issue, she profiles the Indian sub-continent's famous writer – Saadat Hasan Manto.

SEND US YOUR LETTERS

Has something you've read in *BBC Knowledge* 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.

Email us at: edit.bbcknowledge@wwm.co.in

We welcome your letters, while reserving the right to edit them for length and clarity. By sending us your letter, you permit us to publish it in the magazine. We regret that we cannot always reply personally to letters.

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BBC Knowledge

CONTENTS

123RF

46
Cover story
Surviving Space
Are we close to making our home away from Earth?

FEATURES

64 Do social networks make us antisocial?
Connecting with people online is great, but are you really connected to the person, or the screen?

70 The robots who can learn
Will Artificial Intelligence have an emotionally fruitful future? The machines of the future are gearing up to surprise you

76 Should we let pandas go extinct?
Pandas are the poster child of the world of conservation, but how endangered are they really?

82 The cars that drive themselves
They say 'to err is human', but an autonomous vehicle isn't without flaws *yet*.

88 Is King Arthur a historical figure?
Did he fight Roman troops in France – or Anglo-Saxon invaders in Britain? And where *is* Camelot?

38

82

46

REGULARS

12 Q & A
Curiosity killed the cat, but it still got its answers. Check out our great questions and answers this issue

22 Snapshots
Take a look at engaging photographs that inform and entertain

26 Discoveries & Innovations
This might not be the only universe to exist, and F1 cars are about to get faster! Find out more

38 On the Shelves
The must-read books that capture the lives, myths and legends of India, and the latest must-have gadgets

42 News from the World of Travel and Food
From a romantic gondola ride on canals in Venice to the comfort food that is *poutine*, this world trip is a visual treat

56 Portfolio: India's Wild West
See Gujarat's Rann of Kutch and its inhabitants blossom and revel in the rain

95 Puzzle pit
Challenge your grey cells with a veritable buffet of teasers and puzzles

98 In Focus: Harry Potter
The Boy Who Lived turns 20 this year. Join us on a journey to relive the magic

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

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letters

Life After Man by Duncan Geere was an interesting and scary article. Having crowned ourselves the current Big Brother species on Earth, we have naturally started becoming weaker and more frustrated with what we have done in the past hundred years. One hundred years is obviously too little time on the great human timeline. Even 40 years ago, we thought we were safe, but not any more. Fear has set in. As we see in the article, we have committed the crime, however unknowingly, and now await the sentence.

I want to put this thought forward: it is not quite the end. The Doomsday Clock can be reset from 2.5 to 7 or 17 or even 30. But how?

In *BBC Knowledge*, we talk about science, not about miracles or the 'unknown'. But again, science and the unknown are interlinked. Science evolves from the unknown. Consider dark energy. It can't be discarded as a non-scientific topic. Another example is chromosomes and genes. Only 2 to 3% of human genes contribute to the human phenotype and its biological functions. The rest are called 'dark chromosomes', almost 98% of whose purpose has not identified (just like dark energy). Cell biologists have moved very quickly from genes controlling the cell, human nature and functions to the 'environment' controlling the cell, etc (epigenetics). An enzyme telomerase that revives a dying cell can be enriched in the cells by a simple process called 'happiness'. Sounds odd, but it has been proved in cancer research.

I believe the human brain cell, which is obviously the causative cell for the events that led to this article, can be modified and fixed. The human conscience is like a cog wheel – if 51% rotates in the right direction, then 49% should follow. I personally feel there are only two blocks to this happening: fear and greed.

In a decayed human brain cell (one with twisted thinking), we need quite a lot of telomerase activity. Happiness is the pill, followed by self-love, love, exercise and good food. If we can achieve this, there will be clarity as to why we are given space on this planet, and, then, it's gonna be okay.

PS: I started reading *BBC Knowledge* with my 13-year-old son after I deleted my FB, Twitter and Instagram accounts. It's a great feeling really :-)

Dr C Arul Murugan,
MRCPCH (UK), paediatrician and neonatologist
(via email)

The Life After Man issue of *BBC Knowledge* was full of knowledge. The **Discoveries** section – the scientific information about 'dark energy', dinosaurs, movement of wagon wheels in old films, the causes of shrinkage that come with ageing, the need for sleep and the cause of memory loss, etc – was outstanding in look and content. **The Life After Man** feature was also fabulous and quite thrilling to read. Best wishes to the *BBC Knowledge* team.

Pradip Chakraborty,
Nainital, Uttarakhand (via email)

It's been four years since I collected my first copy of *BBC Knowledge.* I could not believe how much is packed into a single magazine.

The current issue was really interesting. **Life After Man** made a great cover story, and the Post Apocalyptic Timeline was the best part of it. I was not very surprised to learn that we would leave behind nothing but plastic and nuclear waste. What else can Man give Mother Earth?

The next thing I loved in the issue was the **Indian Authors** series. We all know about foreign authors to a certain degree, but getting to know our Indian authors was a whole new experience for me. The **Q&A** section is what I read first. The questions and answers are equally interesting.

My other favourite sections are **Gadgets** and **Books**. Keep up the good work! I am already waiting for the next issue!!

Kartik Wardhan,
via email

According to Wikipedia, 'knowledge' is a familiarity, awareness or understanding of someone or something such as facts, information, description or skills, which is acquired through experiences or education by perceiving, discovering or learning. *BBC Knowledge* proves the definition successfully. It shapes our dreams into realities and enlightens us day by day.

The Viruses that Made Us Human was eye-catching and spectacular, and made imperative reading. **Life After Man** was yet another appealing topic. Every page of the magazine is filled with stupefying and perplexing facts, starting right from **Snapshots** (Rodents of Africa), **Discoveries & Innovations** (crows being intelligent in Japan, discoveries of the galaxy, drowsiness detector in cars), **How to Save the Stag Beetles**, to name a few. I truly gained a wealth of knowledge.

May is regarded as examinations month. It would be good if a list of careers after 10+2 level as well as of renowned colleges worldwide could be published. Students will get clarity regarding pursuing different careers. It would be a great help for students like me who want to study abroad.

Debalina Biswas,
West Bengal (via email)

Disclaimers: Letters may be edited for clarity and length. All views expressed on this page are the writers' own opinions. *BBC Knowledge* accepts no responsibility for them, or any disputes arising thereof

OUR FOLLOWERS TELL US HOW HARRY POTTER HAS CHANGED THEIR LIFE?

The Harry Potter series is a scintillating and invigorating experience for me. All the characters, how they deal with the inevitable situations, through fantasy, have taught me some truths about life. The series has taught me that true friendship has the power to overcome all troubles. Facing our fears will only make us stronger and there will always be some people who will be there for us, no matter how alarming the circumstances are.

Oindrila Ganguly via Facebook

Harry Potter taught me about love, friendship and to keep going on, irrespective of the hardships you face.

Jasmine Abubaker via Facebook

Instagram

Harry Potter has always given me the hope I have needed in my saddest times. He always gave me a new world to enter, a world of my own. He gave me the strength to speak up for the right, to trust myself while doing the right thing. He taught me to live.

sanat_k_s

Harry Potter has given me an amazing childhood that I will never forget! He has inspired me to do every single thing on this planet even if it seems impossible and to overcome criticism and the failures of life. I've learnt that bravery, courage and friendship are the three gems of one's life. I've also learnt that one mustn't tell lies and also that "happiness can be found in the darkest of times if one only remembers to turn on the light."

_mehar12

The Harry Potter series has widely nurtured young people's imagination. It has let me see loads and loads of adventures. Harry's bravery is an important aspect of the books.

rutuja_016

It has taught me that every successful person in this world has started out as nothing more than a student. If they can do it, why not me?

manas_55

Nothing in this world begins without imagination.

investing_in_knowledge

It showed me the power of hope, loyalty and resilience. It also opened up great new worlds of the imagination.

vikrants11

I can never get bored of Harry Potter; I can watch it time and again. I'm so thankful to J K Rowling for giving all of us a magical childhood. Harry Potter has taught me so many things: to stand up for what you believe, something that is really worth fighting for, and that there are important things in the world like friendship and bravery.

a.ffi

Harry Potter made me realise how friends can sometimes be more important than family; sometimes, friends *are* your family. How love can be so passionate that you would die for it. How people can be so easily misunderstood. And how even the greatest villain is nothing in front of love and friendship and trust!
Harry Potter has helped me understand life!

aditi_kuriwal

Harry Potter made me understand how love is the most powerful magic in the world.

anuragmishra_rox

HARRY POTTER QUOTES THAT INSPIRE ME

"Happiness can be found in the darkest of times if only one remembers to turn on the lights."

nidhi.7

"It is impossible to live without failing at something, unless you live so cautiously that you might as well not have lived at all, in which case, you fail by default."

vairarchi

"It is our choices that show what we truly are, far more than our abilities."

This Albus Dumbledore quote inspires me a lot! Your ability to do something is your strength; whether you use your strength for a good cause or a bad one depends on the choices you make!

imvarsha1268

LIFE ON MARS

We asked our followers on social media what three items they would take on their maiden trip to Mars. Here are their responses

facebook

- My personal digital assistant, sunscreen and did someone mention books?
  Rushabh Agarwal
- Books, books and books! Did I mention books?
  Yashaswini Suman
- I would take a camera, diary, and a flag of my country.
  Anand Kumar
- Doraemon, camera, my medicines
  Renesme Singha

twitter

Books, camera & cards
ChandraBhanu Solanki@cbsxact7

My mobile, big speakers & my friends. #PartyOnMars
V!RU@VSwami

Personal computer, portable gym & books!
AmarShah@amarshah30

Instagram

I'd take along a copy of *BBC Knowledge* and fries from the J
Rohit Ahuja (rohit_ahuja97)

I would take
a) One sapling of cactus {since they are known to survive extreme conditions}
b) A book {since it's good to have it as company}
c) A pencil and paper {in order to note my experiences on the Red Planet}
Sreepriya Sridharan (sreepriyasridharan)

a) A book to keep me busy
b) A telescope, so when I land on Mars, I would get a close look at the gas giants
c) A journal to track my journey
sci_feed

A power bank for those who take their smartphones with them
Nitin vatts (Vattsnitin)

Diary to pen my thoughts, Kindle, and earphones
Nidhi (_nidhi_.7)

a) A note book so that I can record my experience
b) Drawing files
c) Lot of colours to capture Mars and show how the planet looks to others
Tanya Sehgal (tanya.sehgal1129)

Just a towel. If you're a frood, you'd know why
Samhita Prajapati (samhitap)

A horse to go around on, bum spray, and lots of books.
Mahesh Sagari (maheshsagari)

I'll take a camera with photos of Earth in it that'll remind me of my planet, take some *BBC Knowledge* magazines with me and a pen and a diary with me to write down some important points.☺
Gurmehar Sandhu (_mehar12)

A Mars travelogue, a Martian-to-English translator, and an oxygen tank to breathe.
AnonA (the_anonymous_a)

Harry Potter to prevent boredom, Stanley Kubrick's *A Space Odyssey* for irony's sake, music to stay active, and a camera to prove I was there
Lipsa Kataria (cosmic_horizon001)

Jars of Nutella, comics, and telescope to make sure the earth is doing fine without me
mamoulgirl (mamoulgirl)

Music, football, and videogame
Param Sejpal (paramsejpal_11)

Music,1 friend, and some drawing material
Aditi Harsh (aditi_harsh)

Samosas, bat-ball, and a very precious photo of our former Captain Dhoni
Ankur Yadav (ankuryadav9935)

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Q&A

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Alexandra Cheung
Environment/ climate expert

Prof Alice Gregory
Psychologist, sleep expert

Prof Mark Lorch
Chemist, science writer

Dr Helen Scales
Oceans expert, science writer

Luis Villazon
Science/tech writer

Prof Robert Matthews
Physicist, science writer

YOUR QUESTIONS ANSWERED

WHAT IS THE DARKEST HUMAN-MADE SUBSTANCE?

In 2014, researchers at UK-based Surrey NanoSystems unveiled Vantablack, a coating that absorbs up to 99.96 percent of light that falls onto it. Vantablack is made up of millions of carbon nanotubes barely 200 atoms across, and it can be used to absorb stray light in the sensitive instruments of satellite observatories. When it is applied to ordinary objects, however, it creates the illusion of making them look totally flat. You can even buy a watch with a Vantablack dial! RM

As no light reflects off an object coated with Vantablack, it's impossible for our eyes to make out any three-dimensional features

PHOTO: SURREY NANO SYSTEMS

WHAT IF EARTH HAD TWO MOONS?

The consequences of a second moon orbiting the Earth depend on how massive that moon is and how far from the Earth it orbits. The most obvious effect would be that the ocean tides would be altered. Tides could be either smaller or higher and there could be more than two high tides per day. If the gravitational influence of a second moon were extreme, it could lead to phenomenally huge ocean tides (up to a kilometre high), which would also result in frequent tsunamis. It could also lead to enhanced volcanic activity and earthquakes. AGu

IN NUMBERS

8

The number of years that orangutans can nurse their offspring – the longest time of any wild mammals.

12

The number of seconds (± 7 seconds) that all mammals take to defecate, regardless of size.

8

The percentage of male sheep that are homosexual.

WHY DO CATS LIKE SMALL SPACES?

Cats can spend 18 hours a day sleeping. As they are solitary animals, they want a safe hiding place to snooze.

But a cat curled in a tiny box, even out in the open, is probably just avoiding your cold floor. Cats are happy in room temperatures around 14°C warmer than is comfortable for humans, and, if there isn't a convenient sunbeam to lie in, they will make do with a cosy shoebox. LV

THE THOUGHT EXPERIMENT

HOW CAN I SURVIVE A ZOMBIE APOCALYPSE?

1. HEAD FOR THE HILLS

The spread of zombie disease can be modelled using epidemiological simulations. A 2015 study at Cornell University found that cities would be almost completely infected within a week, but remote mountains would be untouched after four months. The reproduction ratio (R0) is the average number of new infections that each zombie creates. If R0 is between zero and one, the epidemic will eventually die out.

2. LAY LOW

If the zombies need to eat brains to survive, humanity may be able to simply wait out the crisis. A human brain only contains a maximum of around 2,000 calories, so even the slow and shambling kind of zombie will need to feed every few days just to maintain its metabolism. And any humans that are eaten can't rise to become new zombies, so the disease would also spread more slowly.

3. FIGHT BACK

Conversely, a 2009 study at the University of Ottawa predicted that, even if a cure for the virus is found, zombies will eventually overwhelm the population by infecting us faster than we can be treated. Of the possible scenarios, the only one with a happy ending gave us just 10 days to destroy all the zombies, with a series of increasingly devastating counter-attacks.

PHOTOS: ALAMY, SCIENCE PHOTO LIBRARY, GETTY X2, NASA ILLUSTRATIONS: RAJA LOCKEY

Agrobacterium tumefaciens in action

CAN PLANTS GET CANCER?

Yes. Crown galls are a kind of plant cancer, caused by the bacterium *Agrobacterium tumefaciens*. This causes uncontrolled growth of plant cells around the infection, just like a tumour. Other tumours can be triggered by fungi or physical damage. But plant cells are anchored in place by the cell walls, so plant cancers never spread far or metastasise to other tissues. LV

HOW DO MICROBEADS AFFECT FISH?

Plastic microbeads (orange spheres) in a facial scrub

There's no doubt that fish and other aquatic animals eat plastic fragments (under 5mm). These include the 'microbeads' that are added to toiletries and household products, as well as fibres washed from synthetic clothing. A recent study found three-quarters of flatfish in the River Thames have eaten microplastics. Even deep-sea animals have synthetic fibres in their guts. The impacts of this are complex. Some animals suffer from blocked digestive tracts, leading to starvation. Another concern is poisoning from microplastics coated in toxic chemicals. There's still much we don't know about exactly how plastics and toxins accumulate in food webs. HS

HOW DO THEY MAKE SPACESUITS AIRTIGHT?

Spacesuits are made of lots of different layers that each protect the astronaut from a different aspect of the outside environment. Only the innermost layer – known as the bladder – is airtight. It's made of urethane-coated nylon that has machine-welded seams. The gloves are attached using airtight bearings that lock into place but still allow the hand to be rotated. These use precisely machined aluminium and titanium couplings with Teflon coatings for lubrication to prevent the metals cold-welding together in the vacuum of space. Astronauts also breathe pure oxygen so the suit can be inflated at less than a third of normal atmospheric pressure. Even so, spacesuits aren't perfectly airtight. NASA allows the suits used on the ISS to leak up to 100ml of air per minute. LV

Astronauts breathe oxygen before and during a spacewalk to rid their bodies of nitrogen, which could form dangerous bubbles

WHY DO BOLOGNESE, STEWS AND CURRIES TASTE BETTER THE NEXT DAY?

Collagen in meat breaks down into gelatine at temperatures between 71 and 96°C. A stew that's been bubbling on the stove will continue to break down its collagen for half an hour after you take it off the heat. In the fridge, this will set to a firm jelly and, when you reheat it, the gelatine will melt to create a silky feel in the mouth. Tomatoes also benefit from long and slow cooking to release flavour molecules within the skin, and a speedy mid-week spag bol won't have time to reach peak tastiness until it has had those extra hours to marinate. Free water in a dish will tend to soak into starch, taking dissolved flavour with it – pea and ham soup tastes better the next day, because the ham stock has been absorbed by the pea starch. But there's a psychological aspect too. Chef and food writer James Kenji López-Alt tried to perform scientific comparisons and found little difference when tasting fresh and day-old dishes side-by-side. Perhaps we get habituated to the cooking smells the first time round, and things taste better with a clear nose the next day. LV

WHY IS RED LIGHT USED ON SUBMARINES?

The human eye is less sensitive to longer wavelengths, so red light is chosen to preserve the night vision of the crew while still allowing them to see their instrument panels. Submarines switch to red light when it's dark outside and crew members need to use the periscope or go on watch duty. RM

WHAT CONNECTS

...SMILING AND LONG LIFE?

1

Smiling probably evolved from displays of social submission. Chimpanzees make a smiling face when they are afraid. In humans, this may have later evolved into an expression to diffuse aggressive encounters.

2

Now that smiling indicates a positive mood, it's also correlated with reduced stress hormones and blood pressure. Numerous studies have linked both of these to your chances of having a heart attack.

3

Marriage also lowers your heart attack risk, and a 2009 study found that people who frown in college yearbook photos are five times more likely to get a divorce than those who smile.

4.

And overall, smiling correlates with good health. Researchers who looked at photos of 230 baseball professionals from the 1950s found that the players with the most genuine smiles tended to live the longest.

PHOTOS: GETTY X5, ALAMY, DEANSCARDS.COM ILLUSTRATIONS: RAJA LOCKEY

CAN YOUR BODY BE OLDER THAN YOUR AGE?

While age is usually thought of as just the number of years you've been alive, people with identical ages often look – and seem – very different. In 2015, scientists at King's College London published research suggesting that measuring the activity of around 150 specific genes gives a measure of 'biological age' linked more strongly to longevity than mere chronology. But genetic activity is only one factor differentiating biological and chronological age. Exercise, diet and weight can also make a big difference. This has led to various questionnaires – such as the BBC's online quiz 'What's My Real Age?' *(bit.ly/age_quiz)* – which can give clues about your current 'real' age, and offer advice on what you can do about it. When using these quizzes, do bear in mind that some of the measures are still controversial. RM

WHY DO YOUR EARS POP?

The air pressure on your eardrum is normally balanced because your middle ear is connected to your sinuses via a narrow duct called the Eustachian tube. If the outside air pressure changes too quickly though (in an aeroplane coming in to land, for example), the Eustachian tube can't equalise the pressure fast enough and the eardrum bows in or out. The popping sound occurs when the pressure rebalances and the eardrum suddenly flips back. LV

PHOTOS: SHUTTERSTOCK, GETTY X2 ILLUSTRATIONS: RAJA LOCKEY

LONGEST LIVING LAND VERTEBRATES*

*Where possible, ages have been taken from the oldest known individuals

QUESTION OF THE MONTH

COULD YOU WALK ON A NEUTRON STAR?

No. A neutron star has such an intense gravitational field and high temperature that you could not survive a close encounter of any kind. First of all, just getting onto the surface of the neutron star would be problematic. Its gravitational pull would accelerate you so much you would smash into it at a good fraction of the speed of light. Even before you arrived, the difference in gravitational pull between your head and feet would already have ripped your constituent atoms apart. Once there, though, your atomic nuclei and their free electrons would impact the surface with sufficient energy to spark thermonuclear reactions close to the super-dense surface. You would become a puff of gamma rays and X-rays, as your light elements were transformed into a cloud of heavy elements, neutrons and ultra-relativistic electrons. Even if you were somehow magically transported onto the neutron star, therefore avoiding this energetic impact, the million-degree temperatures at the surface would vaporise (and ionise) you immediately. The intense gravity would then flatten what was left of you as you merged into the super-dense crust of the neutron star. Under these circumstances, taking a leisurely walk would be extremely difficult! AGu

WHAT'S IN

...LIPSTICK?

The ingredients of lipstick need to create something that provides a glossy, smooth colour, which doesn't wipe off immediately, *and* is considerate to a rather delicate part of the body. The major constituents of lipstick are just wax and oil, but your favourite lippy could also contain materials derived from sheep, insects, fish and hot chillis! ML

WAX
30 per cent
Often a mixture of beeswax, carnauba and lanolin (from sheep wool). Together these form the main structure of the lipstick.

OIL
65 per cent
Typically castor oil, this provides glossiness and dissolves the dyes.

DYES
5 per cent
This varies depending on the colour, but a scarlet shade might contain carmine red, which is derived from scale insects.

PLUS...
GUANINE: Derived from fish scales, this gives the lipstick pearlescent sheen.

CAPSAICIN: The chemical that give chillis their heat is added to some lipsticks to make the lips swell slightly, giving them a plumped-up look.

WHY DO PLANETS ORBIT IN THE SAME DIRECTION?

This is simply the result of the initial rotation of the cloud of gas and dust that condensed to form the Sun and planets. As gravity condensed this cloud, conservation of angular momentum increased the rotational speed and flattened the cloud out into a disk. Hence, planets that formed within this disk of material all ended up orbiting the Sun in the same direction, in almost the same orbital plane and with the same spin direction (apart from Venus and Uranus that were probably hit by other bodies, altering their spin). AGu

ARE SPACE LAUNCHES BAD FOR THE ENVIRONMENT?

Space launches can have a hefty carbon footprint due to the burning of solid rocket fuels. Many rockets are, however, propelled by liquid hydrogen fuel, which produces 'clean' water vapour exhaust, although the production of hydrogen itself can cause significant carbon emissions. Rocket engines release trace gases into the upper atmosphere that contribute to ozone depletion, as well as particles of soot. Rocket launches are nonetheless relatively infrequent, meaning that their overall impact on our climate remains much smaller than aviation's. But it's not just our immediate environment; 'space junk' is a growing concern as disused satellites and other objects accumulate in our planet's orbit. AC

PHOTOS: GETTY X3, NASA ILLUSTRATIONS: RAJA LOCKEY

HOW DOES 'GLOW IN THE DARK' WORK?

A lot of things can glow in the dark, including your washing powder and, of course, those funky stars you stick on a child's bedroom ceiling. They work through phenomena called phosphorescence and fluorescence. The material absorbs energy (usually in the form of a particular colour light) and then releases it as another colour light. Fluorescent materials do this all at once, so, when you shine UV light (from a torch or the Sun) on washing powder, it absorbs the UV and then emits it as blue colour (which we associate with clean clothing, which is why the washing powder people add it to the mix). Meanwhile phosphorescent materials, like glow-in-the-dark stars, do their emitting much more slowly. This enables them to shine for a few minutes after the bedroom lights are switched off. ML

WHY DON'T WE FALL OUT OF BED MORE OFTEN?

When we sleep, a lot goes on in our bodies. We continue to breathe and growth hormone is released – we do not need to be awake for these things to happen. Similarly, we have some awareness of our body position and movements, and some people even manage to sit up or walk during sleep! Most of us have enough awareness to ensure that we do not fall out of bed, but this ability develops over time. Young children are still growing and understanding how their bodies fit into the world around them, which is why they might benefit from a bedrail. AGr

WHO REALLY DISCOVERED?

DNA

Friedrich Miescher

Oswald Avery

Francis Crick and James Watson are most often associated with the famous genetic molecule, but their work in the 1950s came over 80 years after the identification of DNA by a Swiss physician searching for the 'building blocks' of life. Friedrich Miescher had focused on proteins in cells, but, in 1869, he discovered a strange substance also lurking in the nuclei of the cells. He named it 'nuclein', and suspected it would prove at least as vital to cells as proteins. Crick and Watson were not the first to show he was right, either. Their celebrated discovery of DNA's double helix structure was prompted by key experiments by a team led by the American biochemist Oswald Avery. In 1944, working at the Rockefeller University in New York, they published the results of painstaking studies using bacteria that revealed that DNA passed genetic information from one organism to another. This went against the accepted wisdom that proteins must be the carriers of genetic information, as DNA was 'obviously' too simple a molecule to perform so complex a role. Crick and Watson agreed with Avery – but his own claim to a Nobel was blocked by sceptics until the 1960s, by which time he was dead. RM

Francis Crick *(left)* and James Watson

CAN EATING A LOT OF SUGAR REALLY LEAD TO DIABETES?

Yes. Too many calories of any kind will lead to obesity, which increases your chance of developing diabetes. But a 2013 study at Stanford University found that adding 150 calories of sugar per day to your diet increases your diabetes risk by 1 per cent, even after accounting for obesity, physical activity and total calorie intake. So sugar calories are particularly harmful. LV

WHY IS OZONE DEPLETION WORSE OVER ANTARCTICA?

Ozone depletion occurs when ozone molecules in the upper atmosphere are destroyed by chemical reactions with halogen gases, such as chlorine. Cold conditions above Antarctica in the winter months encourage the formation of extremely cold, high-altitude clouds. These clouds provide the ideal conditions for chlorine that was previously trapped in stable molecules to be transformed into highly reactive chlorine gas, which accumulates over the long polar night. As winter ends, sunlight breaks apart the chlorine gas molecules, freeing billions of chlorine atoms, which go on to react with ozone molecules, causing a sharp dip in ozone levels: the ozone 'hole'. AC

WHY DOES DEPRESSION MAKE YOU DREAM MORE?

People suffering from depression may experience unusual patterns of sleep. Typically, they move into REM sleep (the stage in which we are most likely to dream) more quickly, and there may be a greater number of eye movements per unit of time during this stage of sleep. People who are depressed may wake up more frequently during the night, and are, therefore, more likely to remember their dreams. Finally, there is some evidence that certain medications for depression can increase the frequency of nightmares. Other medications appear to do the opposite, but nightmares can occur during withdrawal from these drugs. AGr

PHOTOS: SCIENCE PHOTO LIBRARY, GETTY X4, CATERS NEWS

TAKE ME TO YOUR LEADER
This little spider is commonly known as the 'alien butt spider', thanks to the 'eyes' on its abdomen. The markings deter predators, by making the spider look like a much larger animal. The colourful arachnids are widespread across the east coast of Australia, living in a variety of different habitats.

Snapshots

Honey trap

CALIFORNIA, USA

What a sweet shot! Developing worker honeybees nestle inside the individual wax cells that make up the insects' honeycomb.

As bees develop, they undergo holometabolous metamorphosis – a lifecycle that includes four stages: egg, larva, pupa and adult. In this photograph, protective wax caps put in place by worker bees have been removed, revealing the pupae just days before they are ready to emerge as fully grown adults. "These bees are pale because their cuticle [outer shell] has not yet hardened – in fact, even when they emerge as adults, they can take a few hours to fully harden," says Adam Hart, a BBC presenter and entomologist. "This means that very young bees are more or less unable to sting – a great time to mark them if you want to follow individuals through their lives!"

PHOTO: NATIONAL GEOGRAPHIC IMAGES

Like the wind

VARS, FRANCE

Yes, that is someone cycling. Down the side of a mountain. This is Eric Barone, also known as Le Baron Rouge, setting a new world speed record for mountain biking on 18 March 2017. He reached a speed of 227.7km/h (141.5mph) while bombing it down the snow track at Vars ski resort in France.

"The only thing propelling the bike was gravity," explains Marc Amerigo, lead engineer of the project, "so Eric's bike, helmet and latex suit were all designed to minimise air resistance. We made a 3D scan of the bike with Eric sitting on it, and then added external 'fairings' to the frame to get an optimal airflow. He also has pieces of foam under his suit to make him as aerodynamic as possible."

Eric Barone has a taste for speed. As well as working as a stunt double for actors like Sylvester Stallone and Jean-Claude Van Damme, the 56-year-old Frenchman also holds the world record speed for bicycle on gravel – an equally impressive 172km/h (107mph).

PHOTO: GETTY

DISCOVERIES

DISPATCHES FROM THE CUTTING EDGE

PHOTO: GETTY

Some theories suggest our Universe is just one of many – and new evidence could lend weight to these ideas

COSMOLOGY

HAVE ASTRONOMERS FOUND THE FIRST EVIDENCE OF THE MULTIVERSE?

'Cold spot' found in the cosmic microwave background may have been caused by our universe colliding with another

IT'S a trippy thought: somewhere, in a parallel universe, a version of you is the prime minister. In another parallel universe you're a pop star, and, in another, you're a Nobel Prize-winning scientist. But that's exactly what it would mean if the multiverse theory were correct.

It's an idea that has long fascinated authors and film-makers. But, while it may seem to be little more than a fanciful science fiction trope to most, many prominent physicists take the theory very seriously. Now, researchers from Durham University may have found evidence of the multiverse's existence.

It all comes down the so-called 'Cold Spot' found in the cosmic microwave background (CMB) – the traces of electromagnetic radiation left over from the early stages of the Universe following the Big Bang. The Cold Spot is the largest known structure ever discovered, covering an area billions of light years across. It is around 0.00015 degrees colder than the area that surrounds it. There are other cold regions in the Universe caused by random fluctuations in the CMB but none as large as the Cold Spot – a fact that has puzzled cosmologists since its discovery several years ago. ▸

HONEST JOHNS

It seems honesty really is the best policy. A team at University College London has found that, when we act in a truthful manner, our brains find it more satisfying, because a region called the striatum becomes highly activated.

THE FOUL-MOUTHED

Swearing can help to increase our strength and stamina. The effect is thought to be due to the stimulating effect foul language has on the sympathetic nervous system. @%#$!

GOOD MONTH

BAD MONTH

STRADIVARIUS OWNERS

Thinking about dropping millions on a Stradivarius violin? You might want to keep your money in your pocket: a study at Pierre and Marie Curie University, Paris, has found modern listeners prefer the sound of new, much cheaper violins.

CHEESE LOVERS

Edam it! Eating cheese made from raw milk could fuel the rise of superbugs. An antibiotic-resistant gene found in bacteria from dairy cows could cause difficult-to-treat infections similar to MRSA in humans, researchers at the University of Bern have found.

An artist's impression of multiple 'bubble universes'

The leading theory was that the Cold Spot is not cold at all, but is instead caused by a vast area of relatively empty space dubbed a 'supervoid'. Radiation passing through this void would have its energy reduced, thus making the area appear cooler.

However, new measurements suggest that there is no such supervoid in the direction of the Cold Spot. Assuming this is correct, then simulations of the standard model of the Universe give odds of just 1 in 50 that the Cold Spot arose by random fluctuations.

"This means we can't entirely rule out that the Cold Spot is caused by an unlikely fluctuation explained by the standard model," said lead researcher Tom Shanks. "But, if that isn't the answer, there are more exotic explanations. Perhaps the most exciting of these is that the Cold Spot was caused by a collision between our Universe and another bubble universe. If further analysis of CMB data proves this to be the case, the Cold Spot might be taken as the first evidence for the multiverse – and billions of other universes may exist like our own."

The team now plans to further test their theory through more detailed observations of the CMB.

"BILLIONS OF OTHER UNIVERSES MAY EXIST LIKE OUR OWN"

EXPERT COMMENT

What is a bubble universe?

According to the theory of cosmic inflation – an idea that is accepted by most, but not all, leading cosmologists – the Universe expanded incredibly rapidly in all directions in a tiny fraction of a second following the Big Bang, much like a balloon does as it is blown up. After this initial quick burst, it continued to expand, but much more slowly. In contrast, the theory of eternal inflation states that following the Big Bang, inflation did cease in some pockets of space, but also continued in others. This means that we could live in a so-called 'bubble universe' – an area of slowly expanding space embedded in a much larger, rapidly expanding space that is still undergoing inflation.
What's more, there might also be countless other bubble universes embedded in this larger space that are being propelled away from us at breakneck speed. In some of these bubbles, the laws of physics could be completely different from those that apply in our own Universe – making these other universes very strange worlds indeed.

PHOTOS: GETTY X2

MEDICINE

LAB-MADE HUMAN BLOOD IS NOW "TANTALISINGLY CLOSE"

Now here's a bloody good piece of research! A team at Boston Children's Hospital has generated blood-forming stem cells in the lab for the first time, a breakthrough that could enable the development of more effective treatments for genetic blood diseases

To create the cells, the team used a combination of chemical processes and genetic engineering to coax human pluripotent stem cells – cells capable of forming any adult cell – to differentiate into hemogenic endothelium, an embryonic form of tissue that gives rise to blood stem cells. They then implanted the resulting tissue into mice. Weeks later, a small number of the animals began producing several types of human blood cells. Some mice were even able to mount a human immune response after vaccination.

"We're tantalisingly close to generating bona fide human blood stem cells in a dish. This is the culmination of over 20 years of striving," said researcher George Daley. "We're now able to model human blood function in 'humanised' mice. This is a major step forward for our ability to investigate genetic blood disease."

Although the cells made from the pluripotent stem cells are a mix of true blood stem cells and other cells known as blood progenitor cells, they proved capable of generating multiple types of human blood cells when put into mice.

"This step opens up an opportunity to take cells from patients with genetic blood disorders, use gene editing to correct their genetic defect, and make functional blood cells," said researcher Ryohichi Sugimura. "This also gives us the potential to have a limitless supply of blood stem cells and blood by taking cells from universal donors. This could potentially augment the blood supply for patients who need transfusions."

The lab-produced blood stem cells can develop into different types of blood cell

IN NUMBERS

50

DEGREES C

The temperature reached by human mitochondria, the energy factories found in our cells.

100

YEARS

The time the human race has left to colonise another planet to ensure its survival, according to physicist Stephen Hawking.

1.33

x 10^{29}KG

The minimum size a star needs to reach in order to shine, as recently calculated by researchers at the University of Texas at Austin.

The tiny lambs appeared to develop normally inside the artificial wombs

BIOLOGY

PREMATURE LAMBS LIVE IN 'PLASTIC BAG' WOMBS

Talk about a womb with a view… researchers at the Children's Hospital of Philadelphia in the USA have created a plastic bag-like artificial womb and successfully used it to incubate premature baby lambs for up to 28 days. That's a huge improvement on the maximum 60 hours achieved in previous attempts to develop artificial wombs.

Extreme prematurity (where a baby is born less than 26 weeks into a pregnancy) accounts for one-third of infant deaths in humans. Currently, premature babies are placed in incubators, and put on ventilators to help them breathe. But this can lead to lung problems later in life, and the development of other organs is often impaired.

In contrast, the 'biobag' system developed in Philadelphia is designed to more closely mimic conditions inside the mother's womb. The infant's lungs 'breathe' amniotic fluid, just as in a real womb, and their hearts pump blood through an artificial umbilical cord into an external oxygenator. This oxygenator is a substitute for the mother's placenta in exchanging oxygen and carbon dioxide. Nutrients are supplied via the umbilical cord, while the bag protects the foetus from changes in temperature and light, as well as keeping germs at bay.

"[Extremely premature] infants have an urgent need for a bridge between the mother's womb and the outside world," said research lead Dr Alan W Flake. "If we can develop an extra-uterine system to support growth and organ maturation for only a few weeks, we can dramatically improve outcomes for extremely premature babies."

PHOTOS: CHILDRENS HOSPITAL OF PHILADELPHIA, SALK INSTITUTE ILLUSTRATION: DANIEL BRIGHT

THEY DID WHAT?!

RESEARCHERS GOT CRAYFISH TIPSY

How did they do that?
A team at the University of Maryland plunged two groups of social crayfish into a tank spiked with booze. Previously, one group had been housed together in a tank for 10 days, the other group had been kept in solitary conditions. The team observed the animals over three hours to determine how 'drunk' they were.

What did they find?
When crayfish are tipsy, they stand more upright and begin thrashing their tails around before finally flopping over onto their backs – a sight eerily similar to the scenes in UK town centres on a Friday night. The team found that it took larger quantities of alcohol to trigger drunken behaviour in the loner crayfish.

Why did they do that?
Though they are keen to stress the fact that the research is still in the preliminary stages, the researchers say that socially-isolated humans could show a similar increased tolerance to the effects of alcohol. This could help to explain why those who spend a lot of time on their own often drink more heavily.

HEALTH

THE BENEFITS OF EXERCISE: NOW IN PILL FORM

We're all told to exercise more, but that isn't always possible for those with physical disabilities. For such people, the benefits of aerobic exercise have always been out of reach. But, now, a team at the Salk Institute for Biological Studies in San Diego, California, has developed a pill that engenders such effects chemically, with mice given the drug able to burn fat more effectively while exhibiting increased stamina. When people exercise regularly, their bodies become more adept at using fat rather than glucose as an energy source. It's been known for some time that this ability is linked to the expression of a gene called PPARD – mice that were genetically engineered to have this gene permanently activated proved more resistant to weight gain than normal mice, and had more stamina.

The new research involved giving mice a chemical compound called GW1516, which also activates the PPARD gene, over a period of eight weeks. Mice given GW1516 could typically run for 270 minutes before becoming exhausted, compared to 160 minutes for the control group. Closer examination showed that when the PPARD pathway is activated, the expression of 975 different genes within the muscles is affected, with those involved in burning fat increased and those involved in breaking down glucose suppressed.

"PPARD is suppressing all the points involved in sugar metabolism in the muscle, so glucose can be redirected to the brain," explained researcher Dr Michael Downes. "Exercise activates PPARD, but we're showing that you can do the same thing without mechanical training."

The research sheds new light on the factors affecting endurance, and offers disabled patients the hope of improved quality of life.

Calf muscle of a mouse, stained to show three different types of muscle

NEUROSCIENCE

"WE CAN GAIN INSIGHT INTO WHAT GOES WRONG IN THE BRAINS OF PATIENTS WITH NEURODEVELOPMENTAL DISORDERS"

Neuroscientists have grown 'spheroids' made of human cells. Dr Sergiu Pasca, who was involved in the research, explains how these 3D structures could be used to better understand the brain

Transferred to plates where they cannot attach, stem cells form sphere- like structures

Where do the cells come from?

The ability to transform skin cells into 'induced pluripotent stem cells' has been a revolutionary step and holds great promise for understanding psychiatric disorders. These stem cells can become anything. You can now take a simple skin biopsy and grow cells in a non-invasive way to become cell types of interest.

But there are limitations to what you can do with neurones derived through conventional methods, which involves growing a single layer of cells at the bottom of a petri dish. One is that the cells don't interact in the same way as they would in the brain. So we've been building three-dimensional spheroid cultures. People have been calling these cultures 'mini-brains', which isn't accurate. It resembles parts, but not the entire human brain.

How do you make a 'spheroid'?

We move stem cells to plates where they cannot attach, so they curl and start making balls. We call them 'spheroids' because they're sphere-like structures. With minimal instructions, you can guide the cells to become derivatives of the ectoderm [embryonic tissue that develops into skin and nervous system]. There are all the cell types that make the cerebral cortex, which is the outer layer of the brain that's responsible for thinking and most higher brain functions.

Which cells have you studied?

The cerebral cortex has two types of neurones. It has neurones that release glutamate at a synapse (a connection with another neurone) – that excite the other neurone. About 80 per cent of neurones in the cortex are 'excitatory' or 'glutamatergic'. We also have the 20 per cent of neurones we call 'inhibitory' or 'GABAergic' because they release GABA, another neurotransmitter, that puts a brake on the activity of cells. There's a balance between the two types: if you have too much excitation, the consequence is epilepsy and seizures.

What have you found so far?

GABAergic cells aren't made at the same time and in the same place as glutamatergic cells, but in deep structures, migrating over many months to reach the cerebral cortex. So, in one dish, we make the glutamatergic cells and, in another, we generate GABAergic cells. After two to three months of maturing, we put them in one tube, label the cells fluorescently and watch them. What happens is really wonderful: the two spheres fuse. Within weeks, they start making connections. We listened to electrical activity and showed they're receiving input from cells around them. So we started recreating a complex neural network, a circuit-like structure that has both cell types, as in the cerebral cortex.

Why are spheroids useful?

We call this a modular system: you can make specific brain regions and put them together. This is ultimately a platform that would allow scientists to ask questions about how different brain cells talk to each other, both in isolation as well as when you assemble them in a dish. We can gain insight into what goes wrong, presumably, in the brains of patients with neurodevelopmental disorders such as autism, schizophrenia or epilepsy, which are still untreatable.

PHOTOS: ANCA PASCA LAB, REX/SHUTTERSTOCK ILLUSTRATION: DAN BRIGHT

INNOVATIONS

The Renault R.S. 2027 Vision would drive autonomously in the pit lane, or while the safety car was out

THE F1 CAR OF THE FUTURE?

Seen here is the Renault R.S. 2027 Vision. This futuristic Formula 1 car concept was unveiled at the recent Auto Shanghai trade fair to showcase the technologies the French motoring giant thinks will become dominant in the sport over the next decade or so. These include hybrid electric/liquid fuel engines, four-wheel drive, a transparent, 3D-printed cockpit, wheels with a built-in LED display, and greatly reduced weight – the R.S 2027 Vision tips the scales at 600kg, over 100kg lighter than current F1 models.

PHOTO: NEWSPRESS

COMPUTING

ZUCKERBERG AND MUSK WANT TO READ YOUR MIND

Two giants of the tech world, Facebook and Elon Musk's latest venture Neuralink, have both announced that they are working on brain-to-computer interfaces.

At Facebook's recent F8 developers' conference, Regina Dugan from Facebook's R&D division Building 8 showed a video of a woman using such an interface to type eight words per minute, and spoke of the company's ambitions to develop a similar system capable of typing hundreds of words per minute within a few years. Dugan has experience in this area: the technology in the Stanford University video was similar to systems developed at DARPA, the US military research agency, while Dugan was director there.

Facebook CEO Mark Zuckerberg later enthused about the technology in a Facebook post, saying: "We're working on a system that will let you type straight from your brain about five times faster than you can type on your phone today. Eventually, we want to turn it into a wearable technology that can be manufactured at scale." Meanwhile at Neuralink, work is in progress on a system to help restore communication to brain injury and stroke victims. Musk says they expect to have a product on the market "in about four years."

NASA's new chain mail: just the job for going jousting on Jupiter

MATERIALS

SPACE ARMOUR

In its ongoing quest to build better spacecraft, NASA has looked to the distant past for inspiration and invented a form of 21st-century 'chain mail'.

The new material was invented at NASA's Jet Propulsion Laboratory (JPL) by a team led by Raul Polit Casillas. Its outward-facing side resembles the surface of a mirror ball and reflects light and heat, whereas the inward-facing looks more like actual chain mail and absorbs heat. It's hoped the material could have applications as protective (and insulating) cladding for spacecraft, in astronauts' suits, or even for creating temporary landing strips. What's more, it's 3D-printed, which means it could be produced on-demand in any putative future base stations on Mars or the Moon.

PHOTOS: ALAMY, MIT, SHUTTERSTOCK, NASA

MEDICINE

FINAL FRONTIER WINS TRICORDER XPRIZE

The DxtER from Final Frontier Medical Devices has won the Tricorder XPrize, a $7m grant to develop an all-purpose medical diagnostic device along the lines of the 'tricorder' used in Star Trek.

The Tricorder XPrize competition was launched in January 2012, as a joint venture between the XPrize Foundation (whose directors include Google founder Larry Page and Huffington Post founder Arianna Huffington) and US telecoms giant Qualcomm. And, now, Final Frontier's device has been chosen as a winner, even though the DxtER isn't actually particularly tricorder-like at all.

Rather than being one single multipurpose device, DxtER consists of several discreet components, including heart rate and respiration monitors, a compact spirometer, and a dual-purpose thermometer and stethoscope called the DxtER Orb. Plus, the DxtER system has been designed – unlike the Star Trek tricorder – for use by patients themselves rather than by medical professionals.

Final Frontier is currently seeking approval from the US Food and Drug Administration (FDA) for its devices. If such approval is granted, treatment times in hospitals could be reduced as there'd be no need for doctors to repeat tests that had already been carried out by the patient at home using DxtER.

Star Trek's tricorder inspired a quest to create a real version

ROBOTS

FIRST SELF-BALANCING ROBOT

This robot is the Planar Elliptical Runner (PER). It's the brainchild of Jerry Pratt and his team at the Florida Institute for Human and Machine Cognition (IHMC). What's unusual about the robot is that it doesn't require advanced AI systems to stay upright.

Similar-looking robots from the likes of Boston Dynamics or Agile Technologies rely on gyroscopes, sensors and advanced algorithms to keep them on their feet, but the PER makes use of a simple, stable design with a single motor that drives its legs in an elliptical motion. The robot, whose gait resembles that of an ostrich, can reach a speed of 19km/h (12mph). However, it has been suggested that were the robot scaled up to human size, this could increase to 48km/h (30mph).

While PER is essentially just a proof of concept, it's hoped that the technological and design lessons learned will eventually help in the development of robots that can go to dangerous or inhospitable places, such as burning buildings. Pratt said: "Running will be eventually useful for any application that you want to do quickly and where wheels can't work well."

TECHBYTES

LARGING IT

A team at MIT has created the world's biggest 3D-printed structure *(above)*. The 15.25m x 3.66m igloo-like dome was constructed from quick-drying foam in just 13 hours by a large, hydraulically mounted 3D-printing robot dubbed, imaginatively, the Digital Construction Platform.

FACEBOOK IS HIRING

Facebook is taking on an extra 3,000 moderators to monitor video content. The move comes after several high-profile incidents in which murders, suicides and sexual assaults were live-streamed using the Facebook Live service.

FASTEST CAMERA

Researchers at Lund University in Sweden have developed a camera that can shoot an incredible five trillion images per second. The camera, which uses lasers rather than natural light, is designed for capturing chemical reactions on film.

SAMSUNG GEAR 360

samsung.com, £199

TECH

Samsung's 360° camera is all about ease-of-use: pop it into the rubberised base, tap the idiot-proof big red button and you're away. The accompanying app will help you line up shots, while uploading new content to social media takes just a few quick taps. It also makes a good job of stitching together your footage to create 360° panoramas, though, in our tests, some darkening was visible around the joins. For really convincing results, we'd suggest dropping the resolution and selecting a higher frame rate. 8/10

SPECS: CMOS 8.4MP x2 for 15MP equivalent, f/2.2 lens, 1600 ISO, 4,096 x 2,048 video, 130g

READ INDIA

INDIA IS 70 THIS YEAR

WORDS: MOSHITA PRAJAPATI

MAXIMUM CITY
Suketu Mehta

A book that captured the spirit and essence of (then) Bombay like no other – from the ghoulish world of the dreaded mafia to the glamorous life of Bollywood, the disappearing bylanes of a city, home to prostitutes with a golden heart, to tales of successful scams and business ideas, the book is a must-read for those enamoured with the city of Bombay.

TRAIN TO PAKISTAN
Khushwant Singh

No book has managed to capture the emotions and pain of Partition like this one. *Train to Pakistan* evocatively exposes the painful horrors committed on and by both sides that have left a cultural mark that will live a long time.

A SUITABLE BOY
Vikram Seth

It's a tome, probably one too long, but it doesn't matter once you lose yourself in the sweeping literature that is a Seth trademark. His are recognisable characters; they could be your next-door neighbours, or even you! Set in post-Partition India, where new freedom challenges old thoughts, this is a mesmerising read for those looking to meet India just a few years into her independence.

THE GREAT INDIAN NOVEL
Shashi Tharoor

Merging one of India's greatest mythological books – the *Mahabharata* – with India's two grand political parties, this creatively-presented account from Independent India's early political days to its contemporary political climate is witty, crafty, and entertaining.

CURFEWED NIGHT
Basharat Peer

Growing up in war-torn Kashmir, Peer gives us an account of life that is often printed across papers but with none of the grime and blood of his personal anecdotes. Blurring the lines between heroes and villains, the book asks how conflict can be addressed in a state that everyone seems to have chosen to ignore.

THE GOD OF SMALL THINGS
Arundhati Roy

In a book that is said to explore the full range of human emotions, its dark misgivings and selfish gains, Roy holds up the misfortune or fortune of Estha and Rahel as a mirror to the ubiquitous Indian family.

OUR MOON HAS BLOOD CLOTS
Rahul Pandita

A personal narrative, gut-wrenching truths, and bitter sentiments mark the tempestuous relations between India and Kashmir in this book written by seasoned journalist Pandita.

A FINE BALANCE
Rohinton Mistry

A critical commentary on India during the Emergency, the drama in this book unfolds in 1975, when four strangers form a bond that helps them hold their sway during sweeping times of corruption, heroism, and cruelty in a new India.

INDIA AFTER GANDHI
Ramachandra Guha

Guha weaves a gripping tale of the hope and defiant resolution of a young nation fighting against internal and external forces and ideologies to take India to its secular potential.

THE INHERITANCE OF LOSS
Kiran Desai

Switching between the past and the present, Desai masterfully keeps the reader interested in the lives of Biju and Sai, separated by generations and countries, but united by a sense of loss.

SACRED GAMES
Vikram Chandra

Thrilling and expressive in its prose and inspired by reality, *Sacred Games* captures the complex and often surprisingly supportive relationship between Inspector Sartaj Singh and the dreaded don G of the Mumbai mafia. The novel was seven years in the writing.

THE PALACE OF ILLUSIONS
Chitra Banerjee Divakaruni

The defining piece in a game of chess is the queen. In the *Mahabharata*, it was the disrobing of the Princess Panchaali that led to the inevitable war at Kurushektra. In this version of the great book, we see the tale unfold through the eyes of Princess Panchaali. A riveting must-read.

INTERPRETER OF MALADIES
Jhumpa Lahiri

A brilliant debut novel by Jhumpa Lahiri, this collection of nine short stories is an elegant exploration of the tussle Indians and American Indians experience while living in the new world.

MALGUDI DAYS
R K Narayan

It could be any village in any part of the country, and that was, is and will continue to be the main draw of *Malgudi Days*. The characters are so real and easy to identify with that you would think they live right in your village or town. A slice of idyllic India, the series is perfect for those sepia-toned nostalgic afternoons.

WANTED

ECHO, ECHO ON THE WALL...

Amazon wants you to put an Alexa-equipped Echo Look in your bedroom, so you can take selfies in your latest gladrags. It can even compare two outfits to tell you which looks best. Just remember to switch it off when you're done…
Amazon Echo Look
www.amazon.com; $ 200

TALKING SPEAKERS

For proof that Alexa/Siri-style digital assistants are becoming ubiquitous, see Vizio's latest soundbars, which have Google Assistant built-in but barely bother mentioning it. Built-in Chromecast is what they shout about instead.
Vizio SmartCast
www.vizio.com; $250 – $500

SNAP HAPPY

Sony's new flagship 4K camera is a mirrorless, 24.2-megapixel affair with a full-frame stacked CMOS sensor. It'll shoot RAW images at a blistering 20fps, while tracking moving subjects is simple thanks to autofocus with a 60Hz refresh rate.
Sony A9
www.sony.com; £4,500

DON'T LOOK MAC IN ANGER

This stand turns your iPhone 6/6s/7 into a replica of the original 1984 Apple Macintosh while charging it overnight. For added retro fun, just add the original MacOS, which you can now run in a browser via www.archive.org.
M4 Vintage Stand for iPhone
www.elagostore.eu; €34.95

SELFIE SERVANT

This tiny quadcopter sports a 5MP camera, weighs just 61g and comes with a charging station that doubles as a smartphone case. It only flies for three minutes, but, as it's designed purely for taking selfies, that shouldn't be too much of a problem.
AirSelfie
www.airselfiecamera.com; €358,

WE HAVE LIFT-OFF

This Lego model of the Saturn V rocket used for NASA's Apollo missions comprises nearly 2,000 pieces, stands a metre tall and, just like the real thing, can be broken down into its S-IC, S-II and S-IVB sections.

We want one.

NASA Apollo Saturn V

www.lego.com; $120

NEWS FROM THE WORLD OF TRAVEL & FOOD

INFO NUGGETS FROM ACROSS THE GLOBE

KENYA

From now to September is the best time to see the **migration of the wildebeest** at the Mara River crossing.

PERIYAR

The **Periyar Tiger Reserve** in Kerala is one of the few sanctuaries that stay open all year round.

NEBRASKA

In Nebraska, **Carhenge** is a weird and wonderful tribute to Stonehenge, with vintage cars instead of rocks!

ANTARCTICA

Barely 525 feet wide, the **Lemaire Channel** strait is so photogenic it's often called the 'Kodak Gap'.

SAN FRANCISCO

Fisherman's Wharf's **Pier 39** has over 1,700 sea lions lounging around on the dock – great selfie opportunities there!

MONGOLIA

Mongolia is the **world's least densely populated place** – only four people per square mile! Great if you're looking for solitude!

NEW ZEALAND

Less known than Milford Sound, **Doubtful Sound** has two layers of water – a dark, fresh-water layer and a lower one of warmer seawater.

SPAIN

The ancient Roman aqueduct in **Segovia** was built around the 1st century AD, and it still supplies water to the city!

ENGLAND

The **white cliffs of Dover** get their white appearance from limestone.They are part of an Area of Outstanding Natural Beauty.

123RFX11

5 GREAT-TO-KNOW FACTS ABOUT
GRAND CANAL
VENICE

The Grand Canal was once where the wealthy of Venice had their *palazzi* on the waterfront. Today, one of the grandest, an 18th-century townhouse, **Ca' Rezzonico**, is a museum of 18th-century Venice.

The 16th-century **Rialto Bridge** is built of white Istrian stone, and legend has it that Satan only agreed to stop his mischief with the construction in return for the soul of the first person to cross the bridge.

Connecting the Doge's Palace and the New Prison, the 17th-century **Bridge of Sighs** was so named by Lord Byron – he imagined convicted prisoners sighing as they went towards captivity. Another theory is that the sighs come from lovers passing in gondolas under the bridge.

St Mark's Campanile (bell tower) seems romantic, but, in the 16th century, criminals were left to rot in cages suspended from the top.

Venice has five 'plague churches', one built each time the city survived an outbreak. The 17th-century **Santa Maria della Salute** *(above)* marks the end of the Grand Canal.

TRAVEL WITH FOOD

POUTINE, Canada

French fries, cheese curds and gravy – this is comfort in a dish, originating in the province of Quebec. Poutine is available from diners and fast-food stalls, and can be topped with *foie gras* for a luxury treat.

SURVIVING SPACE

OUR EXPLORATION OF THE COSMOS IS HAMPERED BY OUR BODIES AND MINDS, WHICH STRUGGLE IN SPACE. SO COULD WE EVER OVERCOME OUR BIOLOGY AND SETTLE AMONG THE STARS?

WORDS: DR LEWIS DARTNELL

ILLUSTRATION: MAGIC TORCH

YOU might have thought from watching videos of astronauts aboard the International Space Station (ISS) that spaceships were pretty benign environments. Floating around in microgravity looks like a lot of fun, and, as you're isolated from the rest of the human population, you're effectively quarantined against catching flu or any other transmissible disease.
But, in fact, space is pretty harmful to the human body. We evolved as social animals under the conditions on Earth, and travelling beyond the planet has a number of negative effects on the body and mind.

So what are the main risks encountered by spacefarers, and what does the latest research have to say about how to solve these problems for long-duration missions in the future?

[GRAVITY]

Freefalling around the Earth in orbit, or coasting through interplanetary space on your way to Mars, gives you the sensation of weightlessness. You're still moving under gravity, but it doesn't load your body, and this has a whole host of knock-on effects. For example, your inner ear can no longer help you orientate yourself, and the redistribution of bodily fluids causes your face to puff up and your eyeballs to distort.

But the long-term effects are more concerning. Without the loading of gravity, your skeleton loses calcium and becomes brittle (like with osteoporosis). Your muscles, especially those involved in supporting your spine and holding you upright, deteriorate and shrink. Plus, your heart becomes weaker when it doesn't have to pump blood upwards. While you remain in a weightless environment, this isn't too much of a problem – and, in some senses, your body is being adaptive in remodelling itself to life without gravity – but it can be hugely debilitating or dangerous when you return to the surface of the Earth or any other planet.

In the long-term future, the solution might simply be to generate artificial gravity for yourself on a spaceship. If you rotate large sections of a spacecraft – giant turning wheels or cylinders – you can exploit the centripetal force from the inside wall that keeps you moving in a circle to create an apparent gravity. We're well familiar with this idea from sci-fi films like *2001: A Space Odyssey*, or, more recently, *Passengers*, but the problem is that the engineering required to build such a large rotating structure in space is pretty challenging.

In the shorter term, spacecraft might incorporate mini-centrifuges. These wouldn't be large enough to walk around or work inside,

LEFT: The Dainese BioSuit has been designed for trips to Mars

FACING RIGHT: In *2001: A Space Odyssey*, apparent gravity was provided by a rotating wheel

FACING FAR RIGHT: Danish astronaut Andreas Mogensen tries out the ESA skinsuit on the ISS

"WITHOUT THE LOADING OF GRAVITY, YOUR SKELETON LOSES CALCIUM AND BECOMES BRITTLE, AND YOUR MUSCLES DETERIORATE AND SHRINK"

PHOTOS: GETTY X4, GETTY/DK IMAGES, ZHAO CHUANG, JUNCHANG LU

but they would fit within the existing structure with just enough space for a single astronaut at a time. Spinning relatively quickly, these could generate artificial gravity for short bursts while the astronaut exercises. The idea is that gravity could perhaps be dosed in small amounts; just enough to prevent the body deteriorating in space. David Green and his colleagues at King's College London have been working with MIT and the European Space Agency (ESA) on another solution: the 'gravity loading countermeasure skinsuit'. This skinsuit looks a bit like a triathlete's sleeveless wetsuit, and incorporates a specific weave of elastic material that provides a graded tension between the feet and shoulders. This elastic loading on the body simulates 1g (Earth's gravity) and is designed to help prevent stretching of the astronaut's spine and muscle and bone wasting. The scientists are running tests on their skinsuit on Earth, and it was recently worn on the ISS by Andreas Mogensen, the first Danish astronaut.

What about developing drugs that could help make exercise in zero-g more effective or stop muscle loss altogether by blocking the degenerative process? Nathaniel Szewczyk, at the University of Nottingham, has been involved in research along exactly these lines. But, rather than experimenting on human test subjects, he has been using microscopic worms.

Caenorhabditis elegans is a nematode worm, but it has two different muscle types that are similar to the heart muscle and skeletal muscles used for movement in humans. As *C. elegans* is such a simple animal, we've already been able to work out exactly how it develops, and we've also sequenced its whole genome. This means that *C. elegans* is a perfect test case for helping scientists understand the effects of microgravity on animal bodies, and they've now been flown on a number of space missions as microscopic astronauts. Szewczyk and his colleagues have found changes in the cellular production of around 100 proteins during spaceflight, many of them involved in muscle-building. "These experiments with *C. elegans* in Earth orbit have enabled us to track how the expression of different proteins responds to weightlessness, and so explore the genetic basis behind deterioration of the body's muscles," he says. "In our current ESA flight, we're specifically testing a few drugs to see if they can reduce muscle loss in worms."

So the hope is that, in the future, astronauts will be able to pop a pill to help protect their heart and muscles while in space. ▸

[RADIATION]

Gravity isn't the only thing that the Earth provides for our bodies. The thick atmosphere and global magnetic field that cocoons our planet protect the surface from cosmic rays. These are energetic radiation particles – spat out by flares on the Sun or accelerated to nearly the speed of light by supernova events – that are exceedingly hazardous to cells.

Astronauts aboard the ISS, and, in particular, any future spacefarers voyaging to the Moon, Mars and beyond will be exposed to this nasty space radiation. These energetic particles damage DNA, causing mutations and could potentially trigger tumours and cancer, and they also turn the lenses of your eyes opaque. But what we understand much less clearly is what irreversible effects cosmic rays might have on your immune system, or on your brain's neurons.

Astronauts can be protected against cosmic rays by providing several metres of radiation shielding to absorb the particle bombardment, and this would be relatively simple on the lunar or Martian surface by burying the crew quarters underground. But providing complete shielding around a spaceship would make it impossibly massive and expensive. So, instead of blocking the radiation, another countermeasure would be to reduce its harmful effects within the body. Dietary supplements and drugs could be taken to mop up free radicals produced in your cells by radiation, or to help with DNA repair. The problem, says radiation physicist Dr Marco Durante, is that current antioxidant supplements aren't particularly effective, whereas radioprotector drugs like Ethyol do work but are pretty toxic. Ethyol, for example, is only occasionally used with patients who have cancer in the head and neck region, where the side effects of radiotherapy are often severe. "The US Department of Defense has developed several compounds in the framework of the homeland security program, and testing these for their effectiveness against cosmic rays in astronauts would be very interesting," Durante says. "As an alternative to drugs, one promising biomedical process is hibernation, because radioresistance seems to be increased at low temperature."

If we can work out how to keep the human body in a state of cryogenic suspension, the crew could sleep through the whole eight-month flight to Mars, and the freezing cold would also help protect their cells from radiation damage. And, if the astronauts are not active, it will also mean that the demands on the life-support system, and the amount of food and other consumables that will be needed, will also be greatly reduced.

But, perhaps, we could go one better. Could it be possible to genetically modify future astronauts to enhance their radiation resistance? New research on strange microscopic animals know as tardigrades elucidates one route we might go down. Takekazu Kunieda, a molecular biologist at the University of Tokyo, has been working on these tiny 'water bears' that are known to be able to survive extremely hostile conditions such as the vacuum of space and punishingly high radiation levels. To try to understand which genes might be behind these prodigious survival skills, Kunieda sequenced the tardigrade's genome and then inserted sections of this DNA into mammalian cells in a petri dish. In this way, they found a new gene dubbed Dsup (for 'damage suppressor'), which acted to prevent the tardigrade's DNA from breaking under radiation. And astonishingly, this gene also reduced radiation-induced DNA damage by 40 per cent in human cells. ▸

Mars colonists would need to shield their base from dangerous cosmic rays

"WHAT WE UNDERSTAND MUCH LESS CLEARLY IS WHAT EFFECTS COSMIC RAYS MIGHT HAVE ON YOUR IMMUNE SYSTEM, OR ON YOUR BRAIN'S NEURONS"

PHOTOS: FOSTER + PARTNERS; GETTY X6

YOUR BODY IN SPACE

Your inner ear can't work in microgravity, which can cause dizziness and space sickness.

Without gravity, your skeleton loses calcium to become brittle and weak, like with osteoporosis.

Long-term exposure to cosmic rays may also impair brain function, which could be critical in an emergency situation

Conditions aboard spacecraft can lead to insomnia, loss of appetite, anxiety and depression

Redistribution of body fluids in zero-g makes your face puffy. Your eyeballs distort, blurring vision.

As your heart no longer needs to pump blood up against gravity in zero-g, it weakens and deteriorates.

"AT LEAST FROM THE ISS, YOU CAN STILL ENJOY THE VIEW OF THE EARTH BELOW"

Privacy tends to be in short supply aboard the ISS

PHOTO: NASA

[PSYCHOLOGY]

Long-duration space travel can take a heavy toll on your mental well-being. ISS astronauts often report problems with insomnia and loss of appetite, and it can be hard to find any privacy in the confines of the craft. Crews also have to be carefully selected to make sure that every member is easygoing – there is the constant threat of something going wrong, and you can't risk astronauts irritating each other too much. It's not like you can diffuse an argument by avoiding each other or stepping outside for some air! You have to spend months on end with the same people, isolated from all your loved ones at home.

At least from the ISS, you can still enjoy the view of the Earth below – on a mission to Mars, the feeling of remoteness will be even stronger. And the signal delay time of up to 40 minutes will mean that you'll not even be able to talk to anyone on Earth – all contact will be by email or video message.

These psychological issues are tricky to detect early on, and, when you're investigating the effects on group cohesion, it's hard to think of scientific ways to measure the outcome. While medical tests might be able to reveal the physiological effects of spaceflight on your body, people might be less inclined to self-report on psychological stresses or problems they are encountering. NASA has been paying particular attention to these psychological effects. In a 2016 report on human health risks, they highlighted several areas needing further study. These include the effects of long-term disruption to sleeping patterns and 'circadian rhythm desynchronisation'. This is when your body's internal cycles of temperature regulation, metabolic activity, and wakefulness, for example, are forced out of rhythm with each other – you're probably familiar with this from jet-lag. But what are the effects of experiencing desynchronisation for months or years of a lengthy space mission? The report recommended more research into how diet and nutrition can affect these circadian rhythms, and whether the timing of meals, for example, might help solve the problem.

One of the best ways of studying psychological effects is in similarly isolated situations back on Earth. Dr Beth Healey has spent more than a year on the Concordia Station in the icy depths of Antarctica, as the ESA's research doctor. During a polar winter, you don't see sunshine for three months, and no evacuation is possible even in an emergency – in this sense, the Concordia scientists are more isolated than ISS astronauts. In one of Healey's experiments, she got the crew to wear trackers. These monitored how mobile each person was, and who they interacted with. "This provided valuable information regarding how group dynamics changed over time and could identify critical time points in the mission where crew members may be more likely to isolate themselves or seek out social interaction, or when conflicts were most likely to occur," she says.

Healey also worked on developing a 10-part cognition test, which is now likely to be adopted into the astronauts' routines aboard the ISS. "The test looks at lots of different variables, for example risk-taking behaviour, reaction times, memory testing, and so on. The astronauts would take this regularly, and any dip in performance would prompt mission control to investigate," she explains.

ABOVE
The team at Antarctica's Concordia Station are more isolated during winter than ISS astronauts

FACING RIGHT TOP
ISS astronauts rely on deliveries of fresh food to top up their supplies, but this wouldn't be feasible on a Mars or Moon base

RIGHT BELOW
From left to right, radishes grown in Moon soil substitute, Mars soil substitute, and Earth soil

PHOTOS: ESA/IPEV/PNRA/B HEALEY, NASA

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"MARS COLONISTS WOULD NEED TO LEARN TO BE SPACE FARMERS!"

[FOOD AND NUTRITION]

Weightlessness presents several problems for eating in space. Without gravity, crumbs are a real health hazard, floating in the air to be inhaled into your lungs. And the redistribution of bodily fluids mean tissues in your head swell and you struggle to smell or taste things properly – just like having a cold. So astronauts often prefer spicy foods, and tend to eat breads like tortillas that don't crumble. Practically all the food on the ISS is pre-packaged and is simply rehydrated and heated up – imagine eating nothing but airline food for months on end. Every six months or so, a resupply vessel is launched from Earth to deliver essential stocks. It's stuffed with food, water, spare clothes, fuel, oxygen and so on.

But, for longer space missions, such as a Moon base or mission to Mars, constant resupply would be prohibitively expensive or outright impossible. We've seen already how hibernation technologies in the future may allow crews to sleep on the way to Mars, and so relieve the necessity for a large amount of travel food, but, when they wake up on arrival, food will once again be a priority. Instead of relying on deliveries from Earth, Mars colonists would need to learn to be self-sufficient – to become space farmers!

In the film *The Martian*, Matt Damon's character cultivates potatoes in regolith (the powdery rocky surface) mixed with his crewmates' excrement to provide nutrients. And this isn't too far off the truth of what space agencies are considering for habitats on Mars (minus the poo). For example, last year, scientists at Wageningen University in the Netherlands made simulated Martian soil and tested which crops could be grown in it. They found that tomatoes, peas, radishes, rye and rocket grew well, but spinach struggled. They are now testing whether potatoes and beans could be cultivated on Mars. The environment is so hostile you would need to provide pressurised, inflatable greenhouses, but scientists remain hopeful that future Martians could live off the land.

And what about meat? Keeping farm animals on an off-world base would be enormously difficult – they would take up a huge amount of space and resources. So instead, future space explorers are likely to be mostly vegetarian, and get small amounts of animal protein from bugs. Insects can be reared in high-density and fed on plant waste. Taikonauts on China's Tiangong-2 space station have been raising silkworms, which could serve as a protein-rich source in the future. So perhaps future Martians will be eating bug burgers in home-grown wheat buns with lettuce and tomato!

Prof Lewis Dartnell is an astrobiology researcher at the University of Westminster and author of *The Knowledge: How To Rebuild Our World After An Apocalypse.*

INDIA'S WILD WEST

The Rann of Kutch in Gujarat, India, has one of the largest salt deserts in the world, but experiences great change when the monsoon arrives. **DHRITIMAN MUKHERJEE** spent 170 days photographing the unique flora and fauna of this area

TEXT BY JANAKI LENIN

Desert fox cubs stand outside their underground den in Little Rann of Kutch. Smallest of three subspecies of the red fox, the solitary desert fox finds a mate in autumn. The vixen gives birth to between four and six cubs and nurses them in a designated nursing chamber. Ten days later, the youngsters venture out of the den while their parents keep a close watch. By late summer, the cubs have become independent.

TOP: A striped hyena lopes across the dry plains of the Rann. Despite being nocturnal, the species is also known to venture out during the day. It likes to live in caves, digs its own den, or moves into burrows made by other animals. Well-known for its scavenging habits and bone-crunching ability, the species also brings down its prey by attacking its flanks.

ABOVE: The salt-encrusted and fossil-embedded sandstone in the Layari riverbed has been eroded by water. Located in the Great Rann of Kutch, these rocks date to the Jurassic period. The River Indus flowed into the Great Rann until 1819, when an earthquake changed its course westward. The sea receded and left a swathe of saline swamps in its wake.

ABOVE: Short-eared owls have tufts of feathers resembling ears. When they are defensive, these 'ears' stick up perceptibly. The bird of prey nests on the ground between March and June.

LEFT: A migrant European roller kills a toad before swallowing it. In the autumn, some populations migrate to Africa through western India. Although they are insect eaters, they also prey on reptiles, amphibians and rodents. Males perform aerial acrobatics during courtship.

RIGHT: A desert fox cub dashes from one burrow to another. The light pelage provides excellent camouflage, but a cub is vulnerable outside the den. Until it becomes independent, its parents feed it regurgitated gerbils and other rodents.

ABOVE: A collared hedgehog rolls up into a ball, the typical defensive posture. The spines protect it from predators such as foxes, mongooses and owls. Endemic to South Asia, it doesn't hibernate during winter, unlike its temperate-zone cousins.

RIGHT: An Indian wild ass gallops across the flooded Rann. It is one of the fastest animals in the country, clocking between 70 and 80 kmph. During the rains, when the Rann becomes flooded, the asses graze on islands of grass. This is also the season when jacks seek out jennies in oestrus.

ABOVE: Bar-headed geese winter here. They hold the record for flying at the highest elevation. In autumn, they move south from their breeding grounds in Mongolia and the Tibetan Plateau over the high passes of the Himalayas, reaching altitudes of up to 6,400m.

LEFT: Bajana, the southern shore of Little Rann, is drenched during the rains. The Rann of Kutch, one of the largest salt deserts in the world, is a vast transitional area where marine and terrestrial ecosystems meld. 'Rann' means 'desert' in Hindi, but, during the monsoon, it stays flooded for a month.

Indian wild asses once ranged from south-east Iran to western India. In 1958 to 1960, an epidemic of *equine trypanosomiasis* decimated the population to just 362. Today, about 4,800 wild asses roam parts of Gujarat and the neighbouring state of Rajasthan. Illegal salt manufacturers and invasive Mexican mesquite trees threaten the species.

LEFT The lesser flamingo is the smallest species of flamingo and also the most numerous. It lays one egg on a mound of mud. Chicks are white and become pink as adults. The crustaceans they catch by stirring up the mud with their feet give them the rich colour.

RIGHT The osprey is, after the peregrine falcon, the world's most widely distributed raptor. It wheels high in the sky, scouting for its favourite prey before swooping to catch the fish with its spiny-soled feet.

DHRITIMAN MUKHERJEE is a wildlife photographer and co-author of *Magical Biodiversity of India* (*http://dhritimanimages.com*).

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PHOTO: GETTY IMAGES

DO SOCIAL NETWORKS MAKE US ANTISOCIAL?

Many of us have experienced the ways in which social media has changed the online world. But should we be worried about it altering our behaviour too?

WORDS: DR DEAN BURNETT

Dean is a doctor of neuroscience at Cardiff University. His debut book, *The Idiot Brain*, is available now. You can follow him on Twitter @garwboy

RECENTLY, I witnessed the unpleasant breakdown of a relationship. One partner accused the other of infidelity and promiscuity; the other retaliated with claims of emotional abuse, drunken behaviour and an inability to perform sexually. All this, in much more sweary language than that conveyed here. It got nasty fast, with children being dragged into it, and friends taking sides and furiously rowing with those who'd taken the other side. All very grim, and it made me vow to avoid any and all of those involved as a result.

That wasn't difficult though, as I'd never actually met any of them to begin with. This whole breakdown happened on Facebook. Some friends of friends had asked to add me to their network, I'd unthinkingly agreed, and thus I ended up with a front-row seat to their hideous break-up. Ironic, that a social network was essentially responsible for the destruction of so many social bonds.

You've no doubt heard many complaints about social networks before. They're time-consuming, invasive, confusing, compromise your privacy and so on. But do they actually make us antisocial? Is there any credibility to that claim?

If, like many do, you draw a clear line between online interactions and real-world interactions, with more importance being placed on the latter, then, yes, arguably there is. But, to really get to the heart of the matter, you have to look at how social networks affect our behaviour and actions towards other people. They can and do have significant impacts on these things, because of the way our brains work. The truth: our social interactions, both online and in person, have a huge effect on our thinking and cognition. The social brain hypothesis, first put forward in the 1990s by anthropologist Robert Dunbar, suggests that our sociable nature is why we have such big brains to begin with. The argument is that primitive humans banded together in communities, and this cooperative approach proved very useful for our survival. But this lifestyle requires a lot of information to be processed; who do you trust? Who will help you? Who owes you favours? And so on. A substantial amount of detail needs to be available at a moment's notice. Basically, you need a lot of grey matter to maintain this. That's the theory, anyway (and there are others).

"THE TRUTH IS THAT OUR SOCIAL INTERACTIONS, BOTH ONLINE AND IN PERSON, HAVE A HUGE EFFECT ON OUR THINKING AND COGNITION"

In support of this, brain imaging studies have shown a network of regions, including cortical midline structures and tempero-parietal junctions, which show increased activity when the subject contemplates being part of a group. Areas like the ventral medial prefrontal cortex and anterior cingulate cortex show increased activity when processing our sense of self, our identity, and when processing awareness of the groups or communities we feel we're part of. This all suggests our social interactions are a major component of our identity, at a very fundamental level.

SOCIAL BUTTERFLIES

Humans need social interactions. Depriving humans of social contact, as when prisoners are sent to solitary confinement, is recognised by psychologists as a form of torture. On the other hand, too much social interaction isn't good either. Social interaction is mentally taxing: engaging with someone is a lot of work for the brain, as it requires mental effort. This explains the apparent contradiction between humans needing social interaction, but also needing privacy. Social interaction wears our brain out, so we need privacy to get away for a bit and 'recharge'.

All this shows that the brain strikes a precise balance to ensure we get the most from our social interactions. But, just as putting 10 times the required amount of sugar into a cake doesn't make it 10 times better, so social networks can amplify aspects of socialising and social relationships in ways that are unhelpful, if not downright harmful.

As early as 2010, professional psychiatrists were arguing that social network addiction was a real phenomenon that should be classed as a clinical disorder, citing a case study of an individual who spent five hours a day checking Facebook, rarely leaving the house to do so, losing jobs and, in one case, interrupting the therapy consultation to ▸

1. Compared with other animals, including our closest relatives, we are quite friendly

2. Dopamine is released by the brain when we enjoy a successful social interaction, giving us a rush of pleasure

3. We can control how we portray ourselves online by only posting the best updates, videos and images

PHOTOS: SCIENCE PHOTO LIBRARY, GETTY X2

Social networking can trigger reward pathways in the brain, and may lead to addiction

We are social creatures – isolation is used as a form of torture and can warp the mind

check their updates – tantamount to opening a beer during an AA meeting. It essentially means cutting off all other forms of social contact to focus solely on social media, to the detriment of your overall existence.

There are explanations for this. A successful social interaction means we experience a real-world reward in the brain. Oxytocin release gives a general sense of well-being and connection, and the mesolimbic reward pathway, buried deep in the centre of the brain, releases dopamine, giving a rush of pleasure. Some argue – and a few studies even provide some evidence – that a successful social interaction online, such as a popular Facebook post or widely shared tweet, can also produce this positive response in the brain.

Unfortunately, these social 'hits' are a lot easier to get online, without all the effort of 'normal' social interactions. Drugs operate on similar principles, triggering the reward pathway, but without the hassle of actually doing the action that the brain would consider deserving of a reward. Over time, the brain adapts to expect these pleasurable signals, and does things like disrupt the areas responsible for inhibitions or conscious self-control to keep them coming. Indeed, a 2013 neuroimaging study at the University of Zurich led by psychologist Dr Katrin Preller revealed that cocaine addicts have diminished activity in areas like the orbitofrontal cortex, resulting in reduced emotional empathy and willingness to socialise. So, if social network addiction is exploiting similar mechanisms to cocaine addiction, social networks may well be having an ironically negative impact on individual's ability to socialise, rendering them more antisocial. More research is needed.

CONTROL FREAKS

Another issue is that people have a greater deal of control over their interactions online, meaning they can decide, to a much greater degree, how others experience them. You can put up only good photos, delete unwise comments, spellcheck, share smart memes, and so on. This satisfies an underlying process the brain engages in known as 'impression management', where we're constantly compelled to present the best possible image of ourselves to others, in order to make them more likely to approve of us.

A 2014 study led by the University of Sheffield's Dr Tom Farrow looked at impression management. Using scanning technology, the team asked subjects to choose behaviours that would make people like them, and that would make people dislike them. Activation was recorded in regions including the medial prefrontal cortex, the midbrain and cerebellum, suggesting that these brain regions are involved in processing the image of ourselves we want to present to others. However, these areas were only noticeably active when subjects tried to make themselves

"AS EARLY AS 2010, PSYCHIATRISTS WERE ARGUING THAT SOCIAL NETWORK ADDICTION SHOULD BE CLASSED AS A DISORDER"

look bad – that is when they were choosing behaviours to make people dislike them. If they were choosing behaviours that made them look good, there was no detectable difference to normal brain activity. Coupled with the fact that subjects were much faster at processing behaviours that made them look good as opposed to bad, the conclusion was that presenting a positive image of ourselves to others is what the brain is doing all the time! It's the brain's default state.

Granted, it was a small and limited study, but it's an interesting outcome nonetheless. And if we're constantly focused on presenting a positive image of ourselves, it's no wonder social networks are so popular, as they offer a much greater sense of control of how we come across.

But this control is a double-edged sword. Even if you're just sitting with friends, the tendency to check your phone rather than talk can be overwhelming. The brain is usually averse to risk, preferring predictable options over less certain ones, and the cool, calm interface on the screen is often subconsciously more reassuring than the chaotic conversation going on around you. The people you're with may consider this behaviour antisocial. And rightly so.

More worryingly, a 2015 survey of men aged 18 to 40 by Jesse Fox and Margaret Rooney in the journal *Personality And Individual Differences* revealed that the amount of time spent on social networking sites, posting selfies and, revealingly, editing selfies to make them look better, was correlated with traits like narcissism and psychopathy. This isn't to say social networks cause these things, but they offer an outlet, a way for them to be expressed free of consequence, where they may otherwise be criticised or challenged, thus ensuring more socially acceptable behaviours.

Another intriguing finding, from a 2015 study led by Prof Joy Peluchette at Lindenwood University, was that certain types of behaviour on social networks – namely extroversion and 'openness' – actually increase the odds of being a victim of cyberbullying. It may sound counterintuitive, but it makes a certain amount of sense. A person may typically keep their more flamboyant or expressive natures suppressed, because social norms deter such things. Subtle signs of discomfort in those around you, awkward body language and responses, muted atmospheres… these all act to keep gregarious or overly personal tendencies in check, to some extent.

However, such cues aren't present online, so you can be as overly expressive or personal as you like on there. But other people may find this unsettling or off-putting, or could see it as cynical attention-seeking. Either way, they react aggressively, and attack the person. But social networks also protect the attacker from the consequences of their actions, introducing a distance and degree of anonymity between themselves and their victim, shielding them from the immediate effects, but supplying the same 'rush' of having lowered someone's status and boosted their own. So social networks again become a way to facilitate and perpetuate antisocial actions.

Spending time socialising with people can be hard work for the brain

Social networks also give us the ability to pick and choose what we see and hear from others, meaning we can end up in the oft-cited 'echo chamber'. Social networks make it much easier to form groups, and constantly remain part of them. This can give us a more 'extreme' leanings, making more intolerant of contrasting views as we grow unused to encountering them. What should be a casual meet-up in a pub can become a blistering row about a football team. Antisocial behaviour, caused by social networks.

It's not all doom and gloom. More nervous or socially awkward people can be liberated by the controlled and organised communication offered by social networks, and great friendships and relationships can form across the world now that would never have been able to exist before. But the truth is, for all that they may sometimes not work that well, the human brain has evolved a variety of systems to make sure social interaction happens as efficiently as possible. Social networks, though, throw many spanners in the works here, causing overall disruption, which can sometimes mean they end up achieving the opposite of what they're built for, and making people antisocial.

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PHOTOS: GETTY X3

ROBOTS ARE EVERYWHERE THESE DAYS, BUT HOW CLOSE ARE THEY TO THE NEXT NATURAL STEP IN THEIR EVOLUTION –THINKING FOR THEMSELVES?

WORDS: DR PETER BENTLEY

ILLUSTRATION: PHIL TOLEDANO

"OUR INTELLIGENT AUTOPILOT SYSTEM IS CAPABLE OF PERFORMING MANY PILOTING TASKS WHILE HANDLING SEVERE WEATHER CONDITIONS AND EMERGENCY SITUATIONS"

ROBOTS are customarily portrayed in sci-fi movies as futuristic creations that walk on two legs and think like a human. But this isn't really an accurate portrayal, as we've been using robots of one kind or another for some time – they just look a bit different. Some of the earliest programmable machines ever invented were looms made to weave fabric in the early 1800s, while robot arms have been used in our factories since the 1960s, and the military have used robotic weaponry such as cruise missiles since WWII.

In fact, these days, our everyday lives are practically overrun by robots hiding in plain sight. Our dishwasher is a robot that stands permanently in the kitchen, washing away the remnants of our meals; our vehicles are robotic devices that listen to the movement of our hands and feet, and manage the firing and transmission of a combustion engine, the movement of suspension, and the braking of wheels. Even our alarm clocks are little robots that follow a simple programme to make sure we wake up at the right time. But how close are we to creating the thinking machines of science fiction?

ROBOT SEE, ROBOT DO

In the last few years, a sea change has begun to take place. Breakthroughs in artificial intelligence and 'machine learning' research are now allowing us to create devices capable of more than following a set of simple instructions – these robots are capable of learning for themselves. For example, the new generation of cars can study our driving styles and adjust how they respond to us. Some can park themselves, perform emergency braking, or drive themselves on motorways. The best digital recording devices can now anticipate or predict the kinds of programmes you might want to watch, and store them without you even asking them to.

And this is just the beginning. Take 'Paul', a portrait-drawing robot that was created by London-based artist Patrick Tresset. Paul understands what it sees by using a software simulation of the neurons used in the human brain's visual cortex – the region that processes information from our eyes. Paul finds the important features and draws what it sees, using lines of different lengths. The images that are produced have a sketch-like quality that makes them almost impossible to distinguish from something that's been drawn by a human.

"Trying to do anything that a human does with a robot makes us realise the complexity of the tasks we perform naturally without thinking," explains Tresset. "It also shows us the complexity of physical reality."

It's one thing to paint a portrait on a fixed canvas, but it's quite another to learn the skills of our most highly-trained and responsible professionals. For example, could an AI ever fly a passenger plane with the same skill as a human pilot, and keep the passengers safe no matter what? Computer scientist Haitham Baomar thinks it could. His research at University College London adds an additional layer of intelligence to aircraft autopilots, enabling them to cope even when the aircraft is faced with unpredictable weather or damage.

"Our Intelligent Autopilot System is capable of performing many piloting tasks while handling severe weather conditions and emergency situations such as engine failure or fire, rejected take-off, and emergency landing, which are far beyond

PHOTOS: PHILIP EBELING, GETTY ILLUSTRATIONS: JOE WALDRON

LEFT: In the last few years, we've seen cars that can drive and park themselves

FAR LEFT: Patrick Tresset with Paul, the robot that can draw portraits

the current capabilities of modern autopilots," explains Baomar.

The AI uses a neural network that operates in a similar manner to the human brain, with many different neural nodes arranged in tiers and each one solving a different part of the task simultaneously. Each successive tier recieves the output from the previous tier rather than the raw input. The nodes each have their own bank of knowledge built up from their original programming rules, plus anything they've experienced.

Just as a human pilot may be simultaneously using one part of their brain to move muscles, one part to assess instruments and another to speak, the AI uses many separate parts of its brain to solve all the different problems of flying. The AI learns directly from observing human pilots, watching their every move in microscopic detail in order to learn how to cope with whatever gets thrown at it. It can then apply those skills .to novel situations, flying new aircraft in scenarios and conditions that it has never seen previously. The system is designed to complement human pilots rather than replace them, but Baomar hopes the AI will improve air safety dramatically.

IRON CHEF

Researchers at the University of Maryland have taken a similar observational approach and used it ▸

WHAT IS MACHINE LEARNING?

Machine learning is a type of artificial intelligence that focuses on enabling a computer to learn new information all by itself. Some learning methods allow computers to find patterns in large amounts of data, such as identifying similar sets of genes across a selection of DNA sequences. Others can cluster data into different groups, allowing them to find different patterns of fraud or normal behaviour in credit card transactions, for example.

Others are taught to recognise data by viewing many different examples, so they can understand text or different objects in a video. Still others learn the 'shape' of data so that they can predict what might come next, enabling them to anticipate where an object may move, or how the stock market might change.

Over many decades, all these different learning methods have grown from two main sources of inspiration: statistical mathematics and biology. Most recently, some of the biology-inspired methods such as genetic algorithms (based on natural evolution) and deep learning (inspired by the way that neurons learn in the brain), combined with some clever new maths, have produced some of the most impressive results we've seen in robotics.

ABOVE: Robot chefs could spell the end of sweating over a hot stove

FACING PAGE: Dr Rana el Kaliouby demonstrates emotion-sensing technology used by her company's artificial intelligence

in the kitchen. Their robots can watch videos of people preparing and cooking food, and, by doing so, learn to perform similar actions.

"We use neural networks to acquire knowledge for our robots by learning the functionality of objects," says Prof Yiannis Aloimonos. "Can this tool be used for scooping; can this object be used as a container? Our neural networks look at many examples and they have been taught to make geometric calculations. The combination of deep learning with geometry leads to recognition of the action being performed."

These AIs learn the underlying 'grammar' rules of action so that they can achieve their intended goal without necessarily needing to perform identical motions. For example, the rules of stirring using a spoon to repeatedly mix a liquid in a pot apply to any liquid and any pot. A simpler AI might only learn how to use one specific spoon for one specific pot, containing one specific kind of soup. This higher-level thinking using such grammar rules is then combined with a large number of processes that track and monitor the hands, the objects, tools and their movements, all continuously running in the background. "All of this implemented in a robot gives rise to the robots of the future that 'understand' the humans around them, and learn from them," explains Aloimonos.

Baomar thinks this form of robotic learning can find countless practical applications. "I believe that, if we give robots the ability to learn from humans or even from other systems, the outcome should be intelligent robots that are capable of learning a wide spectrum of skills, ranging from domestic chores to performing surgery and flying complex machines," he says.

COME WITH ME IF YOU WANT TO LOVE

So the robots of the future are likely to be capable of learning and performing complex, highly-skilled tasks. But how about emotions? Humans are complex creatures, unpredictable and often not entirely rational. Our emotions are just as important as our intellect in driving our actions. Affective computing – software that recognises and interprets our emotions – and human-computer interaction has started to enable AIs to detect emotions.

"We know from years of research that emotional intelligence is a crucial component of human intelligence," says Dr Rana el Kaliouby, CEO of artificial intelligence company Affectiva. "People who have a higher Emotional Quotient [EQ] lead more successful professional and personal lives, are healthier, and even live longer."

Affectiva is using deep learning, a special kind of neural network containing many layers of neurons, to enable computers to detect our

PHOTOS: VOA NEWS, AFFECTIVA ILLUSTRATIONS: JOE WALDRON

emotions from our faces. Their AI is trained on a vast database of more than half a million faces analysed from people in 75 countries, with 50 million new emotion data points – a face expressing emotion such as happiness, sadness or surprise – being added every day.

"We are giving machines the ability to sense and respond to human emotion, something that is deeply human but that today's technology has not been capable of doing," says Kaliouby. "We like to say we are bringing AI to life!"

Tomorrow's robots will not be mere machines, cold and heartless. They will be emotionally aware – and it will happen soon, researchers say.

"I think, in three to five years, we will forget what it was like when our devices didn't understand emotion," says Kaliouby. "It's similar to how we all assume that our phones today are location-aware. Someday soon, it will be the same for emotions."

Tresset wonders what the robots that learn will be able to do in the future. "Robots can already learn, but, as long as they are not able to take the decision to produce art, they cannot be seen as artists. Intentionality is very important in art," he says. "If a robot on an assembly line starts to hit a car to produce a sculpture, then will it be an artist? If a military drone starts to dance in the sky, will it be an artist?"

"When we design intelligent robots," says Aloimonos, "it is as if we are trying to understand ourselves – it is what the ancient Greeks referred to as 'gnothi seauton' ['know thyself']. This quest will never end."

"I THINK IN THREE TO FIVE YEARS WE WILL FORGET WHAT IT WAS LIKE WHEN OUR DEVICES DIDN'T UNDERSTAND EMOTION"

Dr Peter Bentley is a computer scientist and author based at University College London.

FIVE OF THE SMARTEST ROBOTS IN HISTORY

1966 ELIZA

One of the first examples of a chatterbot. When running a script dubbed DOCTOR, ELIZA could ask and answer questions like a psychotherapist. It didn't understand a great deal, but, with some clever programming, was still able to convince many users of its intelligence.

1994 VIRTUAL CREATURES

Computer artist and researcher Karl Sims created a group of virtual creatures that inhabited their own virtual universe. Using genetic algorithms, they evolved until they could swim, crawl, jump and compete against one another. Unfortunately, they were too concerned with their own virtual lives to talk to us.

1997 DEEP BLUE

Deep Blue was catapulted into public consciousness when it won a chess game against grandmaster Garry Kasparov – the first supercomputer to achieve such a feat. However, it was given a lot of help from human programmers and used pretty basic AI methods to think of its moves, so maybe it was not so bright after all.

2011 IBM WATSON

IBM Watson was the first AI to beat human players at the US TV quiz show *Jeopardy!*. This AI was clever enough to process text and then found likely answers to the questions asked using its internal body of knowledge, which comprised around 200 million pages of content. Sadly, it struggled to answer some basic questions.

2015 DEEP-Q NETWORK

This earlier work from the team behind AlphaGo, the AI that defeated a master of the complex Japanese strategy game Go, learned how to play 49 classic Atari games just by looking at the screen – it didn't get any help from programmers. While it was brilliant at a lot of the games, it couldn't get the hang of Pac-Man.

SHOULD WE LET PANDAS GO EXTINCT?

These black and white bears have been a conservation mascot for decades. But do they have a right to hog the limelight?

WORDS: JULES HOWARD

THERE is a skull that sits on a shelf on our wall. There is a hint of antiquity to it, though I must confess that it is a replica. Upon noticing the sharp teeth, children assume it is from a dinosaur. They place it on their heads and go "ROAR!". Adults know better: they assume it is from some sort of cat, because they see its large canine teeth.

They are both wrong. Neither the adults nor the children ever notice the molars that have become stretched wide like those of a horse – an adaptation forged in the depths of China's bamboo forests to combat starvation. For the skull is actually that of an herbivorous bear: a giant panda, of course. There is always surprise when I tell people this, it's as if they've completely forgotten that there are bones under the skin of this celebrity teddy bear. This is understandable, because the panda has become so much more than just 'a bear'.

Pandas are a conservation mascot, a marketing tool, a symbol of the wild we are losing, and a conservation big-hitter worth paying to save. Or so we're told. Yet, after five decades of our conservation efforts, they have offered us little 'bang for our buck', and a bitter frustration has begun to play out publicly about their worth in recent years. Like Premier League footballers who fail to live up to their hype, nasty slurs about the pandas have crept onto the pages of newspapers and websites, blaring things like "Stuff the pandas!". Meanwhile, wildlife presenter and naturalist Chris Packham has lamented their costly conservation as pointless and said we should "let them go with a degree of dignity".

But are they really a pointless animal? Do they have worth? These are interesting questions to dwell upon, for, if you look closely at pandas, you begin to understand that wildlife conservation is far from just black and white. It is shades of grey, and is only given value by us.

A CUDDLY CONCEPTION

Let's start at the beginning. How did pandas come to capture the public's imagination? What is it about them that we came to love?

In 1966, while panda conservation was still in its infancy, zoologists Ramona and Desmond Morris put together a list of why pandas would come to creep into the public consciousness in their book *Men And Pandas*. Included in their ▸

PHOTO: GETTY

"IN 2016, HUA YAN BECAME THE SIXTH PANDA TO BE RELEASED BACK INTO THE WILD"

list was the fact that pandas (appear to) have big eyes; that they sit up vertically like us and have no tail; they are playful and round; and they lack any obvious sexual features that "embarrass the human eye and work against the animal's popularity". According to the authors, pandas spent millions of years of going it alone on their own evolutionary journey, and then they hit the publicity jackpot simply because natural selection happened to produce a creature that we humans consider cute and unthreatening. *That* was all it took.

The rest was history. We responded to news of their downward spiral by showering them with concern and cash. And we still do.

Today, panda conservation is big business. Although official financial figures from China are hard to come by, wild panda conservation is aided in part by the rental costs of captive pandas, which are housed in zoos around the world at a cost of hundreds of thousands of pounds each year.

Scotland's Edinburgh Zoo, for instance, pays £600,000 annually for the privilege of housing two pandas named Tian Tian and Yang Guang. Extrapolating up conservatively, the contribution to wild panda conservation from captive pandas in zoos comes to over £20m each year.

Are pandas worth it, then? Is all of that money being well spent? That depends. If your definition of success is the reintroduction of captive-bred pandas to the wild, then the answer is probably no. In 2016, Hua Yan, a two-year-old panda bred in captivity, became the sixth panda to be released back into the wild, and that's after 50 years of effort. No real success there then – or at least not yet.

But, if your definition of success is about panda numbers in the wild, then, yes, undoubtedly, there is reason to be cheerful, for wild panda numbers appear to be rising at last. In 2003, there were only 1,600 wild pandas remaining. Now, 14 years later, there are nearer 1,850 – an increase of 16 per cent. In fact, as of

September 2016, giant pandas are no longer considered officially endangered, they are now listed as merely 'vulnerable' by the IUCN, the global record-keepers of the fates of dwindling species. Thanks to a marked decrease in poaching and an expansion in the species' protected habitat, the future of China's wild pandas looks more secure than before.

It is likely that this trend will continue, so one could argue that the conservation money has been a great success. A species has been saved, by us – or at least by those people who visited zoos to gawp at captive pandas, or gave money to the international wildlife charities that represent them.

STEALING THE LIMELIGHT

But £20m or more each year. That's a vast amount of money. Could that cash be better spent elsewhere? After all, there are many other species far more threatened than pandas on the IUCN's list, few of which may be granted more than a few thousand pounds between them in terms of conservation money.

What about the Nubian flapshell turtle, for instance – a funky-looking reptile whose numbers have fallen by 80 per cent in just two generations? Or the Kurdistan newt, which is restricted to just four streams in an area covering less than 10sqkm? Or my personal favourite,

PHOTOS: PRESS ASSOCIATION, NATIONAL GEOGRAPHIC/AMI VITALE

the geometric tortoise – another critically endangered creature afforded little by way of public understanding or interest. When it comes to wildlife campaigns asking for your cash, these species are unlikely to appear in the advertisements. Couldn't they do with some of our cold hard cash too? The answer is yes, of course they could.

A 2012 analysis by conservation scientist Dr Robert Smith and colleagues highlighted just how hard it is for many threatened species to get the airtime they deserve. Of the 1,200 mammals then threatened with extinction, just 80 species were used by conservation organisations to raise funds. And which species did they use? Predictably, it was generally those creatures that had large, forward-facing eyes.

This was a particularly depressing finding. The message that reads loud and clear is that we hold up a magnifying glass to nature, and see only our own reflection in the glass. We buy cute and always have – and the marketeers know it. In this way, it is probably true to say that pandas benefit from having a body that's shaped like a teddy bear. The Kurdistan newt just cannot compete. But this is not the fault of pandas – it's the fault of humans for being so easily fooled.

SAVE THE PANDA, SAVE THE WORLD

At this point, let's consider the argument from the other way around. Why *shouldn't* conservation organisations use the marketing power of pandas to further their worthy aims? What's so bad about cashing in on a beautiful bear if, by saving it, we may save thousands of other species with whom it lives in the wild?

For this reason, pandas and certain other 'charismatic megafauna' are often given special value, because they can act as 'umbrella species'. The argument goes that if these animals are protected, then so too are the other creatures that live within their shared habitats. Looking after a bear or a cheetah or tiger, for instance, protects everything else – the spiders, birds, lizards, mites and frogs – that may happen to ▸

ABOVE: Scientists don costumes and douse themselves with panda pee in an attempt to prevent the animals becoming attached to humans

FACING: Zoologist Desmond Morris said that we love pandas because they're playful, appear to have big eyes, and look cuddly

ABOVE: The geometric tortoise and the Kurdistan newt don't receive much funding, despite being critically endangered

share the same habitat, but that no one really cares enough about.

Conservationists use this argument quite a lot, so how does the 'umbrella species' claim stack up? Pretty well, at least in theory. A 2015 study by Prof Stuart Pimm and Binbin Li from Duke University highlighted that protecting the giant panda's habitat enhances the survival prospects of many other species, including 70 per cent of forest birds, 70 per cent of mammals and 31 per cent of amphibians found nowhere else on Earth. But, while the umbrella analogy is laudable on paper, some conservationists have mixed feelings about it. "Habitat protection is pretty vital," argues Anne Hilborn, a carnivore biologist from Virginia Tech, "but many species face lots of other threats – overexploitation, pollution, climate change, disease – that preserving habitat alone will not protect against."

Habitats are more complex than we like to imagine, and they may not always remain unchanged once protected. Dr Sarah Henshall of Buglife, an NGO that focuses on the conservation of invertebrates, sees potential in using charismatic megafauna such as pandas to secure wider species protection but also urges caution.

"Improving the quantity, quality and connectivity of habitat will certainly benefit invertebrates," she explains. "However, the devil is in the detail. The rare stuff is rare for a reason – species may need very specific conditions and microhabitats to prosper, so a broad-brush habitat approach to saving species will not always work."

In other words, umbrella species do have their uses, but lesser species are bound to get wet in the face of relentless, driving rain made worse by

"WHAT'S SO BAD ABOUT CASHING IN ON A BEAUTIFUL BEAR IF, BY SAVING IT, WE MAY SAVE THOUSANDS OF OTHER SPECIES?"

PHOTOS: GETTY X2, ZIGMUND LESZCZYNSKI / NATIONAL GEOGRAPHIC

human interference. Ultimately, only the creatures holding the umbrella may stay dry. Pandas are one of them because, like it or lump it, we value them more than most. It's for this reason that their fortunes are finally on the up.

PANDAS WITH PURPOSE

Since the giant panda has been downgraded from 'endangered' to' vulnerable', I believe it has taken on a new role. As well as offering glitz and glamour, the panda is now one of the minority of creatures that is being saved. It is a success story, 50 years in the making, and it has happened on our watch. We should be much more proud of pandas than we are – we need more success stories like them.

Pandas have quite clearly been overused as a conservation character in recent decades. But perhaps as audiences become more savvy and questioning about the dreams they are being sold, we will see new umbrella species that come to dazzle us, and we'll attain a wider, deeper understanding of how conservation really works.

I really hope so. For I can't help but wonder whether in the future it may not be us that saves the panda, but the pandas that end up saving us. If these much-loved bears can encourage us to look after our ecosystems, then we could make the world a healthier place and improve our chances of survival.

Pandas, like this tiny, three-month-old cub, are incredibly difficult to breed in captivity

PHOTOS: GETTY X3

WHAT YOU NEED TO KNOW BEFORE YOU GET IN A DRIVERLESS CAR

ILLUSTRATION: BEN THE ILLUSTRATOR

Autonomous vehicles can take much of the danger out of driving, but they also present us with new problems to solve. So what needs to be figured out before the technology gets the green light?

WORDS: ROB BANINO

REMOVE humans from the driving equation and cars will be safer. That's the thinking behind the push for autonomous vehicles – and the reason why, like it or not, they're coming to our roads.

"Autonomous vehicles reduce the risk of collisions, and that's recognised by insurers," says Ian Crowder from the Automobile Association (AA) in the UK. "If the technology proves to be much more reliable than humans, who can be subject to tiredness, stress or distraction… there's every possibility that situations that would typically lead to collisions will be removed."

Safer cars and safer roads are attractive prospects, in both human and financial terms. According to the Department of Transport and the Department of Business, Innovation and Skills, the intelligent mobility market is estimated to be worth £900bn annually globally by 2025. This is why car manufacturers are pushing to develop the vehicles, and why the UK government is investing heavily to help them. Last year saw £39m of a £100m fund awarded to projects working on enhanced communication systems between vehicles and roadside infrastructure, and trials of autonomous vehicles in Greenwich, Bristol and Milton Keynes.

But what's controlling these cars if there's nobody at the wheel? The short answer is a lot of extremely sophisticated technology. Audi, the first manufacturer to receive permits to test autonomous vehicles on public roads (in Nevada in 2013 and Florida in 2014), uses differential GPS (said to be accurate to within a few centimetres), 12 radar sensors (to scan the road in front of the car), four video cameras (to spot road markings, pedestrians, objects and other vehicles), a laser scanner (that emits nearly 100,000 infrared light pulses per second, covering a zone of 145° on four levels around the car to profile its surroundings) and a powerful computer to process everything the sensors detect. And all of those systems need to work together so that the car always knows where it is, where it's going and what's around it.

SEEN IN A BAD LIGHT

Some of these systems have been shown to work, and have found their way into cars with adaptive cruise control or parking assist. But relying on them to safely conduct a journey on open roads alone is a big step. Still, it's a step that many companies including Tesla, Google, Fiat Chrysler, Renault-Nissan and Uber (with the help of Volvo) are in the process of taking. Although their efforts have, on the whole, been safer than normal cars (in terms of the number of accidents per miles driven), they have encountered problems. For example, Renault-Nissan's CEO Carlos Ghosn admitted to CNBC that the system in its vehicles is confused by cyclists "because sometimes they behave like pedestrians, and sometimes they behave like cars."

Meanwhile, the cameras on Tesla's vehicles have been said to struggle with the glare from sunshine, particularly at dawn or dusk. And sunlight's not the only natural phenomenon that can throw a spanner into the works: rain interferes with what a driverless car 'sees' through its cameras, and reduces the effectiveness of any laser scanners, as the drops can bend and reflect the light pulses.

Problems like these have led to some high-profile incidents. Last December, Uber had to withdraw the 16 test vehicles it was trialling in San Francisco after California's Department of Motor Vehicles revoked the cars' licences. The local authority said that the ride-hailing company didn't have a permit to operate autonomous vehicles on the city's roads, but its decision came after footage emerged of the vehicles running red lights and veering into cycle lanes. Then in March, Uber temporarily suspended its self-driving programme after one of its cars flipped onto its side in a crash in Tempe, Arizona.

Perhaps the most notable failure happened in May 2016, when a Tesla Model S running in Autopilot crashed into a truck in Florida, killing driver Joshua Brown. Tesla told investigators that the Autopilot was

"GIVEN THAT PEOPLE'S LIVES ARE AT STAKE IF AN AUTONOMOUS VEHICLE FAILS, PERHAPS THE ROADS AREN'T THE BEST PLACE TO TEST THE TECHNOLOGY UNTIL WE CAN BE SURE IT'S MORE RELIABLE"

PHOTO: GETTY X2, REUTERS

not at fault, but there had been a "technical failure" of the automatic braking system.

TESTING THE COMPETITION

Failures are to be expected during the testing and developmental phases. "It's only through using the technology and trying it in real life that it's going to be improved, because even the best developers are not going to recognise every possible scenario that an autonomous vehicle might encounter," Crowder points out. But, given that people's lives are at stake if an autonomous vehicle fails, perhaps the roads aren't the best place to test the technology until we can be sure it's more reliable. Especially when we could put autonomous vehicles through their paces in another way: motor racing.

"In many ways we're ahead of the industry," says Justin Cooke, the chief marketing officer of Roborace, the championship for autonomous electric vehicles that's expected to debut this year. "Roborace was developed to evolve technology that will be used on the road, and accelerate the speed at which both electric and autonomous technology is being tested for road cars."

But, despite the speed and competition, racing is arguably a less extreme test environment as there are no pedestrians, roadworks, junctions and ▸

ABOVE: Cyclists ride on roads and pavements, which can confuse the technology in autonomous cars

RIGHT: Autonomous vehicles use a wide variety of sensors to 'understand' their surroundings

crossings to worry about, and all of the traffic's moving in the same direction – albeit very fast. Hence, unlike the autonomous vehicles being trialled on the road, the Roborace cars won't have someone onboard to take control if something goes wrong. So what happens if a car goes awry during the course of a race?

"All the cars will be equipped with a 'safe stop' that the engineers control back in the pit," explains Cooke. "If the car goes off course for any reason, it can be brought to an immediate stop using this button. In fact, it's even safer than a human-driven race car, as the robocar can literally stop instantly, because there's no delay from a human reacting to a problem and then performing an emergency stop."

The cars' first competitive public outing in February brought mixed results. Two driverless cars took to the city-centre circuit ahead of the Formula E race in Buenos Aires but only one finished. The other overshot a bend and crashed into the barriers – although, encouragingly, the car that completed the race not only achieved a top speed of 186km/h (116mph) but also successfully avoided a dog that strayed on to the track.

THE BLAME GAME

Road-going autonomous vehicles don't have the luxury of a pit crew, however. Which is why the vehicles being tested on our roads need to have a qualified driver in the driver's seat ready to take control in case of an emergency. It's a policy that's likely to be retained if – or more probably when – autonomous vehicles are given the go-ahead, meaning you won't be able to stumble out of a pub drunk and expect your car to drive you home.

But this approach creates more conundrums: if the 'driver' isn't actually driving, doesn't that make them a passenger? And, if the driver fails to react correctly and has an accident, is it their fault or the car's? The more cynically minded might see this as a 'get out of jail free' card for manufacturers of autonomous vehicles. Uber blamed the instances of its cars running red lights in San Francisco on human error, and there are reports that Joshua Brown was watching a film when his Tesla crashed.

"It does raise issues for insurers, because you have the transfer of liability if there's a collision involving a driverless vehicle," says Crowder. "It's something that the insurance industry certainly needs to think about, and indeed *is* thinking about. If it's a software failure that leads to a collision, there need to be fairly robust procedures in place to ensure that such a claim can be met promptly, and that there are the processes in place to do that."

The Association of British Insurers is pushing car manufacturers to ensure that autonomous vehicles can collect core data in the event

HOW COULD DRIVERLESS CARS CHANGE MOTORING?

It's early days for autonomous vehicle technology but it has the potential to have some profound effects. Especially if it completely rules the driver out of the equation…

PARKING

Some cars already have 'parking assistance' that allows the vehicle to manoeuvre itself into tight spots. But they require the driver to be there 'just in case'. If a driverless vehicle could be trusted to park itself, it could drop you off at your destination and find a space on its own.

LEARNING TO DRIVE

It's likely that anyone operating a vehicle, autonomous or not, will still require some sort of training in order to do so. But the arrival of autonomous vehicles is expected to result in changes to the Highway Code and possibly the skills taught while a new driver is learning.

TAXIS

If a car can take you anywhere without you having to drive, why do we need taxi drivers? Uber has stated that its plan is to eventually operate an autonomous fleet. So while it may be goodbye to awkward conversations with drivers, there may also be considerable job losses.

SLEEPING

If autonomous vehicles reach a point where the controls can be entirely handed over to the car, there'd be no need to stay awake during the journey. You could simply get in, buckle up and nod off. That'd certainly make long highway drives a lot more pleasant…

TOURISM

You're visiting a city and you want to see the sights. Would you rather get on a tour bus, or hop in a car and let it ferry you from one destination to the next? While it might be fun to jump on an open-top bus, there's always the threat of rain spoiling the trip.

ROAD HAULAGE

Goods reach us aboard vans or lorries, but drivers can only be at the wheel for a specific number of hours each day. Autonomous vehicles could make long trips without rest stops. Faster journeys and greater fuel efficiency equals lower costs… and potentially another career in jeopardy.

PHOTOS: VOLVO, ROBORACE ILLUSTRATION: BEN THE ILLUSTRATOR

Volvo has been working on self-driving technology, using sensors that keep track of the road and surroundings

Roborace allows driverless technology to be tested, without putting drivers' lives in jeopardy

"IF – OR WHEN – AUTONOMOUS VEHICLES ARE GIVEN THE GO-AHEAD, YOU WON'T BE ABLE TO STUMBLE OUT OF A PUB DRUNK AND EXPECT YOUR CAR TO DRIVE YOU HOME"

of an accident, and that the information is made available to prevent drivers being unfairly blamed. The data would cover a period from 30 seconds before to 15 seconds after an incident, and provide a GPS record of the time and location of the incident; confirmation of whether the vehicle was in autonomous or manual mode; if, while in autonomous mode, the vehicle was parking or driving; when the vehicle went into autonomous mode, and when the driver last interacted with the system.

HIGH-TECH HACKING

But what if someone is controlling the vehicle who isn't the driver? In other words, what if an autonomous vehicle is hacked? This has already been proven possible with conventional vehicles: cyber security experts Charlie Miller and Chris Valasek have managed to take over various vehicles' electronic control units remotely. Hacking is therefore an enormous concern for everybody, not just in terms of losing control of the vehicle but also regarding what that vehicle could then be used for, as Crowder points out.

"[Hacking] is a concern and it's something that's often raised… it could open the way towards terrorism or other criminal activity. But that's a risk that's already there – with cars that have keyless technology, for example. Certainly, the manufacturers will need to be on top of the technology to make it hack-proof, but everybody knows that car thieves are often one step ahead," he says.

Being "one step ahead" means that the people who abuse the technology – the thieves and hackers – are often the ones who can design the best security systems. Uber certainly thinks so: the company hired Miller and Valasek shortly after they demonstrated what they could do to a car being driven miles away, using only a laptop.

Although autonomous vehicles have the potential to make our roads safer, there are still a lot of bugs to work out with the technology, and questions to answer regarding its use. The only thing we can say with any certainty is that it's going to be a long time before the human element is completely taken out of the driving equation.

Rob Banino is a freelance science and technology writer.

King Arthur | The Big Questions

IS KING ARTHUR a historical figure?

Did he fight Roman troops in France – or Anglo-Saxon invaders in Britain? AND WHERE IS CAMELOT?

A new film about King Arthur has been released. Nick Higham answers some of the most pressing questions on the iconic warrior-king

IS IT POSSIBLE TO SAY WITH ANY CERTAINTY WHETHER OR NOT A HISTORICAL ARTHUR EXISTED?

There is no shortage of modern books claiming to reveal the 'real' Arthur. They place him in locations and historical periods as wide-ranging as pre-classical Greece and Roman Dalmatia to 'Dark Age' Britain. British Arthurs remain the most popular, but they are far from mutually compatible – identified with regions as far-flung as Cornwall and Argyle. In fact, there are so many of them that they tend to cancel each other out.

Academic specialists often argue that Arthur was purely a figure of mythology, or they suggest that, while he *may* have existed, we're not in a position to say anything more about him. Such fence-sitting overlooks the fact that it is the responsibility of those coming up with theories to prove them, not of others to disprove them. Until there is a broadly accepted theory on offer that sits comfortably with

ABOVE: Arthur depicted in a 12th-century floor mosaic in Otranto, Italy

FACING PAGE TOP TO BOTTOM: Arthur leads his troops into battle in a manuscript miniature from c1150; a c14th-century illustration shows the king and his knights seated at a round table; Arthur on his throne in Matthew Paris's c1250–52 *Flores Historiarum*

PHOTOS: AKG-IMAGES/GETTY IMAGES/BRIDGEMAN/ALAMY

the evidence, we should be sceptical of an Arthur doing any of the many things attributed to him.

WHAT ARE THE EARLIEST SOURCES WE HAVE FOR KING ARTHUR, AND HOW IS HE DESCRIBED IN THEM?

Potentially the earliest material to name Arthur is *Y Gododdin*, a collection of Old Welsh verses in the *Book of Aneirin*. Arthur appears in a verse honouring a British hero, Gorddur, about whom it's written, "though he was not Arthur". *The Book of Aneirin* was written in the second half of the 13th century but the reference to Arthur is in the least 'modernised' passages, copied perhaps from a text dating to c800–1000.

It's not clear what kind of figure the *Y Gododdin* had in mind when it referred to Arthur – was he a man or a demi-god? – but this poetry comes from the British Old North and is based loosely on sixth-century events. It is not impossible that this referred to Artúr, a Scottish prince who died fighting the Miathi (a people around Stirling) in c596. Arthur is better known, though, from the *History of the Britons* (*Historia Brittonum*), written in 829/30 in Gwynedd. Chapter 56 portrays Arthur as a British *dux bellorum* ('general of battles'), listing 12 'God-given' victories over the Saxons, which close with the battle on the "mountain of Badon", where he single-handedly kills 960 of the enemy. The *History of the Britons* was written 12 generations after the time in which the deeds were set, so it's essential that we explore what sources underlie it. It's been argued that the list of victories was extracted from a battle-catalogue poem of a type linked with other early Welsh leaders. But this doesn't seem particularly plausible to me. Many of the 12 battles in the *History of the Britons* are associated with other leaders and appear to have been lifted from earlier works. This implies that the list was made up by the author.

Finally, there's the *Welsh Annals* (*Annales Cambriae*), a 10th-century chronicle written at St Davids, which has two entries for Arthur. One reference – for his c516 victory at Badon – probably derives from the *History of the Britons*. But the entry for c537 introduces new material ("The battle of Camlann in which Arthur and Medraut fell…") so presumably came from a different source. Given that the *Welsh Annals* are 16 generations removed from events, there seems little reason to think the dates bear much historical weight.

THERE SEEMS TO BE A PAUCITY OF SOURCES FOR ARTHUR IN THE CENTURIES AFTER HE IS SAID TO HAVE LIVED. WHY IS THIS?

Assuming that we place him around AD 500, one explanation is that there is little material of any sort written in Wales that survives from this period. That many works have been lost is obvious. The majority of surviving texts are short inscriptions on stone, none of which name Arthur.

We are aware of narratives written by only two British writers of the period – Patrick and Gildas. Patrick's interests centred on his mission to Ireland and he was probably earlier than the conventional dating of Arthur. Gildas wrote a 'historical' introduction to his sermon, urging the Britons to return to the Lord and put aside their evil ways. This includes a brief account of the British/Saxon war up to the "siege of Badon mountain", in the year of his own birth. The *History of the Britons* described the battle of Badon as Arthur's finest victory but, in Gildas's account, Ambrosius Aurelianus was apparently the British leader, not Arthur.

There is, of course, another explanation for why Arthur is all but invisible in contemporary sources – and that's because he was not a real person doing important things at this time.

WHICH FIGURES ARE MOST OFTEN PUT FORWARD AS THE HISTORICAL INSPIRATION FOR KING ARTHUR? HOW PERSUASIVE ARE THESE CLAIMS?

The earliest historical figure to be identified as the 'original' Arthur is Lucius Artorius Castus, whose career is set out in two inscriptions from Roman Dalmatia, discovered at Podstrana in modern-day Croatia. Since the 1920s, there have been various attempts to portray him as the individual around whom the Arthurian legend developed.

More recently, it's been suggested that Castus led a group of Sarmatian warriors moved to Britain by the Roman emperor Marcus Aurelius in AD 175, then commanded them in a war against the Caledonians. But he served only as third-in-command of the legion at York, so is unlikely to have had experience of leadership in war in Britain.

Those wishing to establish a link between Castus and Arthur have interpreted the ▸

longer inscription to suggest that Castus led 'British' troops to Armorica (ie Brittany) – which is later reflected in the 12th-century writer Geoffrey of Monmouth's depiction of King Arthur leading his armies into Gaul to fight the Romans. However, the better reading of this inscription has "Armenia", not "Armorica", suggesting that he led 'British' troops to war in the east.

Another figure sometimes identified with Arthur is the British king Riothamus, who was defeated by the Goths near Bourge, central France in c470. Riothamus means 'most-kingly', which led the 20th-century historian Geoffrey Ashe to suggest that this was a title, rather than a name – and that Riothamus's true name was Arthur.

Conversely, it has been suggested that 'Arthur' is a title, and that the 'real' name of this elusive man was Owain Ddantgwyn, an obscure figure known only from a late Welsh genealogy. Another theory is that Arthur should be identified as Arthwys ap Mar, a name that occurs in the later medieval 'lineages of the saints'. While each theory has supporters, none stand up to close examination.

WHAT DOES THE NAME 'ARTHUR' TELL US ABOUT HIS POSSIBLE ORIGINS?

It allows three possible sources. There is the Old Welsh 'Arth-' and Old Irish 'Art-' meaning 'bear', and so perhaps suggesting a Celtic origin. But Old Welsh 'Bear-man' gives us 'Arthwr', not the 'Arthur' that we find in all the early texts, so this appears unlikely.

Could 'Arthur' be derived from the Greek name Arktouros? It's possible. However, this was known in the west only as a star-name (Arcturus is the brightest star in the northern night sky), never as a personal name.

A stronger case can be made for the Roman family name Artorius, which was used from the late Republic through to at least the third century AD, and shows up on inscriptions in various western provinces – though in neither Gaul nor Britain. The shift from Artorius to Arthur fits sound changes in Brittonic/Old Welsh that we know were occurring in the late Roman and sub-Roman periods. There were several figures called Arthur or Artúr (the Irish equivalent) from the late sixth century onwards, one of whom may have been the source of the name used in the *History of the Britons*.

> THE SEARCH FOR ARTHUR IS COMPROMISED BY THE LACK OF SURVIVING SOURCES FROM 'DARK AGE' WALES

A stone replica of Excalibur at Podstrana, Croatia, home to two inscriptions on the life of the Roman soldier Lucius Artorius Castus

MUCH OF THE ARTHURIAN LEGEND COMES FROM LATER MEDIEVAL WRITERS. WHY DID HE BECOME SUCH A CELEBRATED FIGURE AT THIS TIME?

The architect of Arthur's fame was Geoffrey of Monmouth, whose *History of the Kings of Britain*, written in Latin in the 1130s, built on the vision of history offered by the ninth-century History of the Britons. The new work proved immensely popular and was translated/adapted into French by Wace in c1150 and English by Layamon in c1200–20. The legend provided an ideal space in which to explore such contemporary issues as the source, nature and obligations of royal authority, chivalry and knighthood, and Christian behaviours appropriate to the lay aristocracy.

We find Arthurian storytelling in virtually every language spoken in medieval Europe but its focus was French, which was the most important language of the period and the one most closely connected with the crusades and knightly activity more generally. By the 13th century, his stories were increasingly imbued with Christian meaning, and no longer a narrative account of his supposed reign.

HOW MUCH OF THE MEDIEVAL ARTHUR MIGHT BE BASED ON EARLIER SOURCES, AS OPPOSED TO PURE LITERARY INVENTION?

There have been numerous attempts to see ancient origins in various aspects of the medieval Arthur, including the sword in the stone, the grail, and the sword in the lake. But for any of these to be convincing there has to be a credible line of descent from the earlier occurrence to its arrival in French literature around 1200. Take the claim that the medieval sword in the stone and grail stories derive from Scythian (nomadic people from central Asia) practices, which were documented in the works of Herodotus in the fifth century BC. This requires a complex explanation as to how they were carried to western Europe in the Roman period and remained embedded there until reappearing almost a millennium later in France.

In both instances, it seems likelier that the medieval stories had more recent origins. The grail arguably derives from depictions of St Mary bearing a dish from which the Holy Ghost rose as flame, an image later combined with the cup of the last supper. The 'sword in the stone' may have originated in a miracle that was associated with St Galgano in late 12th-century Italy.

HOW DOES THE ARTHUR LEGEND ADD TO OUR UNDERSTANDING OF 'DARK AGE' BRITAIN?

The Arthur legend is unlikely to tell us anything much about the British 'Dark Ages', unless and until we are reasonably sure that we can identify him as a historic figure. That time seems a long way off, and may never come.

PHOTOS: GETTY IMAGES

Cadbury Castle in Somerset, one of – but far from the only – reputed location of King Arthur's court, Camelot

A depiction of Layamon, who translated Wace's French version of Geoffrey of Monmouth's history into English

AND WHAT DOES IT TELL US ABOUT THE MEDIEVAL PERIOD WHEN MUCH OF IT WAS WRITTEN?

The Arthurian legend sheds a lot of light on the later periods in which the story was written and rewritten. For example, it provides an important reservoir of the medieval languages in which it was set down. It also illustrates ways in which ideas were changing. In the mid12th century, we experience Arthur as a king and commander but, by the final decades of the century, the spotlight had fallen on his court. For example, writers like Chrétien de Troyes focussed on secondary figures such as Perceval, Gawain and Lancelot and debated issues like attitudes towards women, the role and responsibilities of high birth, the foundations of knightly esteem, lay education and training for knighthood.

The grail stories linked Arthur to the last supper and the crucifixion. Such stories illustrate contemporary concerns regarding conduct appropriate to elite Christian society.

ASIDE FROM ARTHUR HIMSELF, WHICH PARTS OF THE LEGEND MIGHT BE DRAWN FROM HISTORICAL EVENTS AND FIGURES?

Many Arthurian characters are likely to have had a literary life before they were sucked into Arthur's world, and a few may have been real people. King Mark of Cornwall (the uncle of Tristan and husband of Iseult) bears an obviously Roman name (Marcus), which occurs on sub-Roman inscriptions. Tristan may derive from Drustan, a name known from a 'Dark Age' inscription near Fowey in Cornwall but equally perhaps from legendary Pictish material (as Drust or Drest). That Chrétien de Troyes claimed to be telling his own version of the story suggests that it was circulating in France in the 12th century, perhaps told by Breton raconteurs.

The knight Sir Kay (also Cei, Cai) may come from Gaius, a common Roman forename (his is one of the earliest names associated with Arthur in Welsh stories).

Culhwch – the central character of a medieval Welsh Arthurian prose narrative, who courts Olwen, a giant's daughter – probably draws on other categories of folktales, not Arthurian storytelling. Whether or not real people underlay these literary characters is, though, far from clear.

WHERE MIGHT CAMELOT HAVE BEEN BASED?

Camelot first appears in Chrétien de Troyes' late 12th-century French romance *Lancelot* or the *Knight in the Cart*. Given that this story was very much his creation, the name is likely to have been made up, presumably based on Geoffrey of Monmouth's 'Camblan' or Wace's 'Camble', with '-lot' added to fit the rhyme (meaning 'share', 'fate'). There have, however, been numerous attempts to identify Camelot. Winchester was a candidate in the later Middle Ages, then South Cadbury Hillfort in the reign of Henry VIII, based presumably on nearby names such as the river Cam.

Colchester in Essex and the Roman fort at Slack near Huddersfield have also been put forward as possible Camelots, because they were called Camulodunum (literally 'fortress of the god Camul') in Roman Britain.

Before taking any of these too seriously, we surely have to show that there is a good chance that Chrétien had drawn the name from a reliable and near-contemporary source. That seems highly unlikely.

WHAT ARE YOUR THOUGHTS ON THE NEW FILM ON ARTHUR? AND WHAT ARE YOUR FAVOURITE MODERN DEPICTIONS OF HIM?

I enjoy discovering what each director makes of the story, what aspects he/she chooses to prioritise, and what messages there are for a contemporary audience.

As for my favourite recent depictions, Jerry Bruckheimer's *King Arthur* (2004) was entertaining, though hardly "the untold true story that inspired the legend"! The greatest 'Arthur' films, though, have to be Disney's *Sword in the Stone* and *Monty Python and the Holy Grail*, which still makes me laugh.

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PHOTOS: ALAMY/BRIDGEMAN

SAADAT HASAN MANTO

Saadat Hasan Manto felt deeply and wrote strongly; his work invigorates and disturbs

RECENTLY, at a one-day session of the Karachi Literature Festival in London, I listened to actor Nimra Bucha read from Saadat Hasan Manto's short pieces in Urdu. The occasion was a session on the Partition, where artists, performers and storytellers were presenting artistic and literary works. The hall was packed, we were in London, you would have expected that the reading would be in English. But Nimra chose to read in Urdu. Manto, she said, was best understood in the language in which he wrote. Her powerful, moving reading, Manto's powerful, searing prose, made for an electric, charged moment.

It would not be an exaggeration to say that Saadat Hasan Manto was perhaps Pakistan's most famous writer. In his short life – he died when he was a mere 48 years old – he produced a formidable body of work, comprising short stories (his forte), journalistic articles, prose pieces, plays, a novel, commentaries and more. Writing was like oxygen to him, and he could not live without it, just as he could not live without his other passion, liquor – which was what killed him in the end. But the intensity with which he wrote, and the depths of pain, despair and cynicism in what he wrote about might equally well have killed him. Readers who come to Manto again and again often wonder how one man could have carried so much rage and despair inside him. Shortly before he died, he composed his own epitaph: "Here lies Saadat Hasan Manto and with him lie buried all the secrets and mysteries of the art of story writing. Under mounds of earth he lies, still wondering who among the two is the greater story writer – God or he."

Manto began his literary life as a translator. Born in a village called Samrala near Ludhiana in undivided India, Manto grew up in a family of barristers. Always interested in literature, he was introduced to Russian and French writers such as Gorky, Chekov, Victor Hugo and also Oscar Wilde by Abdul Bari Alig, a scholar and a writer. He also began to translate them into Urdu, starting with Victor Hugo. Later, he studied at Aligarh Muslim University and soon began work with a daily called *Masawat*. During this time, the 1930s, he became associated with the Indian Progressive Writers Association (IPWA). His association with IPWA brought him in contact with many writers, including Ali Sardar Jafri, and he began writing seriously.

Manto experimented with many different forms of writing: he began with two short stories, the first one based on the Jallianwala Bagh tragedy (even at this early stage, he felt very connected to political battles and the abuse of power by the colonial state). Shortly after his stint at *Masawat*, he joined All India Radio and produced a number of radio plays. Later, he produced collections of stories and essays and also experimented with screenwriting for films in Bombay.

> "MANTO'S MOST POWERFUL PARTITION STORY WAS *TOBA TEK SINGH*, WHICH POIGNANTLY DESCRIBES THE DILEMMA OF A MAN CAUGHT WITHIN NO MAN'S LAND BETWEEN THE BORDERS OF INDIA AND PAKISTAN"

STRONG VIEWS

By all accounts, Manto the writer was brilliant and Manto the human being was not an easy man to get along with. He felt things strongly and expressed them strongly. In the 1950s, he put together a series of letters that were addressed to a mythical Uncle Sam. In one of them he wrote, almost as if he could read the future, about where he saw US-Pakistan relations going.

Among Manto's friends was the writer Ismat Chughtai. Funny and irreverent, Chughtai's prose is acerbic and nuanced, and, in many ways, gentle, unlike Manto's that is often like the thrust of a knife in the reader's belly. It is often said about Manto that he was tried for obscenity six times for his writing, three times in British India and the other three in Pakistan. The first time he received a court summons from the British Crown was in 1944, the same day his friend Chughtai received one too. In her case, she was accused of being obscene in her story *Lihaaf* (The Quilt) and, in his, it was for his story, *Bu* (Smell). Chughtai describes the incident with her characteristic humour: "Manto phoned to say a suit had been filed against him as well. He had to appear in the same court on the same day. He and Safiya (his wife) landed up at our place. Manto was looking very happy, as though he had been awarded the Victoria Cross." He joked with Chughtai and told her husband, Shahid, "Be a man and come to Lahore with us... Fried fish and whiskey…" Once in Lahore, Manto and Chughtai spent the time shopping and visiting friends. Chughtai wrote that each time she lost courage about fighting the case, it was Manto who would get furious at her and encourage her to fight on. Chughtai says: "Manto, Shahid and I roamed around… shopping… When we were buying shoes, the sight of

A MANTO LIST

Manto's delicate feet filled me with envy…" Manto told her he hated his feet because they were 'so womanly'. Later, after Manto died, Chughtai remembered this dialogue and wept at how his feet had swollen up and become 'a detestable sight.'

A PARTITION DEEPLY FELT

The 1947 Partition of India came as a major shock to Manto. Terrible violence overtook the lives of millions of people, and human beings turned against each other for no other reason than that they belonged to a different religion. Manto was deeply impacted by this brutality. Much of his best-known writing comes from this time, and the short, scathing pieces he wrote became iconic as descriptions of the violence of Partition. Among the best known works are stories like *Khol Do*, which speaks of the sexual assault of a young woman, *Thanda Ghosht* in which he describes how a Sikh man returns after killing and desecrating the corpse of a Muslim woman and tries to be intimate with his wife, and how she stabs him to death, turning his body as cold as that of the one he violated.

Manto's most powerful Partition story was *Toba Tek Singh*, his last piece of literary work, which poignantly describes the dilemma of a man caught within no man's land between the borders of India and Pakistan, and who, when asked where he comes from, can only respond in gibberish. In the six-and-a-half decades that have passed since Manto's death, this story has been translated and retranslated, performed and re-performed hundreds of times, and the name Toba Tek Singh (the name of a real village in Pakistan) has become a metaphor for the experience of Partition.

When Partition took place, and it became imperative for many people to move to a new country, Manto refused to move, preferring to stay on in his beloved (then) Bombay, but circumstances persuaded him to do so. The story goes that, one evening, as Manto sat drinking with his friends and colleagues, a Hindu man among them remarked that, had it not been for the fact that Manto was his friend, he would have killed him. For Manto, who had never thought of himself in terms of religion, and for whom his writing and perhaps his drinking were important, the hatred contained in this remark was unbearable. It is said that, the very next day, Manto packed his bags and took his family to Lahore, never to return to India.

In Lahore, he found a number of important writers who provided him the oxygen in his life and some succour for the tragedy of having left his beloved Bombay behind. Writers like Faiz Ahmed Faiz, Ahmad Rahi, Ahmad Nadeem and others could be found in Lahore's well-known Pak Tea House, which was the scene of many discussions and arguments. Often stories were shared and discussed in an atmosphere of lively debate.

EMOTIONS ON PAPER

Manto's entire collection of writings comprises as many as 22 collections of stories, a novel, three collections of essays, two of personal sketches, and a series of radio plays. While the genres in which he chose to write were quite varied, his sense of dark humour, and the people he chose to focus on – sex workers, pimps, communal killers, animal killers – were meant to make his readers uncomfortable as they confronted the dark truths that Manto made apparent. Manto was not unaware of this. In his words: "If you find my stories dirty, the society you are living in is dirty. With my stories, I only expose the truth." To a judge quizzing him on his work, he said: "a writer picks up his pen only when his sensibility is hurt."

Despite writing as if his life depended on it, and being highly regarded as a writer, Manto never made large amounts of money. Indeed, finances were a real struggle, and the tragedy of his life was that, whatever money he did earn, was spent mostly on drink. The toll this took on his family – his wife and daughters – has not received much attention until recently. In one of his letters to Uncle Sam, he wrote: "You would not believe, uncle, that despite being the author of 20, 22 books, I do not own a house to live. If I earn 20-25 rupees based on the rate of seven rupees per column, I take the *tonga* and go buy locally distilled whiskey."

Today, more than 60 years after his death, Manto's life and work remain of considerable interest to readers, and any discussion on him always arouses strong emotions. Women readers often feel that, although Manto professed to love women and wrote about them in his stories, especially as sexual beings with agency, in reality his stories reduced women to the sum of their parts and are, therefore, misogynist. Whether or not this is true, Manto's life and work remains the subject of intense discussion as is evident from the number of books that continue to be written about him, and recent films on his life. As the writer Mohammed Hanif said, "Reading Manto made you realise that literature did not always have to conform. It does not always have to tell polite stories."

Urvashi Butalia is the director and co-founder of Kali Women, India's first feminist publishing house. A recipient of the Padma Shri award, she is a historian whose research focuses on the Partition and oral histories. Her book, *The Other Side of Silence*, collates the tales of the survivors of the Partition.

PUZZLE PIT

CROSSWORD NO. 39

ACROSS

8 Staunch follower (8)
9 Factory siren (6)
10 Common speech (10)
11 Long journey (4)
12 Advances or makes progress? (4,2)
14 Erroneous, false or incorrect (8)
15 Decoration added to food (7)
17 Is contrite (7)
20 Edible snail (8)
22 Athens locale (6)
24 A word meaning 'half' (4)
25 Beyond usual bounds (4,3,3)
27 Edible seed (6)
28 Became more intense (8)

DOWN

1 Stick or cling to (6)
2 Sharp and eager (4)
3 Revokes, abrogates or cancels (8)
4 Early Greek astronomer (7)
5 Sounds like a bird? (6)
6 Transgress, violate or infringe upon (10)
7 Habitation (8)
13 Feelings (10)
16 Replied or responded (8)
18 Two less than a score (8)
19 Pays heed (7)
21 Big name on the internet (6)
23 Barrel-maker (6)
26 Divisible by two (4)

HOW IT'S DONE

The puzzle will already be familiar to crossword enthusiasts, 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 English. Good luck!

SOLUTION OF CROSSWORD NO. 38

PUZZLE PIT

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.

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

FIND YOUR WAY OUT OF THE MAZE

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.

IREEE [*][*][ ][ ][*]

RAHCI [ ][ ][*][ ][*]

IPSTLN [ ][ ][*][ ][*][ ]

HORTGW [*][ ][ ][*][ ][ ]

You cannot fly like an ___ with the wings of a __ - William Henry Hudson (5,..,4)"

HEAD & TAIL

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

Sodium bicarbonate	Baking	
Sparkling drink		
Gaseous H2O		
Streak of steam		
Become fainter or quieter		
Deactivation mechanism		
Swap with someone		Places

ENIGMA CODE

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

The clue: Drop a catch

			G		
			G		
G					
G					S
		G			
					G
		G			

DOUBLE BARRELLED

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

_ _ _ _ _

- B A N D
- C A S T
- S H E E T
- S W O R D
- W A Y

BRAIN TEASERS

1) What does this illusion mean? *ENTURY*

2) Mike, Bob, and Dan each have a different favourite sport. One prefers baseball, one basketball, and one football. Mike doesn't like basketball. Dan doesn't like basketball or baseball. What is each person's favourite sport?

3) What English word can have four of its five letters removed and still retain its original pronunciation?

4) Andrew and Cornelius were two competitive golfers. Their competition didn't stop with the game. As Andrew drew out an iron, he said, "This golf club alone cost me $500." Cornelius retorted, "Mine cost me half a million dollars." Could Cornelius have been telling the truth? Why?

5) What are the next three in this sequence:
I 2 1 F 1 1 F 0 1 F 9 F _ _ _

PICK & CHOOSE

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

1. Hamlet character
2. Football for the Americans
3. A configuration of stars
4. Capital of Ecuador
5. Reduce to ashes
6. Urges rather strongly

INC	RTS	OP	CONS	QUI	EX
HE	AT	HO	SOC	RA	ION
TELL	TE	TO	CER	INE	LIA

BBC KNOWLEDGE QUIZ

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

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

1) Who wrote the *Last of the Mohicans*?
a) Ernest Hemingway
b) James Fenimore Cooper
c) Edgar Allan Poe

2) Which tennis star won her 23rd Grand Slam title at the 2017 Australian Open?
a) Serena Williams
b) Venus Williams
c) Martina Navratilova

3) Which hormone is secreted by the isles of Langerhans in the pancreas?
a) Melatonin
b) Adrenalin
c) Insulin

4) Who is the current UN Secretary General?
a) António Guterres
b) Ban Ki-moon
c) Boutros Boutros-Ghali

5) What does a cetologist study?
a) Birds
b) Trees
c) Whales and dolphins

6) What is the largest and one of the least populated states of the USA?
a) Arizona
b) Alaska
c) Nebraska

7) Silkworms feed mainly on the leaves of which tree?
a) Oak
b) Maple
c) Mulberry

Solutions:

Picture Search: Avocado, bagpipes, ballerina, comb, cradle, dentist, drop, hummingbird, lamp, lily, microscope, oyster, printer, puma, unicycle, yak

Scramble: Words: Eerie, chair, split, growth
Answer: You cannot fly like an eagle with the wings of a wren - William Henry Hudson

Head & Tail: Baking-Soda-Water-Vapour-Trail-Off-Switch-Places

Enigma Code: Bungle, Burgle, Gentle Greens, Regent, Strung Urgent

Double Barrelled: Broad

Brain Teasers: 1 Long time no see (Century - C = ENTURY **2** Mike likes Baseball. Bob likes Basketball. Dan likes Football. **3** Queue, of course, here is another answer: aitch - take away the aitc and you are left with "h". **4** A golf club owned by Cornelius included all of the buildings and golf course. **5** 8 F 7: from the function keys on a computer keyboard. Starting with F12, F11, F10 and then read backwards.

Pick & choose: 1. Ophelia, **2.** Soccer, **3.** Constellation, **4.** Quito, **5.** Incinerate. **6.** Exhorts

BBC Knowledge Quiz: 1. b) James Fenimore Cooper, **2.** a) Serena Williams, **3.** c) Insulin, **4.** a) António Guterres, **5.** c) Whales and dolphins, **6.** b) Alaska, **7.** c) Mulberry

THE BOY WHO'S LIVED... 20 YEARS

WORDS: MOSHITA PRAJAPATI

Twenty years ago, my mother introduced me to a wizard. She thrust *Harry Potter and the Philosopher's Stone* into my pudgy hands. The boy wizard and I were the same age: 11 years old. I was fascinated with the cover of the book – a scrawny boy wearing spectacles with a lightning bolt scar hidden partially by his fringe of jet-black hair, staring in astonishment and bewilderment at the red Hogwarts Express. It wasn't long before I was completely obsessed with the Boy Who Lived. As Harry, Ron and Hermione grew, so did I. Enid Blyton's characters from the *Famous Five* and *Malory Towers* series remained in suspended animation, but Harry and his school mates scrambled their way from puberty to adolescence and then adulthood with hilarious and tragic consequences, all of which I could identify with then and sometimes even now. They made mistakes, loads of them. Sometimes they won; sometimes, they lost. But they trudged on, with renewed grit and resolve to do the right thing. And, along the way, they taught me about friendship, love, loyalty, determination, magic and imagination.

On Monday, 26 June, 2017, the day *Harry Potter and the Philosopher's Stone* turned 20, thousands of readers of all ages brought out their wands, wore their house colours, and got nostalgic about a beloved and still cherished part of their childhood that still lives on.

raised wand To the boy who lived!

PLATFORM 9 3/4

PRIVET DRIVE

DID YOU KNOW?

The book has been published in 79 languages across the world.

107 million copies of the book have been sold so far.

The entire book consists of 76,944 words.

'Nothing happened' is the most frequently-used word in the Harry Potter series.

The book was turned down by 12 publishers before being picked up by Bloomsbury with a print run of only 500 copies.

BBC

Knowledge