

BBC

SCIENCE • HISTORY • NATURE • FOR THE CURIOUS MIND

earth

ASIA EDITION | VOL 12 ISSUE 2
MAR/APR 2020



INCORPORATING
BBC
SCIENCE
WORLD

A LIFE WITH LEOPARDS



PPS 1904/04/2018 (025649)
MCI (P) 134/11/2017 ISSN 2529-7503



SGD 8.50 | THB 240 | NT 200 | RM 18

THE **SHARPEST**
TOOLS

p46

SMELLING OUT
DISEASE

p67

PERFECT
BLEND

p52

TV HIGHLIGHTS

How Did They Build That?

A brand new international architecture series that features extraordinary buildings from around the world and explores how they were conceived, designed and constructed.

Premieres 5th March
Thursday at 9:55pm (SG/HK)



Life Below Zero Season 7

Follow the further icy adventures of Life Below Zero's resilient characters as the series charts their day-to-day lives in Alaska.

Premieres 23rd March
Monday at 9:55pm (SG/HK)

Earth's Tropical Islands

Explore iconic Madagascar, Borneo and Hawaii, each an isolated tropical island with contained ecosystems.

Premieres 30th March
Monday at 8:05pm (SG/HK)



Population: 7.7 Billion People and Counting

According to the UN, by the year 2050 there could be ten billion people living on planet Earth. Chris Packham investigates why our population is growing so rapidly and the impact it is having on our environmentally-challenged planet.

Premieres 21 April
Tuesday at 9:00pm (SG/HK)

BBC
earth

www.bbcasia.com

[f /bbcearth](https://www.facebook.com/bbcearth)

[@BBCEarthAsia](https://twitter.com/BBCEarthAsia)

BBC Earth is available in Hong Kong, Indonesia, Malaysia, Laos, Mongolia, Myanmar, Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam. Please call your cable operator for more details or check out our website at www.bbcasia.com.

Also available on

BBC iPlayer



www.bbcplayer.com

Download on the
App Store

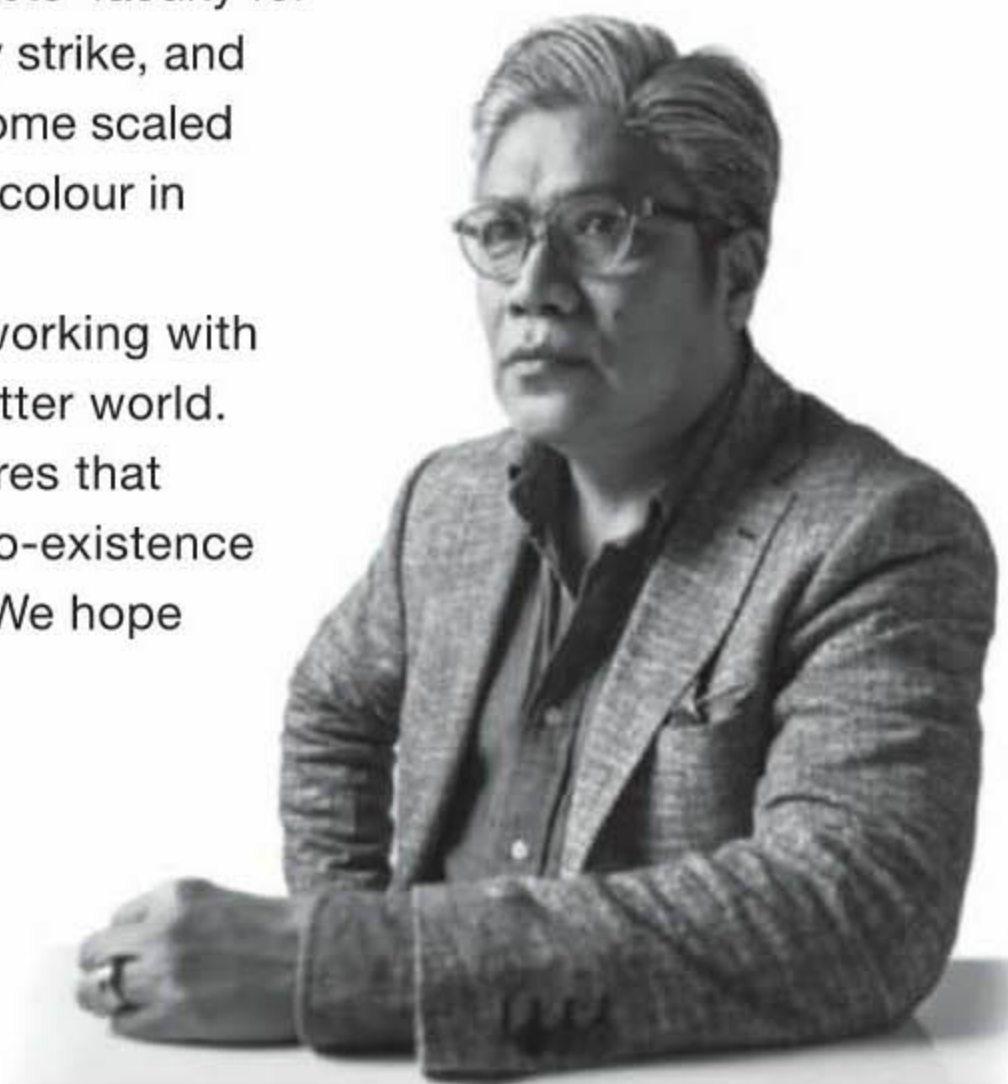
GET IT ON
Google play

ARMED WITH THE METHOD

We have been reasonably proud of our refined ability to create and employ tools to accomplish various tasks, but this characteristic is in no way unique to homo sapiens. Many other animals display this ability – among them primates, birds and fishes – although mostly in order to obtain food.

Through the years, we have obtained ideas from other animals' uncanny abilities and have applied them to create gadgets that make our lives better. These include early warning devices based on common pets' faculty for predicting disasters hours before they strike, and safety apparels that are inspired by some scaled reptiles that can change their form or colour in order to deflect danger.

These all point to the wisdom of working with other living organisms to create a better world. In this issue, we have selected features that highlight the values of harmonious co-existence among creatures that inhabit Earth. We hope you take your cue from them.



Marc S. Almagro
marc@media-group.com.sg

"LIKE" US ON FACEBOOK!  www.facebook.com/BBCEarthMagAsia

✉ 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 and/or on our website. We regret that we cannot always reply personally to letters.



BBC Earth Magazine

Includes selected articles from other BBC specialist magazines, including *Focus*, *BBC History Magazine* and *BBC Wildlife Magazine*.



www.sciencefocus.com



www.historyextra.com



www.discoverwildlife.com

IMPORTANT CHANGE:

The licence to publish this magazine was acquired from BBC Worldwide by Immediate Media Company on 1 November 2011. We remain committed to making a magazine of the highest editorial quality, one that complies with BBC editorial and commercial guidelines and connects with BBC programmes.

The BBC Earth television channel is available in the following regions: Asia (Cambodia, Hong Kong, Indonesia, Malaysia, Singapore, South Korea, Thailand, Taiwan)

SCIENCE • HISTORY • NATURE FOR THE CURIOUS MIND

Know more. Anywhere.

BBC Earth Magazine provides trusted, independent advice and information that has been gathered without fear or favour. When receiving assistance or sample products from suppliers, we ensure our editorial integrity and independence are not compromised by never offering anything in return, such as positive coverage, and by including a brief credit where appropriate.

Experts in this issue...



**MICO
TATALOVIC**

An experienced news editor and science journalist, Mico holds an MSc in Science Communication from Imperial College London. (p26)



**JAMES
HOLLAND**

An English historian, author and broadcaster, James specialises in the history of World War II. (p42)



**HAYLEY
BENNETT**

Hayley is a freelance science writer and editor based in Bristol, UK. She covers biology, chemistry and the environment. (p46)



**DR HELEN
SCALES**

A writer, marine biologist and broadcaster, Helen is the author of the acclaimed book on seahorses, *Poseidon's Steed*. (p72)

FEATURES

26 What Would Alien Life Actually Look Like?

What would life forms in other planets look like?

34 A Live With Leopards

Up close with a mother leopard and her brood in Botswana

42 In Defence of Monty

Is our impression of D-Day architect Bernard Montgomery fair?

46 The Sharpest Tool

Besides humans, other animals are known to use tools effectively

52 Perfect Blend

Migratory birds can benefit from merging coffee plantations with Colombian forests

60 Hitler's Enablers

How some of Germany's elite facilitated the rise of the Third Reich

67 Sniffing Out Disease

Wearable devices of the future will alert people to impending health problems

72 How We Can Save The Oceans...

Ideas run the gamut from breeding tougher reefs to policing poachers from space

79 ...And How They Can Save Us

Oceans are irreplaceable sources of food and ideas for the future

REGULARS

3 Welcome

How the wonderful traits of other animals amplify ours

6 Snapshot

A pictorial round-up of inventions and innovations around the world

97 Scientist's Guide to Life

Nutritionist Leonie Ruddick-Collins, as interviewed by Dr Helen Pilcher, walks us through breakfast

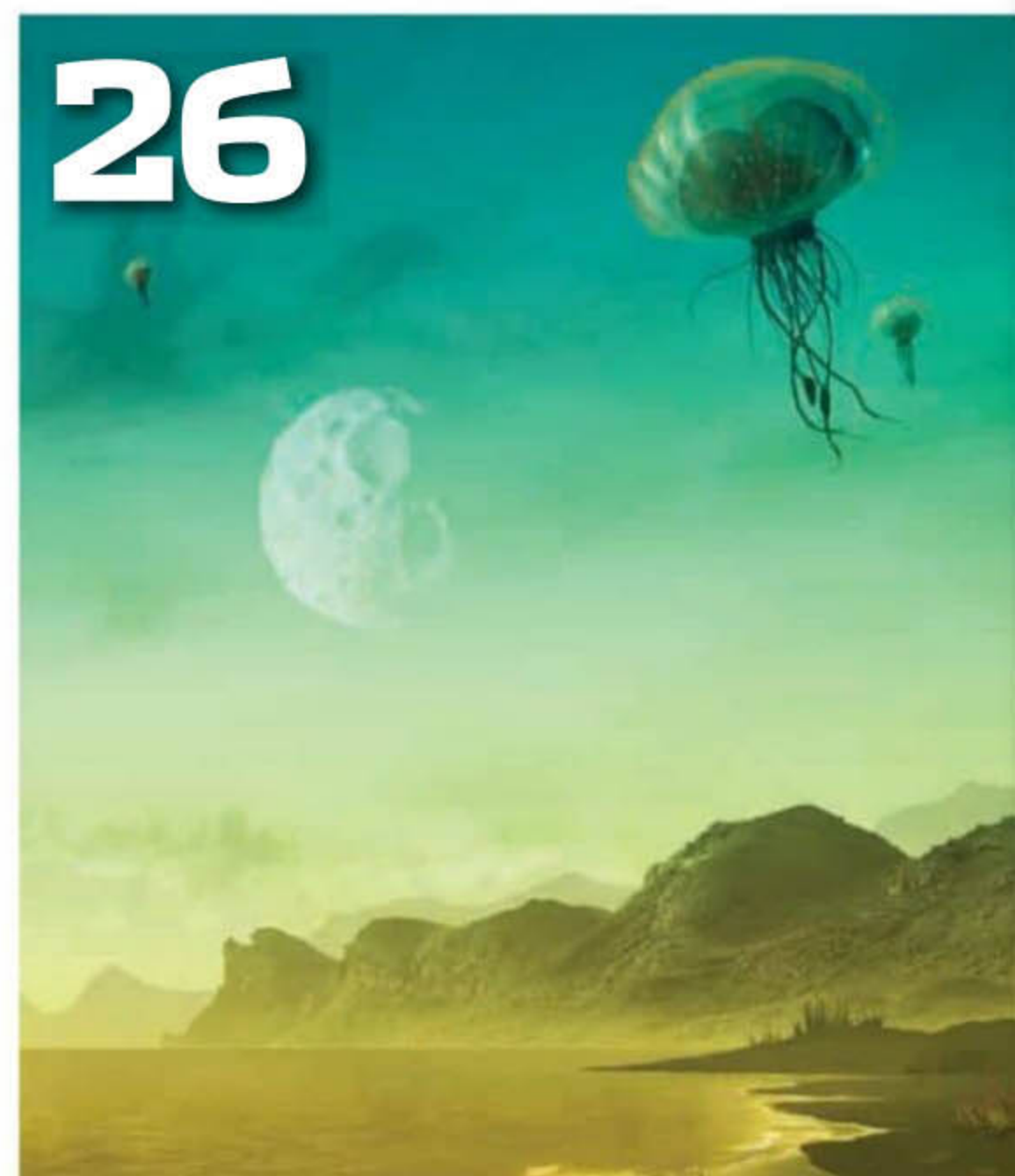
98 Comment

Dr Michael Mosley on why tummy noises may indicate health problems

UPDATE

14 The Latest Intelligence

Pioneering gel could mend damage after heart attack, genes for left-handedness identified, sharks' fluorescence may protect them from infection, and more...



85 Q&A

How far from Earth could aliens detect our radio signals? Why do millipedes have so many legs? Are human and animal bones the same? Why can't we close our ears like we can close our eyes?

RESOURCE

94 What's caught our attention this month

The book *Anatomicum*, video game *Telling Lies*, exhibition *The Art of Innovation: From Enlightenment to Dark Matter*, and gadget *Dodow*

96 Time Out

A fresh crossword puzzle plus the answers to the previous one

SEND US YOUR LETTERS

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



EMAIL US AT:

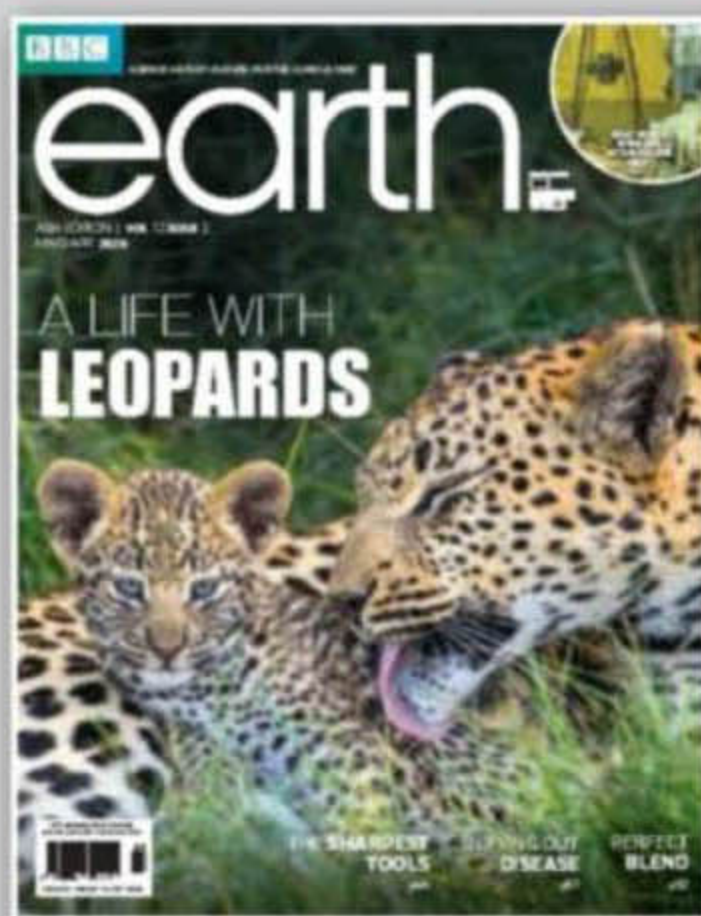
bbcearth@media-group.com.sg

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 and/or on our website. We regret that we cannot always reply personally to letters.

BULK SUBSCRIPTION

Having just one copy of BBC Earth Magazine isn't enough to go around? Not to worry – Discounts on bulk subscriptions are now available for schools, libraries and organisations who are keen to order more than 50 copies per issue.

For enquiries or to place an order, email to subscription@media-group.com.sg or call us at +65 6446 6888 today!



BBC Earth Magazine, MCI(P) 002/09/2017, ISSN 2529-7503, PPS 1904/04/2018 (025649), is published by Media Group Pte Ltd under license from Immediate Media Company Bristol Limited. Copyright © Immediate Media Company Bristol Limited. No part of this publication is to be reproduced, stored, transmitted, digitally or otherwise, without the prior consent of the publisher. The information contained herein is accurate at time of printing. Changes may have occurred since this magazine went to print. Media Group Pte Ltd and its editors will not be held liable for any damages, loss, injury or inconvenience, arising in connection with the contents of the magazine. Media Group Pte Ltd will not accept responsibility for unsolicited contributions. Printer: KHL Printing Co Pte Ltd (197801823M) Address: 57 Loyang Drive Singapore 508968. The BBC logo is a trademark of the British Broadcasting Corporation and is used under licence. © British Broadcasting Corporation 1996

HERE'S HOW TO GET IN TOUCH

PHONE Subscription, editorial and advertising enquiries
Tel: 6446 6888 Fax: 6449 9945

EMAIL Advertising enquiries
specialinterests@media-group.com.sg
Subscription enquiries
subscription@media-group.com.sg

POST Subscription, editorial and advertising enquiries
BBC Earth, Media Group Pte Ltd
20 Bedok South Road, Singapore 469277

ASIA TEAM

Managing Director: Dennis Pua
Publisher: Foo Mei Siah
Editor-in-chief: Marc S. Almagro
Senior Designer: Grace Seng
Marketing Manager: Loke Pei Ling
Marketing Executive: Sheila Devi
Finance Executive: Julie Khong
HR Executive: Wendy Chua
Associate Business Director: Bernard Lim

BBC STUDIOS

BBC STUDIOS, UK PUBLISHING
Chair, Editorial Review Boards: Nicholas Brett
Director of Consumer Products and Publishing: Andrew Moultrie
Head of Publishing: Mandy Thwaites
UK Publishing Co-ordinator: Eva Abramik
UK.Publishing@bbc.com
www.bbcstudios.com

IMMEDIATE MEDIA CO

Chairman: Martin Weiss
Deputy Chairman: Peter Phippen
Chief Executive Officer: Tom Bureau
Director of International Licensing and Syndication: Tim Hudson
International Partners Manager: Molly Hope-Seton
Syndication Manager: Richard Bentley

UK TEAM

Editor: Daniel Bennett
Production Editor: Alice Lipscombe-Southwell
Reviews Editor: Daniel Bennett
Commissioning Editor: Jason Goodyer
Science Consultant: Robert Matthews
Contributing Editor: Emma Bayley
Art Editor: Joe Eden

CONTRIBUTORS

Hayley Bennett, Dr Peter J Bentley, Dr Deborah Bowman, Alexandra Cheung, Marcus Chown, Charlotte Comey, Rowena Crockett, Emma Davies, Prof Alice Gregory, Dr Alastair Gunn, Dr Christian Jarrett, Sarah Knott, Aleks Krotoski, Dr Lucy Maddox, Prof Robert Matthews, Jamie Millar, Michael Mosley, Andy Ridgeway, Andy Rouse, Helen Elizabeth Roy, Dr Helen Scales, Aditya Singh, Luis Villazon, Dr Zoe Williams, Dr Melanie Windridge, Dr Giles Yeo

DISTRIBUTORS

Singapore - Pansing Distribution Pte Ltd
Malaysia - MPH Distributors Sdn Bhd
Thailand - Asia Books Co., Ltd
Hong Kong/China/Macau - Times Publishing (HK) Ltd

SUBSCRIPTION AGENTS

Singapore - ECOM
Malaysia - Worldwide Magazines Services Sdn Bhd
Hong Kong - MI Asia Limited

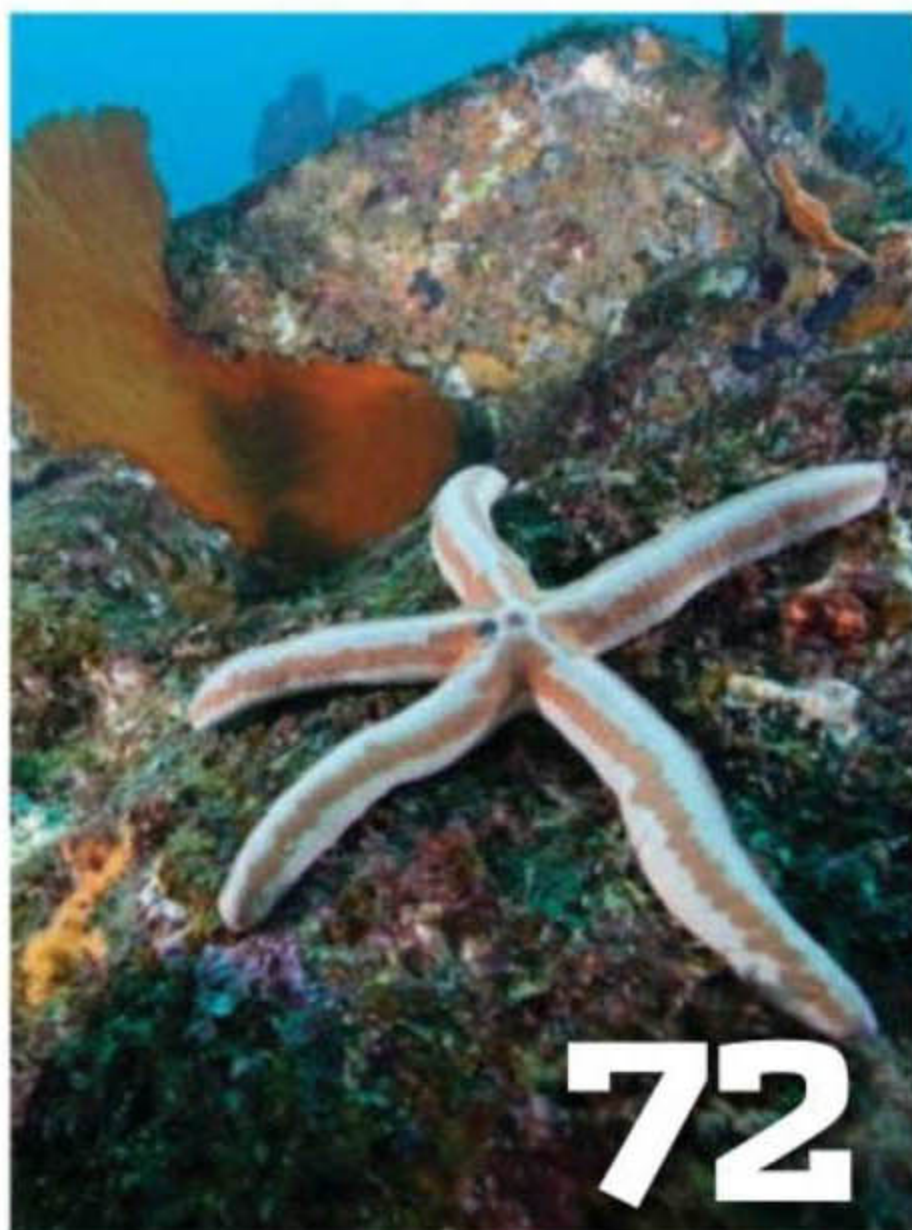
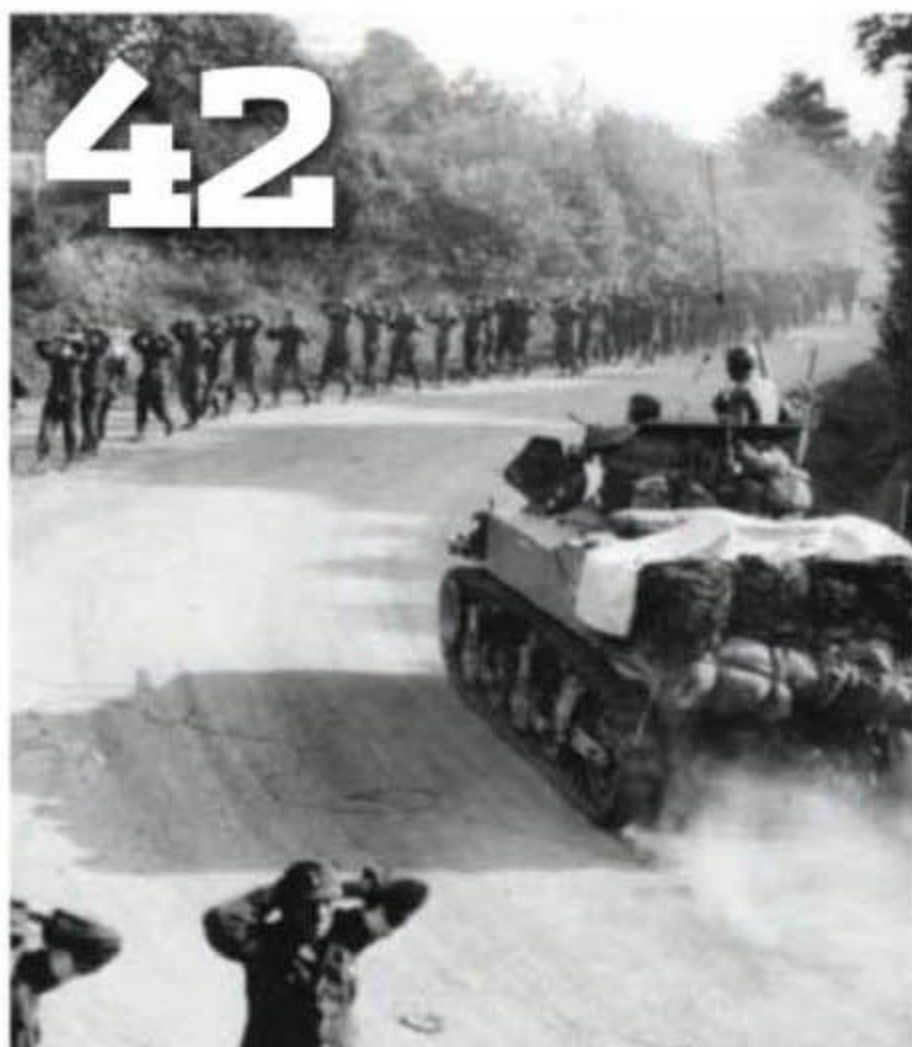
A publication of

MEDIA GROUP

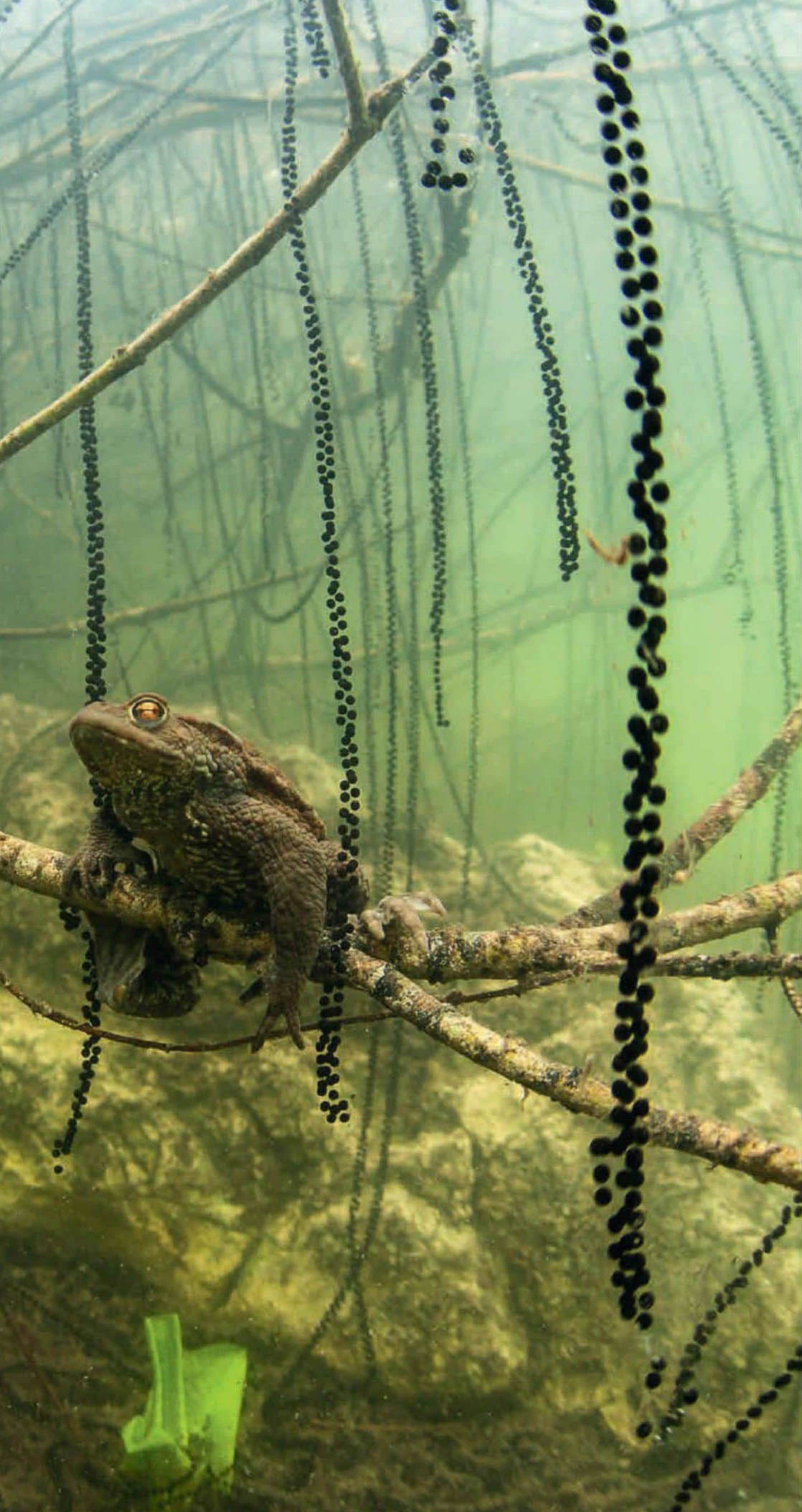


Persatuan Penerbit Penerbit Majalah, Malaysia
Magazine Publishers Association, Malaysia

42







Snapshot



Spawny devil

AIN, FRANCE

This picture shows a male member of the species *Bufo bufo* – the common toad – sitting at the bottom of a lake in the French Alps, surrounded by numerous strings of toadspawn.

Common toads migrate towards their favoured breeding sites once out of hibernation. Scientists do not yet know why certain waters are favoured for this purpose while seemingly identical sites nearby are rejected, but 80 per cent of males return to the site where they themselves were spawned.

Once at the site, males will sit and wait for a female to come along. Competition for mates is fierce, and while this mostly takes the form of croaking contests, fights do occur – as do ‘mating balls’, where multiple males all attempt to mount a single female at once.

If a mate is found, the male will remain mounted on top of her for several days, individually fertilising the long strings of eggs as she lays them.

REMI MASSON/NATUREPL.COM

Snapshot



Hell hole

**KARAKUM DESERT,
TURKMENISTAN**

The Darvaza gas crater, aka 'The Gates of Hell', has a mysterious past. It is thought to have formed in the 1960s, when engineers drilled the site for natural gas. The sudden upward movement of gases caused a dramatic cratering – the Darvaza crater is 69m wide and 30m deep – and released gas into the air.

“About 10 years after the cratering happened, it was still venting gas,” says Mark Ireland, a lecturer in energy geoscience at Newcastle University. “So local geologists purposefully lit it to burn off the gases.”

The crater was expected to burn for a matter of days, but is still alight now, some four decades on. And it's hard to predict when the crater will burn out.

“We're missing a lot of scientific data about it,” says Ireland. “But it's reported that there is life in the crater: certain microbes like certain conditions. Maybe we could learn something about the extremes where life can survive.”

SHUTTERSTOCK









Snapshot



All hail!

GUADALAJARA, MEXICO

The mountain city of Guadalajara, capital of the Mexican state of Jalisco, is home to around five million people. With a subtropical climate, summers in Guadalajara are hot and wet: in the days before this picture was taken, temperatures had been around 31°C, which is about average for the time of year.

But on the morning of Sunday 30 June this year, the city awoke to streets covered in ice up to 1.5m deep. The hailstorm that caused this scene was thought to have been caused by a band of low pressure moving across Mexico, combined with the moist air that comes with summer time in Guadalajara. The governor of Jalisco, Enrique Alfaro Ramírez, tweeted that he had never witnessed scenes like it.

Thankfully, no one was injured during the storm – although hundreds of homes were damaged, and dozens of cars were swept up in the flood of ice.

GETTY IMAGES

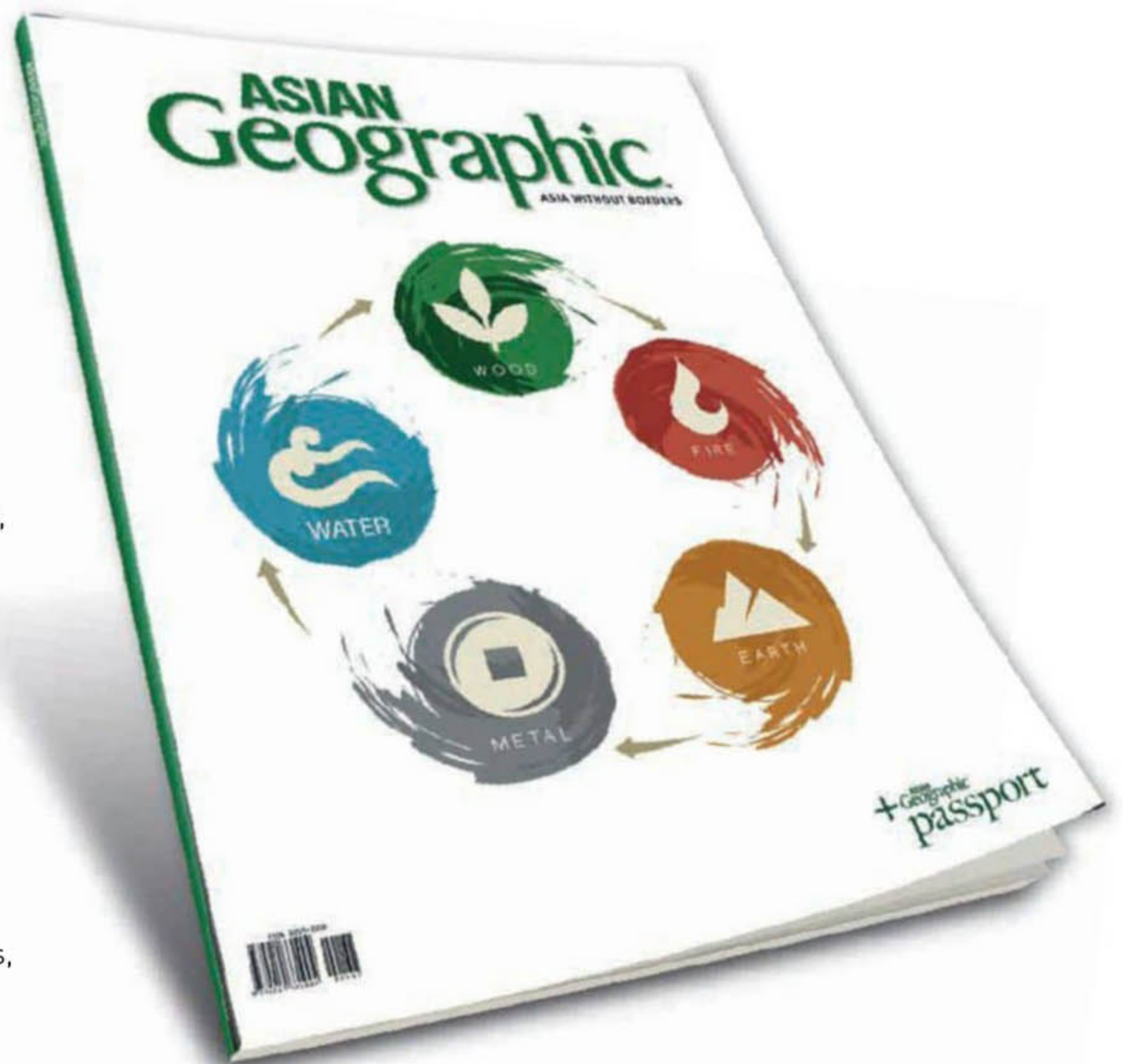
SUBSCRIBE E-MAGAZINE TODAY!

ASIAN Geographic magazine
is going through a rehaul!
Featuring 2020 editorial lineup

Elements of Life, Colours of Asia

In 2019, *ASIAN Geographic* is celebrating 20 years of bringing Asia to the world, and we have an exciting lineup ahead in 2020. Our editorial calendar will be based on a philosophical approach to Wu Xing, or the five elements in Chinese philosophy – Water, Wood, Fire, Earth, and Metal – with our last issue of the year projected to focus on bringing these elements together, all through travel.

Our first five 2020 issues will be colour-coded in blue, green, red, brown, and silver, respectively, to address our concurrent themes, and each issue will include a *PASSPORT* section that will focus on a specific region in Asia. The sixth and final issue of the year will be an *ASIAN Geographic PASSPORT* special edition that will combine all these elements and their associated colours, making the entire year's publication come together in a stunning, rich hue – making up the perfect collection!



NO. 140 ISSUE 1/2020

+ PASSPORT SECTION
FEATURED REGION:
SOUTHEAST ASIA



Water

An inherent part of our lives, the water element is downward and inward, and its energy is stillness and conserving. This issue covers everything blue, whether by taking a plunge into the waters – where we will swim amongst issues of ocean governance, conservation, sustainability, or diving – or even just by sipping on the Asian-native butterfly pea flower tea from the pods planted in your garden.

NO. 141 ISSUE 2/2020

+ PASSPORT SECTION
FEATURED REGION:
WEST ASIA



Wood

Wood, sometimes translated as Tree, symbolises growth and longevity, much like the bamboo stems that are strong, flexible, and some of the fastest growing plants in the world. As the first phase of Wu Xing, it also signifies the birth and beginning of life. This issue celebrates and navigates through the most important thing known to the living: Life itself.

NO. 142 ISSUE 3/2020

+ PASSPORT SECTION
FEATURED REGION:
EAST ASIA



Fire

The motion of fire is upward and its energy is expansive, representing dynamism, strength, persistence, and prosperity. This issue will look at brightness, warmth, heat and the full bloom of flowers, fruits, and creativity in the arts and culture of Asia.

NO. 143 ISSUE 4/2020

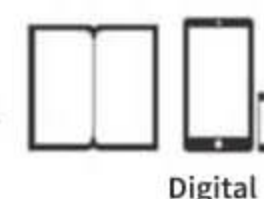
+ PASSPORT SECTION
FEATURED REGION:
CENTRAL ASIA



Earth

Earth is a balance of both yin and yang. Its motion is inward and centering, and its energy is stabilising and conserving. Earth is associated with practicality, hard work and stability. In this issue, we look at Asia balancing sustainability, conservation, and economic growth, as well as exciting solutions that can spur a new green economy while shining a spotlight on marine and wildlife conservation.

VISIT OUR NEW WEBSITE TO GET YOUR SUBSCRIPTIONS TODAY!
www.asiangeo.com/subscribe



Digital

Platforms

eMagazine

18,000 – 25,000

Monthly average of online downloads



Website

www.asiangeo.com



Social Media



226,500
followers



5,000
followers

Our Readership



ASIAN Geographic
Circulation

92,000

COPIES PER ISSUE



Bringing Asia to the
hearts and minds of over

428,000

READERS ACROSS ASIA



Readership

2.5million

A YEAR

NO. 144 ISSUE 5/2020

+ PASSPORT SECTION
FEATURED REGION:
SOUTH ASIA



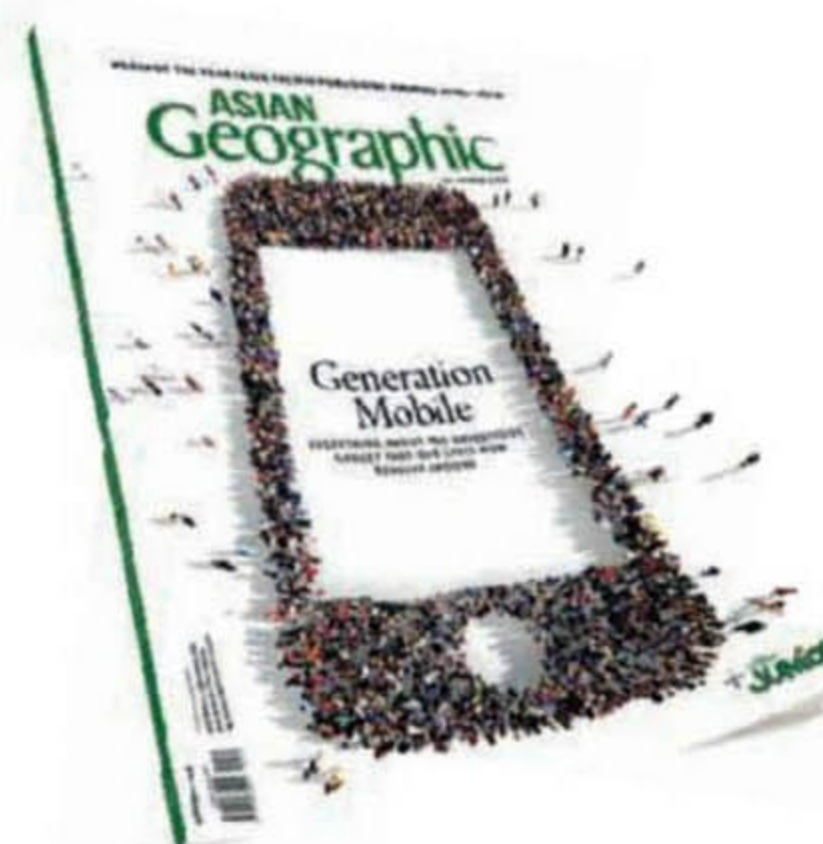
Metal's motion is inwards, and its energy is contracting. Metal attributes are firmness, rigidity, persistence, strength, and determination. This issue of ASIAN Geographic looks at all the special festivals and remembrance days that are celebrated by different countries and cultures all across Asia, as we contract and combine the things that make this continent so vast, yet so unique.

NO. 145 ISSUE 6/2020

The Colour Edition:
Passport

TRAVEL ISSUE

This PASSPORT special edition will bring all the five elements together into a full circle, as it is meant to be, and we will explore all the corners of Asia through Wu Xing. Water, Wood, Fire, Earth, and Metal will encompass the largest continent in the world, and all the regions in Asia will be seen through this exceptional lens.



80%

EDITORIAL

20%

ADVERTISEMENTS

CONNECT WITH ASIAN GEOGRAPHIC PRINT, MOBILE, SOCIAL, ONLINE, TABLET.



ANDROID APP ON
Google play

Download on the
App Store

Flipster

JOOmag

MAGZTER

pressreader

Qoo10

SCOP

zinio



NEUROSCIENCE

A treatment for anxiety is all in the mind **p17**

ENERGY

Capacity of shale gas to meet energy needs is lower than expected **p19**

MARINE BIOLOGY

Sharks' fluorescence may protect them from infection **p20**

ZOOLOGY

Senetic secrets of sex-changing fish discovered **p22**

PIONEERING GEL COULD MEND DAMAGE AFTER HEART ATTACK

World-first trial shows promise for pioneering treatment following heart attacks

There are more than 100,000 hospital admissions in the UK due to heart attacks every year, but there are few effective treatments for repairing the resulting damage to cardiac tissue. Following a heart attack, scar tissue can develop which can reduce the performance of muscles and eventually lead to ►

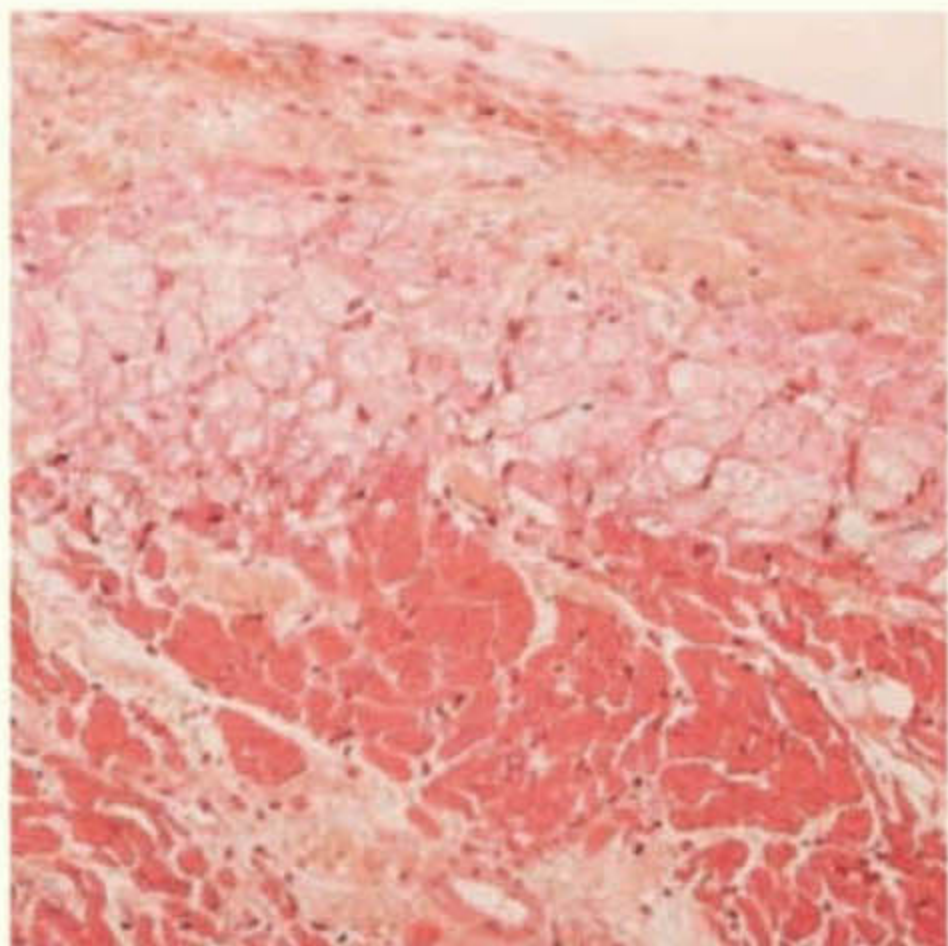


Visualisation of a heart attack, in which blood flow to the heart is interrupted

NEWS IN BRIEF

GENES FOR LEFT-HANDEDNESS IDENTIFIED

Researchers at the University of Oxford have identified areas of the human genome associated with left-handedness. The team made the discovery after analysing the genomes of 400,000 people, including more than 32,000 left-handers, stored in the UK Biobank database. They found four genetic variants that contribute to left-handedness. Three of these are associated with proteins involved in the structure and development of the brain.



In this microscope image of heart tissue, the darker regions along the bottom are muscle fibres that have died following a heart attack

► heart failure. Now, researchers at the University of California, San Diego think they may have a solution – an injectable hydrogel that can form a scaffold around damaged cardiac muscle and encourage the growth of healthy, new tissue.

Dubbed VentriGel, the material has passed its initial safety trials. It is made from the natural scaffolding of cardiac muscle tissue – also known as extracellular matrix, or ECM – which is taken from pigs. The tissue is then stripped of muscle cells, freeze-dried and milled into powder form. It can then be turned into a fluid that can be easily injected into heart muscle in a minimally invasive procedure.

The team tested the gel in a preliminary study of 15 patients who had sustained moderate damage in the left chamber of the heart following a heart attack. All 15 were experiencing mild to moderate heart failure following a heart attack, with half suffering a heart attack within the past year.

The patients all took a six-minute walking test as well as a heart function assessment and a heart health questionnaire before receiving up to 18 injections of VentriGel into



Prof Karen Christman led the development of VentriGel

the damaged region via catheter.

The researchers then monitored the patients' progress for six months after treatment, repeating the tests at the three-month and six-month marks.

"Although the study was designed to evaluate safety and feasibility and not designed to show whether VentriGel

effectively helps improve heart function, we observed some improvements in patients," said senior author Prof Karen Christman. "For example, patients could walk longer distances. We also observed signs of improving heart function in patients who experienced a heart attack more than one year prior to treatment."

SCIENTISTS PAWS-ITIVE WE'VE ALTERED DOGS' BRAINS

Over the centuries, humans have bred dogs for different tasks, like hunting, herding or companionship. This has led to huge variation in our pooches' physical characteristics. But new research suggests that our meddling has shaped their brains as well. A US-based team used an MRI scanner

to study 62 dogs from 33 breeds, and found that brain anatomy varied considerably, and seemed to correlate with the tasks that the dogs had been bred to carry out. However, the variations don't seem to be linked to the size of the animal's brain, or its skull shape.



TRENDING

YOUR GUIDE TO WHO'S SAYING WHAT ABOUT THE HOTTEST TOPICS IN THE WORLD RIGHT NOW



#OrganDonation Week2019

The first week in September 2019 marked organ donation week in the UK – a campaign set up to encourage members of the public to share their stories of organ transplantation and their own personal decisions regarding organ donation.

Stephanie Slater MBE
@StephESlater

I was given the gift of sight in 2016 thanks to my donor and her family! It really has changed my life! Forever grateful! Thanks to @LivOphth St.Paul's Eye Unit for the expert and passionate care I receive too. Have you shared your wishes??

Lucy
@ResearcherLucy

Sadly every day at least three people die whilst waiting for a transplant. A figure which could change if more of us registered. Even with the law change, it is important that your family know your wishes.

#LochNessMonster

After months of analysing DNA extracted from water samples taken from Loch Ness, researchers from New Zealand have ruled out the possibility of Nessie being a catfish, sturgeon, Greenland shark, or plesiosaur. The only plausible remaining candidate is a giant eel.

A/Prof Samantha Pugh
@SamLP

I love the #LochNessMonster story. All science has proved is that we can't find it, which is not the same as proving it doesn't exist!

Lisa Farrell
@ResearchLisa

Duh, it's a mythical creature and therefore transcends DNA. Leave Nessy alone and let us believe. #lochnessmonster



#EuniceFoote

This year is the 2001st anniversary of the birth of Eunice Foote, a little-known pioneer of climate research and first person to make the connection between carbon dioxide levels and climate change.

Request a Woman Scientist
@RequestWSTEMM

You've heard of #RosalindFranklin but how about #LiseMeitner #EuniceFoote #ChienShiungWu? The Matilda Effect: the refusal to acknowledge scientific discoveries made by women researchers. Read on, then share a #ScientificDiscovery you've made.

Joseph DeMarco
@JosephJDeMarco

In 1856, Eunice Foote – a scientist and activist – was the first woman to connect carbon dioxide and climate change. This was 3 years before Tyndall, the man that is widely credited as the first to discover this connection.

#Dorian

Hurricane Dorian wreaked devastation across the Bahamas with winds reaching almost 300km/h before lashing the coast of North and South Carolina.

Josh Morgerman
@iCyclone

I mean it when I say #Hurricane #DORIAN is worst cyclone disaster I've personally witnessed since Super Typhoon HAIYAN. Scale of destruction is jaw-dropping – you can't get your head around it – and task ahead is Herculean. They need HELP. Consider pitching in.

Bill McKibben
@billmckibben

Since records began in 1851, #Dorian is the slowest moving major hurricane (something that scientists have linked to a warming climate). This is what happens when a storm just sits like a blender over the Bahamas.





Macaques suffer from anxiety too

NEUROSCIENCE

A treatment for anxiety is all in the mind

Boosting levels of a protein that stimulates neuron growth could offer new hope

A protein that is found naturally in the brain could decrease behaviours associated with anxiety, according to US researchers. The protein, neurotrophin-3, was found to stimulate neurons to grow and connect within the dorsal amygdala – an area of the brain involved in emotional responses.

The team selected a group of young rhesus macaques who displayed signs of ‘dispositional anxiety’ – the tendency to feel unduly anxious, or perceive a wide range of situations as threatening. They were able to identify neurotrophin-3 as one of the molecules related to this type of anxiety. They used a modified virus to boost levels of the protein within the dorsal amygdala, and found that the macaques’ anxiety decreased.

“Neurotrophin-3 is the first molecule that we’ve been able to show in a non-

human primate to be causally related to anxiety,” said Andrew Fox, co-author of the study and assistant professor in the department of psychology at University of California, Davis. “It’s one of potentially many molecules that could have this effect. There could be hundreds or even thousands more.”

It is estimated that some three million people in the UK have an anxiety disorder, and more than 1 in 10 of us are likely to have a disabling anxiety-related condition in our lifetime. “These disorders are some of the leading causes of disability and days lost to disability,” said Fox.

Currently, patients living with anxiety are offered a range of treatments to manage their condition, but there are no guaranteed routes to overcoming the disorder permanently.

GREEN PAPERS

THE ENVIRONMENTAL STORIES YOU NEED TO KNOW



Highly contentious
fracking site in
Lancashire

INDIA'S PLASTIC BAN

India is set to ban six single-use plastic items, including bags, cups and straws, say officials. The nationwide ban will come into place on 2 October, the birth anniversary of independence leader Mahatma Gandhi. Plates, small bottles and some sachets will also be covered, officials told Reuters. If properly enforced, the measure is expected to cut 5 to 10 per cent from the country's plastic consumption. Indian prime minister Narendra Modi had previously urged people to "take the first big step" towards freeing India of single-use plastic. "On this 2 October, can we make India free from single-use plastic?" he said during his Independence Day speech on 15 August.

ENERGY

Capacity of shale gas to meet energy needs is lower than expected

Shale gas advocates in the UK may be feeling despondent this month

Resources of UK shale gas could be just one-sixth of what was previously thought, according to estimates from the University of Nottingham and the British Geological Survey (BGS).

In a study published in Nature Communications, researchers looked

at the amount of gas in the Bowland Shale, which is an area stretching from Lancashire down into the Midlands, and is viewed as the country's largest and most economically viable shale resource. The new estimates, derived from data taken from UK shales,

BANANA WOES

Banana farmers in some of the world's biggest producing countries could be hit hard by climate change. The changing climate has made conditions more favourable for bananas in recent decades, according to research published in *Nature Climate Change*. But these gains could disappear by 2050 if climate change continues at its

expected rate, the study found. Ten major banana exporters could be negatively affected, including India, the world's biggest producer. The impacts of climate change on bananas have been largely ignored so far, said study co-author Daniel Bebbie. "There will be winners and losers in coming years."

predicted supply could actually amount to less than 10 years' worth. This is in contrast to an earlier 2013 BGS study that found Bowland shale could meet current gas demand for up to 50 years.

The new findings will help to improve people's understanding and government decisions on the future role of shale gas in the UK's energy demand, as the country moves towards carbon neutrality by 2050, said study co-author Prof Colin Snape.

But the authors were keen to stress there is still a large degree of uncertainty in all shale estimates. A "truly foolproof" assessment can only come from widespread test drilling, they say.

"To be honest, I wasn't surprised at all," said Darrick Evensen, a lecturer in environmental politics at the University of Edinburgh.

"Initial estimates come out, and there's only one direction they ever go from there: they always go down"

The downward revision follows a similar trend seen in the US.

"Initial estimates come out, and there's only one direction they ever go from there: they always go down. It's not bad science, it's what they have available at the time to do the estimates," Evensen said.

Here in the UK, the government argues that shale gas could be an important new domestic energy source. It recently indicated it may be willing to rethink its rules on the tremors caused by fracking for shale, which have stunted the industry.

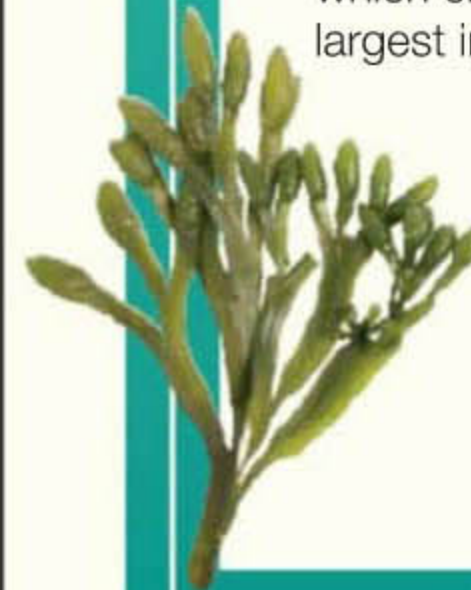
Polls of the general public have long shown that opposition to fracking is far higher than support. In the latest survey, opposition sat at 35 per cent, compared to 15 per cent support. Such 'above ground factors' are actually likely to determine if and how the UK ends up using any shale gas resources, said Laurence Williams, a research fellow in environmental politics from the University of Sussex, who studies the public perceptions of fracking.

"That would be things like government policy, public attitudes, but also some stuff in terms of the relationship between shale gas and climate change and whether that is reconcilable," he said.



GRUB'S UP

Pet food made from insect protein could be more environmentally friendly than using meat, according to Dutch pet food firm Protix, which claims to run the world's largest insect farm.



STAR SEAWEEED

Seaweed farming has "huge potential" to help climate change through its ability to absorb carbon, according to a University of California study.

INSPIRED EXPIRED

SCOOTER POLLUTER

E-scooters are less green than cycling or taking the bus – although they're still greener than cars, according to research by North Carolina State University.



NO PHOTOS, PLEASE

Wildlife selfies are harming animals, experts warned at a penguin conference in New Zealand. There is increasing concern the practice is affecting animal behaviour.



IT IS EASY BEING GREEN

REUSE AND RECYCLE OLD GADGETS

As many as 40 million electronic devices are sitting unused in drawers in the UK, according to research by Ipsos

MORI for the Royal Society. These old gadgets are often hoarded in our homes, yet they contain rare metals that could run out in the next 100 years and are needed for green technologies. To help, you can hold off upgrading

your phone for another year or pass your old phone to a relative, the Royal Society said. If your device is no longer usable, don't just toss it in a drawer. Instead, look up recycling options in your area at recyclenow.com.





FAST-FOOD TEMPTATIONS ON COMMUTE MAKE YOU FATTER

Walking past a smorgasbord of fast food outlets along your commute could make you fatter, according to research by Arizona State University. The study analysed data from 710 female elementary school employees in New Orleans. Commuters who passed within a kilometre of

more supermarkets, grocers and restaurants offering fast food had higher BMIs than those passing by restaurants that offered slower, more formal table service. "The availability and variety of fast-food restaurants along our commute create endless opportunities for a quick, cheap, and unhealthy meal," said Prof Adriana Dornelles, who carried out the research.

IN NUMBERS

7_p

The weekly cost per household of taxing plastic packaging with less than 30 per cent recycled material, as calculated by a team at Imperial College.

SIX MONTHS

The age at which babies begin showing empathy for victims of bullying, as discovered by a study at the University of the Negev, Israel.

110

The percentage that butterfly numbers are up in England, compared to 2017.

MARINE BIOLOGY

Sharks' fluorescence may protect them from infection

Scientists have deciphered how fluorescent sharks light up in the ocean depths. While researchers have known for a while that invertebrates such as corals and jellyfish can fluoresce thanks to special proteins in their bodies, they haven't figured out exactly how sharks can do it – until now.

"Sharks hold so many mysteries and superpowers"

Scientists from City University of New York and Yale University studied two species of sharks – swell sharks and chain catsharks. Both of these species can live at depths of greater than 450 metres, where they are known to glow with a green colour. The team took

samples of chemicals from the sharks' skin, and found that the lighter-coloured areas of skin contained a new type of fluorescent molecule previously unknown to science.

As well as allowing the sharks to glow and therefore recognise each other in the ocean, the fluorescent molecule may even help to protect the animals against infections,

thanks to its antimicrobial properties.

"Studying biofluorescence in the ocean is like a constantly evolving mystery novel, with new clues being provided as we move the research forward," said study co-author Prof David Gruber. "After we first reported that swell sharks were biofluorescent, my collaborators and I decided to dive deeper into this topic. We wanted to learn more about what their biofluorescence might mean to them."

There has been a huge surge of interest in studying fluorescent animals, as if we can harness their abilities then it could help us develop new imaging systems for use in science and medicine.

"Sharks are wonderful animals that have been around for over 400 million years. Sharks continually fascinate humans, and they hold so many mysteries and superpowers," Gruber said. "This study highlights yet another mystery of sharks, and it is my hope that this inspires us to learn more about their secrets and work to better protect them."

Swell sharks spend a lot of time resting on the bacteria-laden sea bed, and scientists think that fluorescent molecules in their skin may protect them from infection





In certain memory tasks, chimps perform similarly to human children

ZOOLOGY

Chimpanzees' memories may work a lot like ours

Scientists have previously established that chimps have excellent long-term memories to help them remember the best places to find food. Now, though, they wanted to explore how the apes' working memories performed.

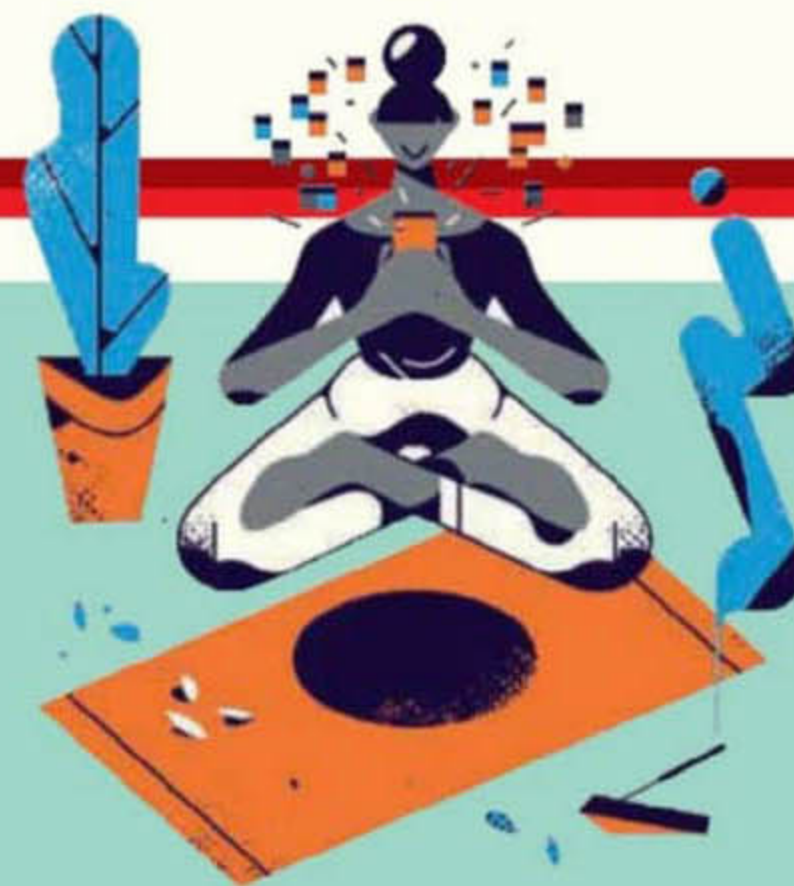
Working memory – sometimes compared to a mental sketchpad – is essential. It allows us to hold new information in our heads and not lose track of what we're doing. For example, remembering the beginning of this sentence as you reach the end of it. To test the chimpanzees' working memories, scientists from the University of St Andrews, the Max Planck Institute and the University of Veterinary Medicine Vienna set out a selection of small, opaque containers and hid food inside some of them, while the chimps watched. The apes then pointed out which box held the food, and if they guessed right, they

got to eat it. After each choice, the containers were hidden for 15 seconds. To retrieve the maximum amount of food, the chimps needed to remember which boxes they'd already searched, therefore testing their working memories.

The team made the activity steadily more difficult by adding more containers and by moving them around between searches. The chimps that performed best remembered four food items, but one young animal managed more than seven.

The scientists further tested the chimps by getting them to carry out a similar activity at the same time. Just like humans, the apes performed worse when they were forced to multitask.

"Our findings suggest that chimpanzees perform similar to seven-year-old children in an intuitive working memory task that does not rely on extensive training," says Christoph Voelter, who led the research.



GAMERS

Playing video games may be the best way to wind down, researchers at University College London have found. People who played a smartphone puzzle game for 15 minutes after work were more relaxed, more energetic, and less stressed than those who were given fidget spinners or mindfulness apps to use.

OPTIMISTS

Being a glass-half-full person may help us to sleep better, a study at the University of Illinois has found. A survey of more than 3,500 people aged 30 to 50 found that those who rated themselves as optimistic were 78 per cent more likely to report good sleep.

GOOD MONTH

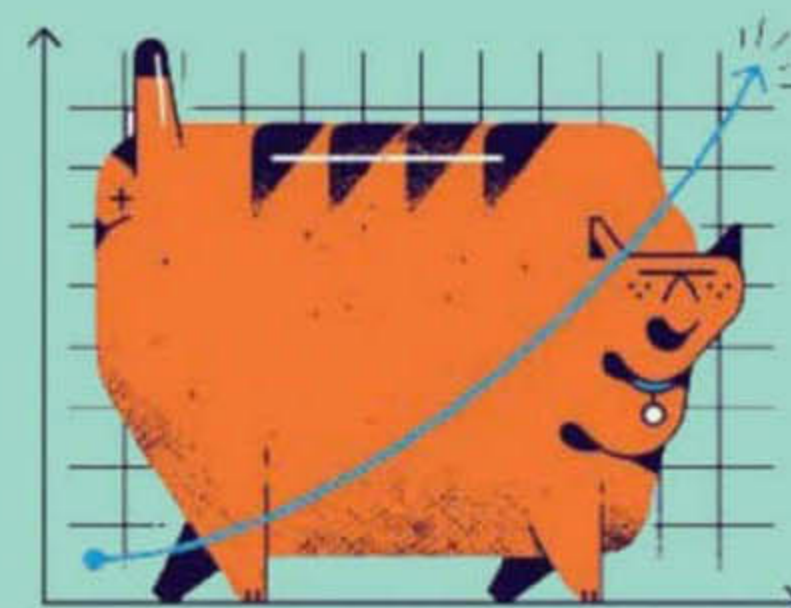
BAD MONTH

FREQUENT FLYERS

Planning a flight? Make sure you're buckled up tight! Changes in the jet stream thanks to climate change are leading to more turbulence. Researchers at Reading University estimate that severe turbulence could rise threefold in the next 50 years.

FAT CATS

We're not the only ones that are prone to middle aged spread. Researchers in Toronto have found that pet cats pile on the pounds as they age, peaking at eight years old. They suggest that cat owners regularly pop their moggies on the scales to make sure they are a healthy weight.



NEVER TOO OLD TO LEARN

Learning multiple skills at once can give older people a mental boost, a study at the University of California, Riverside has found. Participants aged 58-86 enrolled in three to five classes (such as Spanish, photography, IT skills, art and music composition) totalling about 15 hours per week. After six weeks, the participants showed improvements in their memory and cognition skills, putting them on a par with those 30 years younger.



ZOOLOGY

Genetic secrets of sex-changing fish discovered

Around 500 species of fish are known to undergo one of the most startling transformations in the natural world – the complete reversal of sex. Now, a study carried out at the University of Otago, New Zealand on bluehead wrasses, a small-bodied fish that lives in coral reefs in the Caribbean, has found out how they do it.

Most bluehead wrasses begin life as females, but when the dominant male is lost from a social group, the largest female transforms into a fertile male in as little as 10 days. They begin this transformation within minutes of the male's departure, first changing colour and displaying male-like behaviours. Their ovaries then start to regress and fully functional testes grow in their place.

Using the latest genetic approaches, the researchers discovered that the change is

the result of specific genes being 'turned off' in the brain and gonad. The transformation begins when aromatase, a gene responsible for making the female hormone oestrogen, is turned off, though exactly what triggers the aromatase to turn off is not yet known.

"How this stunning transformation works at a genetic level has long been an enigma," said the study's co-lead author Dr Erica Todd. "Our study reveals that sex change involves a complete genetic rewiring of the gonad. We find that genes needed to maintain the ovary are first turned off, and then a new genetic pathway is steadily turned on to promote testis formation."

The amazing transformation also appears to be made possible thanks to changes in cellular 'memory'. As researcher Oscar

Ortega-Recalde explained: "In fish and other vertebrates, including humans, cells use chemical markers on DNA that control gene expression and remember their specific function in the body. Our study is important because it shows that sex change involves profound changes in these chemical marks, for example at the aromatase gene, thus reprogramming cell memory in the gonad towards a male fate."

As many of the genes that are important for sexual development in fish are also important in other animals, the team's discovery could eventually have practical applications for humans.

"Understanding how fish can change sex may tell us more about how complex networks of genes interact to determine and maintain sex, not only in fish but also in vertebrate animals more generally," Todd said.



NATURAL TRANSITIONS



The ability to change sex is surprisingly common in fish species, particularly those, such as clownfish and wrasses, that dwell in a coral habitat.



Adult hens have one developed left ovary, and one undeveloped right ovary. If the left ovary is damaged, the dormant right one can in some cases develop as a testis instead.

In humans, there are several hormone deficiencies that can cause a child to appear female before puberty, but male once puberty has taken place.





Salford, UK

ANTHROPOLOGY

Tuning in to the mystery of Stonehenge

Sound engineers at the University of Salford have created a tiny model of Stonehenge in order to investigate the ancient monument's acoustic properties.

The 157 stones were made by pouring a plaster-polymer mix into individual 3D-printed silicone moulds, which were constructed using highly accurate laser scan data provided by Historic England. The 1:12 scale model is just over 2.5m across and includes representations of many stones that are now missing from the original monument.

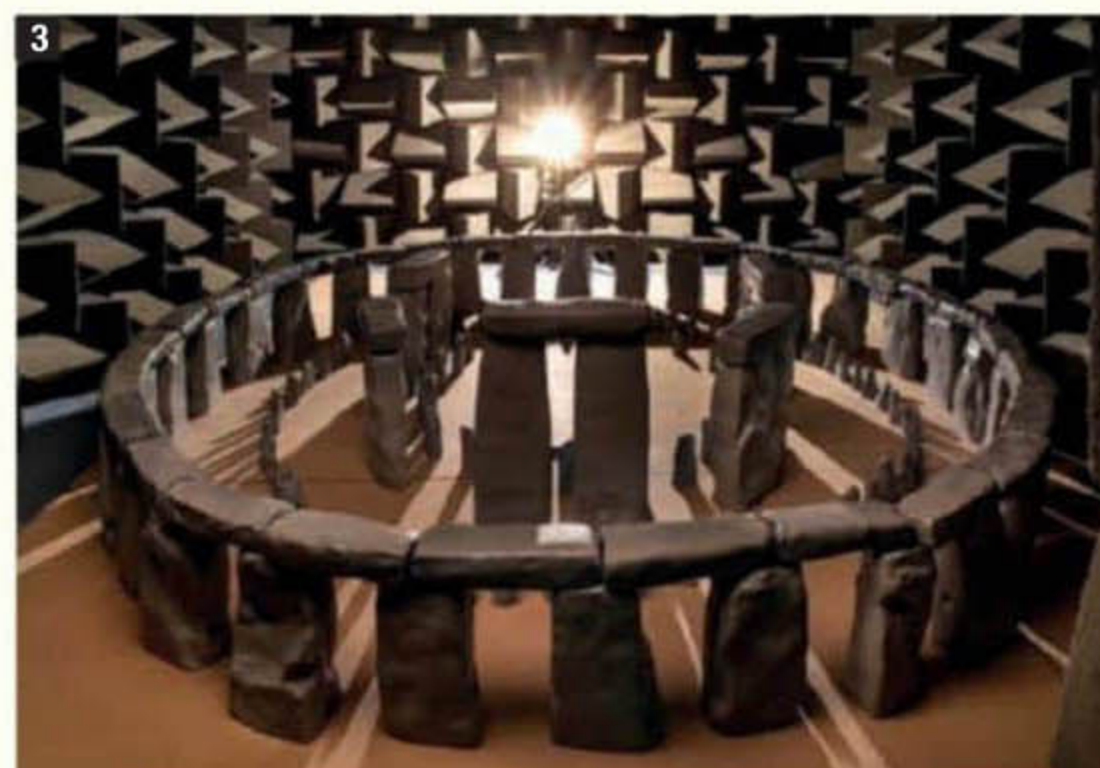
Prof Trevor Cox and his team created the model to test its acoustic properties, in an attempt to shed light on what Stonehenge may have been used for. "There have been very few studies into the sounds created at Stonehenge," said Cox. "We know, for example, that reflections from the stones should have helped to reinforce speech. But by how much? This scale model, which uses archeological mapping techniques to better understand the site's layout, will give us new insights into what our ancestors would have heard in the stone circles."



1. Prof Trevor Cox tested the acoustic properties of the scale model using ultrasonic soundwaves.

2. The 157 stones were carefully positioned to faithfully replicate the structure of the real-life Stonehenge.

3. The completed model was placed into an anechoic chamber for acoustic analysis. The pattern of spikes on the walls are specially designed to completely absorb all sound waves.



DIGITAL VS ANALOGUE

How tech has transformed the creative process

The last time I wrote something linearly – as in, started at point A and ended, unedited, at point Z – was in 2004. The timer had started in an essay exam for my master's degree, and on the desk in front of me was a single blank page. I had to answer the question on the board using only a pen. I hadn't written anything of substance without a keyboard and mouse in more than a decade, and something fundamental had changed. My brain now organised itself in disorganised snippets of phrases and paragraphs that were entirely out of place until they were cut and pasted into their correct order. But that's not how pens work.

The essay I submitted was covered in circles and arrows and scribbles in the margin that begged the examiner to read paragraph three before paragraph one, and to swap out this phrase with another. I can only assume they were in the same boat as me, because somehow I passed.

In the 100th episode of *Digital Human* – 15 years of even more entrenched computer use later – we poked at this mental shift. We decided to make the programme using old skool, non-digital methods: heavy recording machines, limited tape supplies, no copy-and-paste feature, and certainly no 'undo'.

This is entirely different from how we've been making programmes for the 20 years since digital editing tools

“The constraints of the analogue world are foreign to how we create things today”

arrived at the BBC. Nowadays, we don't use razor blades to cut single-use snippets of magnetic tape. Nor do we use sticky tape to paste it into place. We select things with a mouse, occasionally copy the selection so we have another version of it, and paste it elsewhere. We add music underneath, and shift it around at will. None of this is done live – not even my links. Those are recorded separately and slotted in.

In the 100th-episode experiment, everything had to have human hands on it, and every touch degraded the original. Everything had to be done 'as live' – from fading up the music to reading my lines into the story. It all had to be meticulously planned

from the moment the idea came up, because it had to be recorded in one go. It was thrilling, but exhausting in an entirely different way from our regular process because of the analogue constraints.

The digital age doesn't alleviate cognitive heavy lifting, though; it simply pushes it to the end of the process. But the ability to copy in high fidelity and endlessly undo means that we are never entirely done. We can forever edit out a contributor's ums and ahs, we can shift things around. We now have an unlimited toolset in drop-down menus, so we can add fades and filters until the end of time.

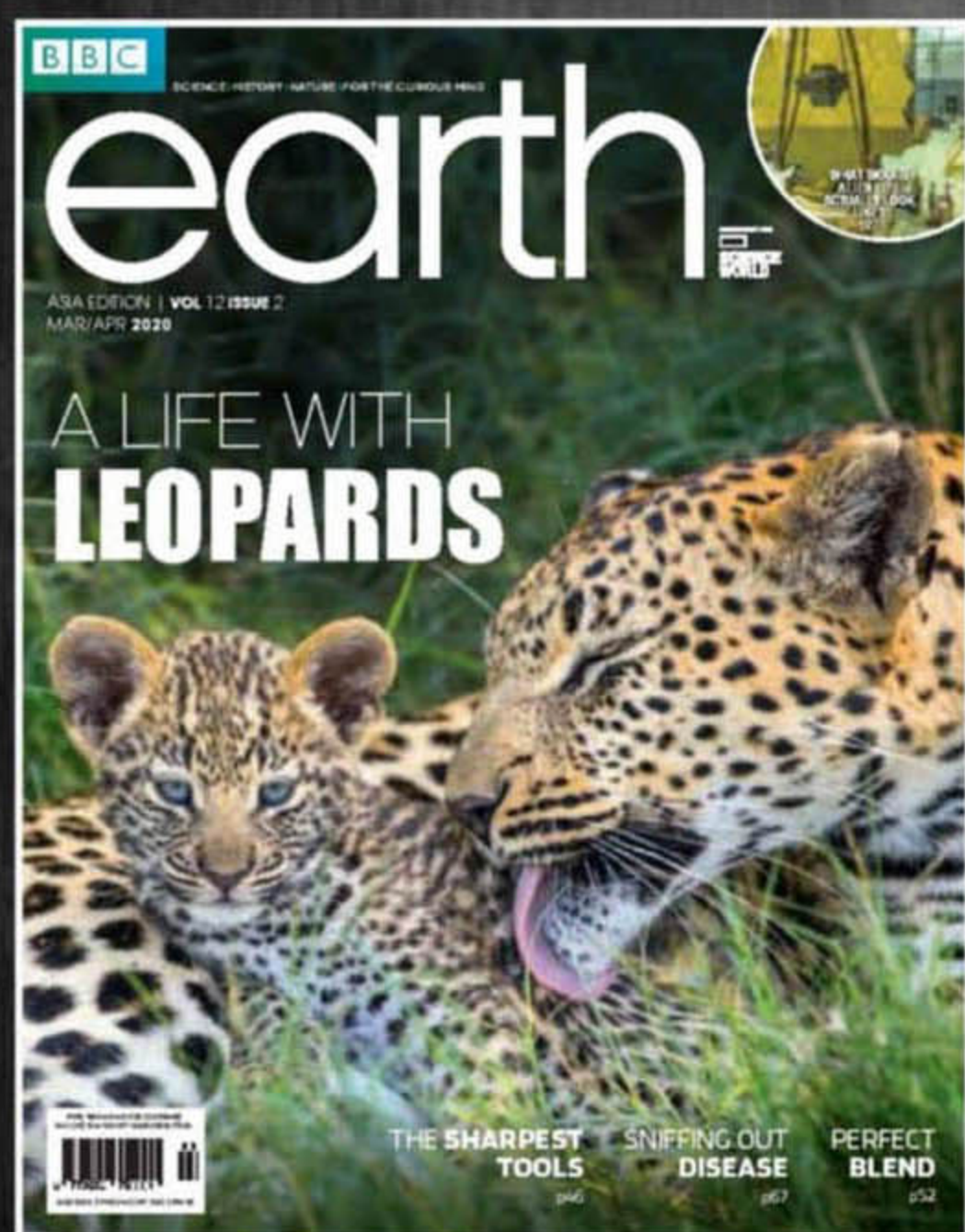
I didn't write this column on paper with a pen, but I wish I had because I've been cutting and pasting it for a week. The constraints on creativity that the analogue world enforces are now quite foreign to how we produce things. Putting the cognitive load at the front end is an entirely valuable, if retro, way to create. And it's something that, combined with the endless toolbox we now have at our fingertips, is powerful indeed. 🌐



ALEKS KROTOSKI

Aleks is a social psychologist, broadcaster and journalist. She presents *Digital Human*.

SPECIAL SUBSCRIPTION OFFER!



4 EASY WAYS TO SUBSCRIBE



GO ONLINE*
e-shopping.sg

READ. EXPLORE

OR EMAIL

subscription@media-group.com.sg
Leeyin@sisterspic.com



FAX TO
SINGAPORE
65-6449 9945

MALAYSIA
03-2282 9831



CALL HOTLINE
SINGAPORE
65-6446 6888

MALAYSIA
603-2282 9830



MAIL TO

Media Group Pte Ltd,
20 Bedok South Road,
Singapore 469277
or
Next Trend Publications S/B
B15-9, The Boulevard, Mid
Valley City, Lingkaran Syed
Putra, 59200 Kuala Lumpur

GREAT REASONS TO SUBSCRIBE

- Every issue delivered direct to your door
- Exclusive subscriber-only offers and discounts

BBC EARTH MAGAZINE SUBSCRIPTION OFFER

YES! I WANT TO SUBSCRIBE!

PLEASE TICK ACCORDINGLY

☐ Singapore, 1 year subscription, 6 issues for SGD48

☐ Malaysia, 1 year subscription, 6 issues for MYR98

*Rates are inclusive of postage in SGP and MYR

PERSONAL PARTICULARS

Title	Surname
Name	
DOB	NRIC
Tel	Mobile
Email	
Address	
Country	
Postal Code	

MY PROFILE

Gender	Age Group	Occupation	Annual Income
<input type="radio"/> Male	<input type="radio"/> Below 30	<input type="radio"/> Executive	<input type="radio"/> Below \$50,000
<input type="radio"/> Female	<input type="radio"/> 31 - 40	<input type="radio"/> Management	<input type="radio"/> \$50,001 - \$100,000
	<input type="radio"/> 41 - 50	<input type="radio"/> Professional	<input type="radio"/> \$100,001 - \$150,000
	<input type="radio"/> Above 50	<input type="radio"/> Businessman	<input type="radio"/> Above \$150,000

YOUR PAYMENT OPTIONS

☐ CHEQUE

Please enclose a cheque made payable to:

Singapore: Media Group Pte Ltd

Malaysia: Next Trend Publications Sdn Bhd

Cheque No.:

Amount:

☐ CREDIT CARD* (VISA & MASTERCARD ONLY) *Singapore dollar only

Debited amount under "Golf Events and Marketing" will be reflected in your credit card statement for subscribers in Singapore.

Name on Credit Card:

Credit Card No.:

Expiry Date:

Amount:

Signature:

Date:

TERMS & CONDITIONS:

- This subscription offer is non-refundable
- Promotion is valid till the end of 30 Apr 2020
- Subscription gifts where applicable are available on a while stocks last basis
- The above subscription rates are only applicable to readers residing in Singapore & Malaysia
- Gifts must be taken as provided and are neither transferable nor exchangeable for cash
- Company reserves the right to replace gift when stock is unavailable
- All prices are inclusive of GST and taxes
- Please allow 4-6 weeks for processing
- Subscribers/Winners will be notified by post
- Subscription gifts/lucky draw prizes are to be collected at address stated on notification letter
- Other terms and conditions apply



Scan this QR Code for
the audio reader

What would alien life actually look like?

As we discover ever more planets orbiting other stars, and plan missions to potentially habitable moons of Saturn and Jupiter, will we find life – and if we do, will we even recognise it?

by MIČO TATALOVIĆ

Our Universe could turn out to be a pretty wild place. Recent astronomical discoveries suggest that billions of Earth-like planets are dotted throughout our Galaxy, which is just one of billions of galaxies in the Universe. “Our best estimates are that one in four stars have a planet that is the same size and the same temperature as the Earth. That’s very high,” says David Charbonneau, professor of astronomy at Harvard University, US.

And many scientists now think there is life on at least some – if not many – of those planets and their moons. One of them is Dr Chris McKay, a planetary scientist at NASA’s Ames Research Center, who says that we can assume that life is widespread based on “two simple facts”.

First, the chemical elements of life, such as nitrogen, hydrogen and oxygen, are widespread in the Universe, as are the two key compounds of life on Earth: liquid water and organic carbon. Second, we know that life was present on Earth very early in its

history – soon after the planet was formed – which suggests that once the conditions are right, life springs up easily and quickly.

“If the origin of life is widespread, then complex life will be widespread,” says McKay. That means we might expect to find more than just single-celled microbes out there. “The best way to find out is to go look.”

Some scientists and entrepreneurs are already thinking about how to get to distant stars quickly. Yuri Milner, a Russian tech

entrepreneur, came up with the Breakthrough Starshot project, which proposes that tiny chips could be attached to craft propelled through space by an intense Earth-based laser. If it works, this would cut the travel time to the closest star system, Alpha Centauri, from 100,000 to just 20 years. The first tests of early designs took place this May.

In the meantime, two NASA missions are set to shine light on the atmospheres of planets that orbit other stars (exoplanets), pinpointing those that could harbour life. The TESS mission started collecting data this year, and the James Webb Space Telescope is expected to launch in 2021. “We know virtually nothing about the actual conditions on those planets,” says Charbonneau. These two missions will change that.

VISIONS OF OTHER WORLDS

Some of science’s brightest minds have already brainstormed what we might expect to find, and their conclusions formed the basis of two cult documentaries, *Natural History Of An Alien* and *Alien Planet*, which first aired in 1998 and 2005 respectively. The two films inspired many people to think ►

**“IF THE ORIGIN OF LIFE
IS WIDESPREAD, THEN
COMPLEX LIFE WILL BE
WIDESPREAD”**



► about how other life may be similar and different on other planets. Indeed, some scientists are now trying to lay down the science of not only how life-as-we-know-it would be different in space, but also of what exotic life that was made of other chemicals might be like.

These shows parted with the common fictional view of sentient green aliens, and they applied rigorous thinking by evolutionary biologists, biomechanics experts and astrobiologists to design plausible living worlds within the restrictions of alien geology and planetary science. Many scientists think the unlikely-sounding creatures dreamed up for these shows two decades ago are still as good a guess as we have for what alien life will look and behave like. Though, with myriad of discoveries since, we also now have new insights that paint an even wilder picture.

“On any planet in the Universe the laws of physics and chemistry will still be the same as here,” says Prof Peter Ward, a palaeontologist at the University of Washington, Seattle. “There’s only a limited number of ways to beat physics.”

Even in outer space, he argues, on an Earth-like planet there would be similar physical constraints leading to the evolution of similar life to what we have on Earth. The premise is that there are only so many ways one can efficiently see, hear, walk, swim or fly – and that natural

**“EVEN ON EARTH, LIFE GIVES
RISE TO RADICALLY DIFFERENT,
SOMETIMES UNIQUE LIFE FORMS
AT DIFFERENT TIMES AND IN
DIFFERENT PLACES”**

selection will largely weed out inefficient body plans, as it has on this planet.

This means we can make educated guesses about what such life would look like, based on our biological understanding of evolution, and our geological and climatic understanding of conditions on other planets. Most of the scientists interviewed for this feature said the educated guesswork in the TV programmes



ABOVE: NASA's Transiting Exoplanet Survey Satellite (TESS) launches onboard a Falcon 9 rocket at Cape Canaveral, April 2018

mentioned previously might not be too wide of the mark – if anything, those visions might be too tame, given the potential for the vast amount of life that might have evolved on very different planets.

“The Universe has a way of surprising us,” says Theresa Fisher, an astrobiologist at Arizona State University, US. “My suspicion is that, with a range of environments that we could be looking at, it could feel very alien.

She says that any life would be expected to follow the broad principles of ecology: it would need to have a way of getting energy, and there would be competition leading to the emergence of predators and prey, for example. But beyond that, it's anyone's guess what life might look like. “There's no reason that it would have to be particularly similar to what we see on Earth.”

STRANGER THINGS

So we can't really say that alien life would look like Earth life. Even on Earth, life gives rise to radically different, sometimes unique life forms at different times and in different places.

When dinosaurs went extinct, what came after them wasn't more of the same. And the flora and fauna of New Zealand, with kiwi birds and practically no land mammals, are very different from those of

the Serengeti, with its elephants and giraffes, or Madagascar with its lemurs.

For unique life forms on Earth, look no further than seahorses, says Dr Lauren Sallan, a palaeontologist at the University of Pennsylvania. The animal shares basic components of other fish but has a unique shape, and reaching that form required a very unlikely evolutionary pathway. “You do get weird things that happen once – both now and in the distant past,” says Sallan.

On an Earth-like alien planet, things could get even weirder. It's possible that we wouldn't even recognise them as life, given that our current efforts focus on finding “life as we know it”, says Casey Brinkman, an astronomer at the University of Hawaii: “There's all sort of possibilities out there for weird stuff.”

Sallan agrees. Any life forms will have to get energy, but the way they would go about it is hard to predict, she says. “They would be filling similar ecological roles, but whether we would recognise them without a lot of study – I doubt it.”

So to start with, astronomers are focusing their search on signatures of life that we know from Earth, such as oxygen. They're also focused on finding Earth-like rocky planets where liquid water could exist. “We have to begin with a search for life as we know it,” says Charbonneau. “There could be life that's very ►

► different than life on the Earth, but we wouldn't recognise that in our data, because we don't know and understand that chemistry very well," he adds.

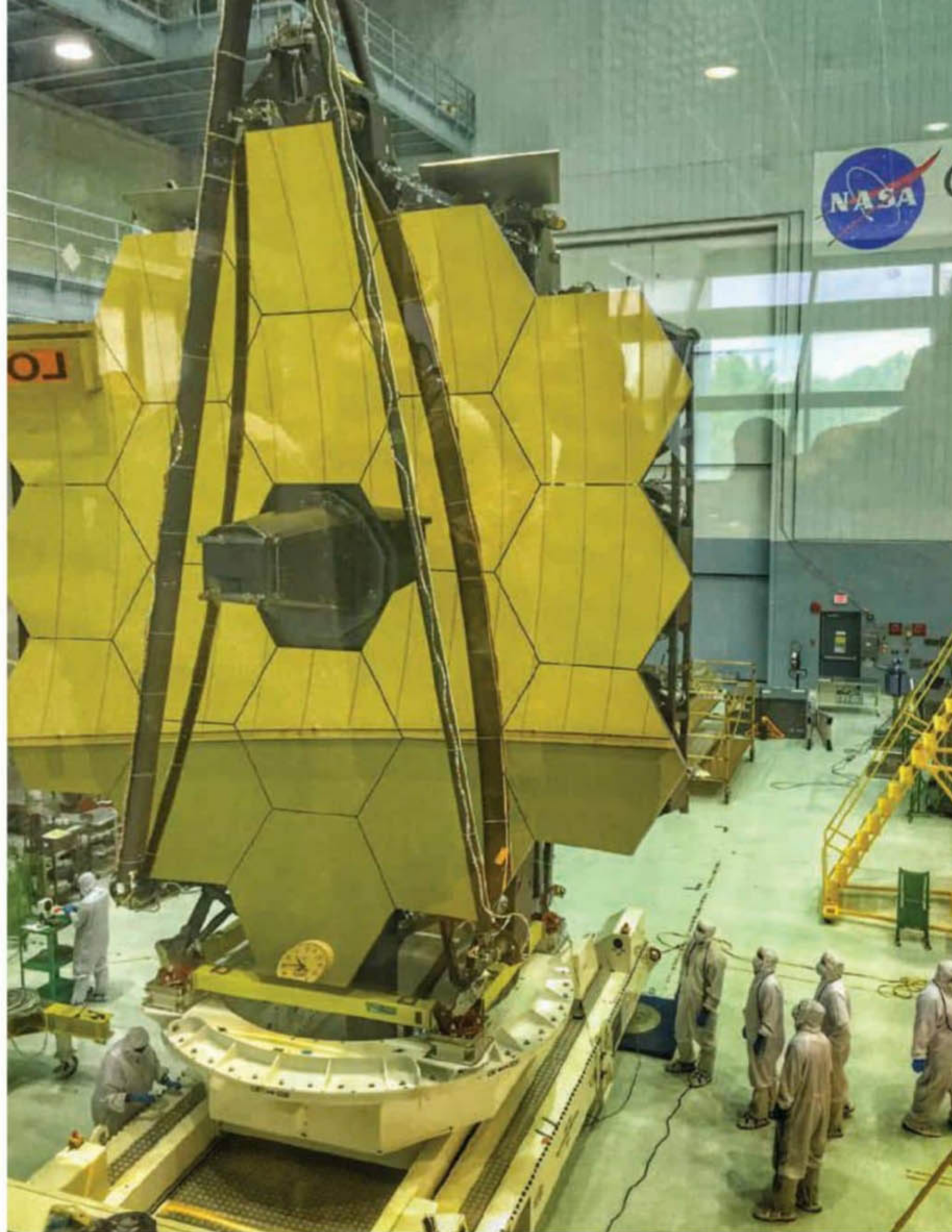
WHEN GRAVITY MEETS BIOLOGY

There are many different conditions on other planets and moons, beyond chemistry, that could affect how life would evolve there. Take gravity, for example. On a bigger or denser planet, the gravity would be higher, meaning that life would evolve to be shorter, sturdier and perhaps with multiple limbs for structural support. Conversely, on a lighter planet with weaker gravity, life could hop, soar and glide more easily, and would be more likely to evolve a lighter, taller build.

The density and chemical makeup of the atmosphere would affect how easy it is for life to take to the skies: denser air would allow for more life forms treating the sky like an ocean they can 'swim' in, while oxygen-rich air would fuel more energetic creatures.

The seasons could be vastly different, too. Many planets have much shorter orbital periods than the Earth's 365.25 days, speeding up seasonal changes to weeks or days rather than months. Some planets have more elliptical orbits that would make seasons much more extreme, with scorching, short summers followed by long, deep-freeze winters.

"MANY SCIENTISTS HOPE WE'LL FIND LIFE IN SPACE WITHIN OUR LIFETIME, POSSIBLY ON THE ICY MOONS OF SATURN AND JUPITER"



ABOVE Launching in 2021, the James Webb Space Telescope will tell us more about exoplanets, their atmospheres and their potential for hosting life

The type and number of stars a planet orbits, as well as how closely it orbits them, would also affect how much solar energy and radiation it receives, and whether photosynthesis is possible or whether life would have to instead rely on chemosynthesis – using energy derived from reactions involving inorganic chemicals rather than sunlight.

The majority of stars are red dwarfs, says Charbonneau, which are less energetic and more durable than our Sun, so could offer longer time periods for life to evolve. But, early on in their evolution, such stars emit a lot of radiation that could be harmful to life and planets' atmospheres, or even eliminate them. Alien Planet envisaged life around such a star as plant-like creatures that could fold up to protect themselves when there are solar flares, and dinosaur-like animals with a third eye on top of their heads to give them early warning that a burst of radiation is on its way.

Closer to Earth, many scientists hope we'll find life in space within our lifetime, possibly on the icy moons of Saturn and Jupiter, such as Enceladus and Europa. "I'm willing to bet you a flat white that in the next 20 years we'll find some life," says Dr Seth Shostak, senior astronomer at the SETI Institute, US. "It will probably be microbial life squirting out of Enceladus or maybe Europa, or maybe under the sands of Mars: there are all these places in our own Solar System where we could find this stuff." ►

WEIRD WORLDS

Life could possibly exist on any number of different types of planets and moons that have very different properties, which would shape the evolution of life there. Here are just a few of them, together with the challenges and opportunities they would pose for life

YO-YO PLANETS

Unlike Earth's circular orbit, these planets have elongated, elliptic orbits that bring them very close to their sun for brief periods of scorching hot summers, and then take them far away from it for long, freezing winters. There would be two brief growing periods when the planet is approaching and departing the sun, when Earth-like life could blossom, but it would have to be adapted to endure the evaporation of its oceans in the summer and snowball planet periods in wintertime.

TIDALLY-LOCKED PLANETS

Many planets orbiting close to their star get locked by their sun's gravity so they always face the sun with the same side. This means one side of the planet is plunged in constant darkness, while the other always basks in sunshine. This could create a massive, ongoing storm in the centre of the Sun-facing side and freeze over the other side of the planet, leaving a strip in-between with possibly Earth-like conditions. Air and ocean circulation could allow the exchange of heat between the two sides, perhaps fuelling some life on the dark side.

LAYERED OCEANS OF GANYMEDE

Some scientists think Jupiter's moon, Ganymede, has several layers of oceans underneath its frozen surface, each separated by a different type of ice that forms at certain pressures and temperatures. If there is life there, it would most likely have originated in the bottom ocean layer where it meets a rocky base. Eventually, some life might have made its way into the next layer, finding an unexploited new habitat and possibly adapting to different conditions there, and later moving on again to yet another layer. This would essentially create vertical continents, each with its own life forms and ecosystems – but all with a common origin.

ROGUE PLANETS

Some planets get ejected from their orbit around their host stars and become lonely wanderers through the Universe. Cloaked in cold and darkness, they could remain habitable for any life, fuelled by the internal engine of their hot cores, for billions of years – but that life would have to adapt to no sunlight and rely on chemosynthesis, like life deep inside Earth's rocks and oceans.

"There is plenty of heat in the interior of a planet for billions of years; it is longer than the lifetime of host stars," says Dimitar Sasselov, astronomy professor and director of the Harvard Origins of Life Initiative.

DISCO-BAR PLANETS

Around pulsar stars created after the explosion of a star, planets would be devoid of much sunlight and any life would have to rely on chemosynthesis, though its chemistry may be very different as such planets are unlikely to have many organic molecules common on Earth. Such planets would be dry, metallic and bathed in the pulsating light of their star.

LIQUID METHANE WORLDS

Titan, the moon of Saturn, appears very Earth-like with its hills, rivers and lakes filled by rains from its clouds. But it couldn't be more different: temperatures are freezing, turning water rock-hard, and the only liquid present is in fact methane, the major component of natural gas here on Earth. If life exists there, it will most likely be based on different chemistry to Earth life, and probably evolve very slowly because colder temperatures slow down chemical reactions.

WHAT ALIENS MIGHT LOOK LIKE

Scientists have long speculated about what living creatures on other planets and moons might look like, based on what we know about those planets and the principles of evolution and bio-mechanics. Here are some of the strange organisms they have imagined...

WALKING PLANTS

On other planets the boundaries between plants and animals could be blurred, and you might have trees with beating hearts, or with feet to move to better positions as they compete for light and water. You could also have an animal that spends most of its time staying still, photosynthesising, only running away if threatened. Or a massive dinosaur-like creature that splays itself out on the ground to get nutrients directly from the soil, and obtains extra energy with the help of photosynthesising plants on its back.

MEGA CREATURES

Cooperation could lead to some fascinating creatures, such as a sea of amoebae acting as single jelly-like mega-creature, thousands of voracious shrimp-like carnivores forming a single organism that devours anything in its way, or a web of intertwined trees that collect water in wide pitchers at the top of their canopies. Similar entities do exist on Earth: for example, the world's largest organism is a 43-hectare forest of aspen trees in Utah, comprised of about 47,000 genetically identical stems, and one massive root system.



► NASA is preparing a mission to Europa for a 2023-24 launch, and is backing a private endeavour to reach Enceladus and study signs of life there. Meanwhile, the European Space Agency is hoping to launch a mission to Jupiter and its moons Ganymede, Callisto and Europa in 2022.

There is early evidence that those moons have oceans of liquid water deep under their icy crusts. This has raised hopes that there might be life there, especially given that we see oases of unusual life in the extreme environments around hydrothermal vents at the bottom of our own oceans.

Indeed, *Natural History Of An Alien* suggested that entire ecosystems may be based around deep-sea thermal vents on Europa, with tall towers of bacteria powered by the warmth and nutrients from the vents rising high above the sea bed, and territorial fish-like grazers sucking the nutrients from those towers, and in turn being preyed upon by streamlined shark-like animals.

In principle, this vision might be possible, says Dimitar Sasselov, astronomy professor and director of the Harvard Origins of Life Initiative, US, a centre that supports multi-disciplinary research aimed at revealing if life is abundant in the Universe. But he adds that because there is less energy available in the dark ocean, so any complex life there would be expected to be much

EXTREME ENDURANCE

Getting oxygen to muscles is a key determinant of an animal's endurance. Here on Earth, cephalopods like octopus use a copper-based molecule in their blood to shuttle oxygen, making them more sluggish than mammals and birds that use iron-based hemoglobin. Scientists have speculated about other types of oxygen transport that could make animals fitter: in atmospheres with more oxygen, we might see creatures that can fly without ever having to stop for a rest.

TINY, BLIND WORLDS

On cold planets and moons without much sunlight, such as the moons of Saturn and Jupiter, life might have to get by with chemosynthesis, giving them a more limited energy supply. This could still lead to similarly complex life, but on a much smaller scale: a miniature version of Earth's life. Also, in worlds without light, such as the depths of Enceladus's oceans, there might be little need to evolve eyes: whole worlds of creatures may exist that sense their environments using other means.

FLOATING WORLDS

On planets with denser atmospheres, animals and plants could reach dizzying heights more easily and essentially 'swim' in the air as a result of their higher buoyancy. Scientists have envisioned flying whales feasting on green clouds of algae, octopus-like creatures and balloon-like plants floating high, using sacs filled with hydrogen or methane, and trees and forests reaching 10 times the height of those on our planet.



smaller. "You have to take anything from today's Earth and recent Earth history of complex life and just shrink it," he says. "Can you have exactly the same behaviour and the same level of complexity but 100 times smaller? Absolutely. What's wrong with a shark that's just 5cm long? Nothing."

Not everyone thinks life on those moons will be complex, though. "If there is life in the Solar System, it's probably microbial," says Dr Yael Kisel, support scientist at NASA's Ames Research Center. And scientists agree that most life in the Universe as a whole is likely to be microbial, especially given that for the majority of the history of life on Earth it has been microbial. "What does a typical alien look like? It's going to be a little blobby thing under a microscope," says Shostak.

That's not to say there won't also be complex, perhaps even sentient life. Any intelligent life might not look like us, though: even here on Earth, if you take a trip to the zoo, most animals there are highly related to you but don't look much like you. But as Shostak jokes, "If you ask trilobites: 'Hey, what do you think the aliens will look like?', they would probably figure they're going to look like trilobites."

In fact, highly advanced and intelligent life, if it exists, might be machine-based. "The majority of the intelligence in the Universe is probably not soft and squishy biology," Shostak says. "The majority of the really smart stuff in the Universe is going to be machinery." This vision of

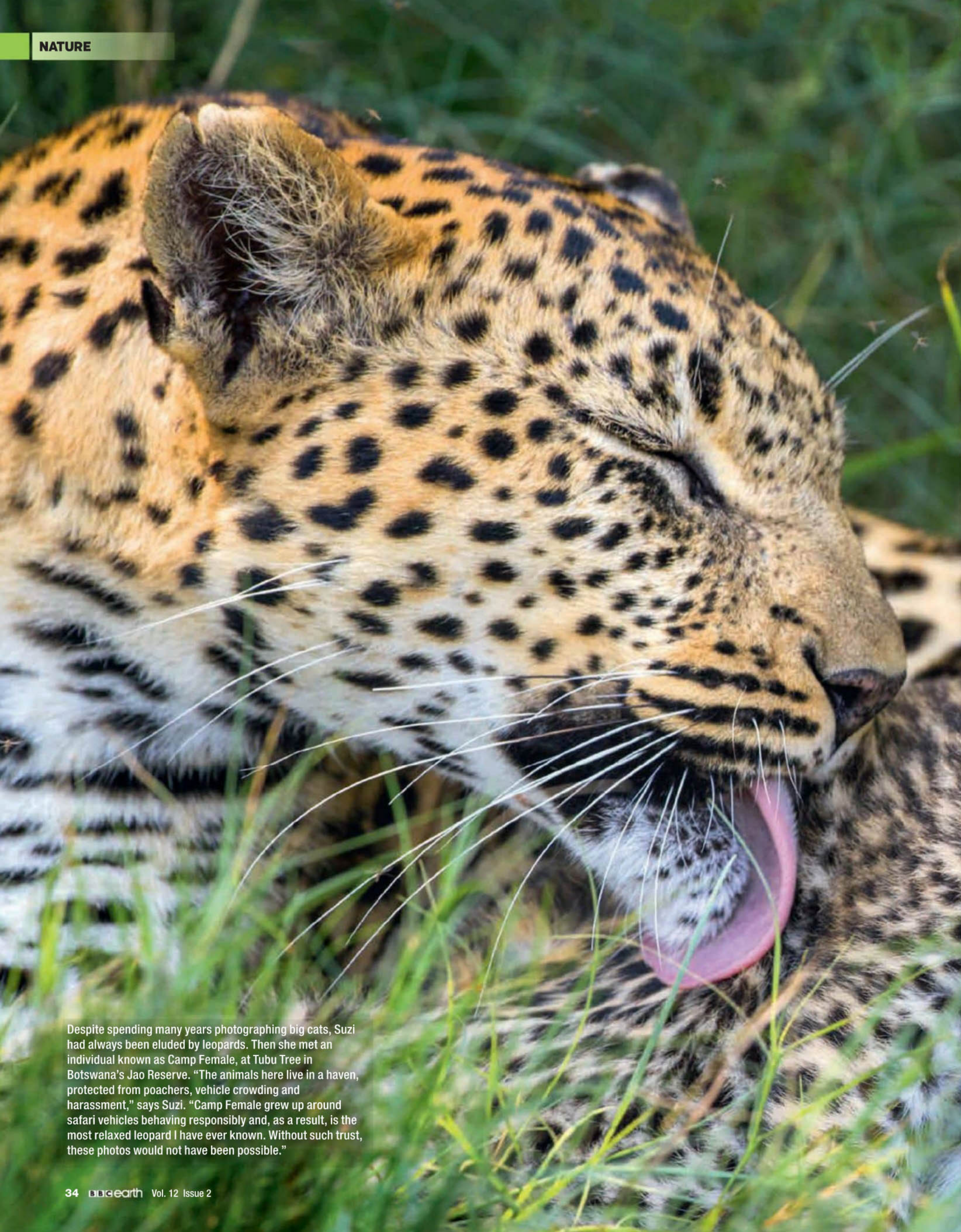
**"HIGHLY ADVANCED AND
INTELLIGENT LIFE, IF IT
EXISTS, MIGHT BE
MACHINE-BASED"**

artificially intelligent, highly autonomous machine life featured in *Natural History Of An Alien*, imagining it travelling the Universe, analysing planets, and adapting to local conditions much quicker than any biological life ever could.

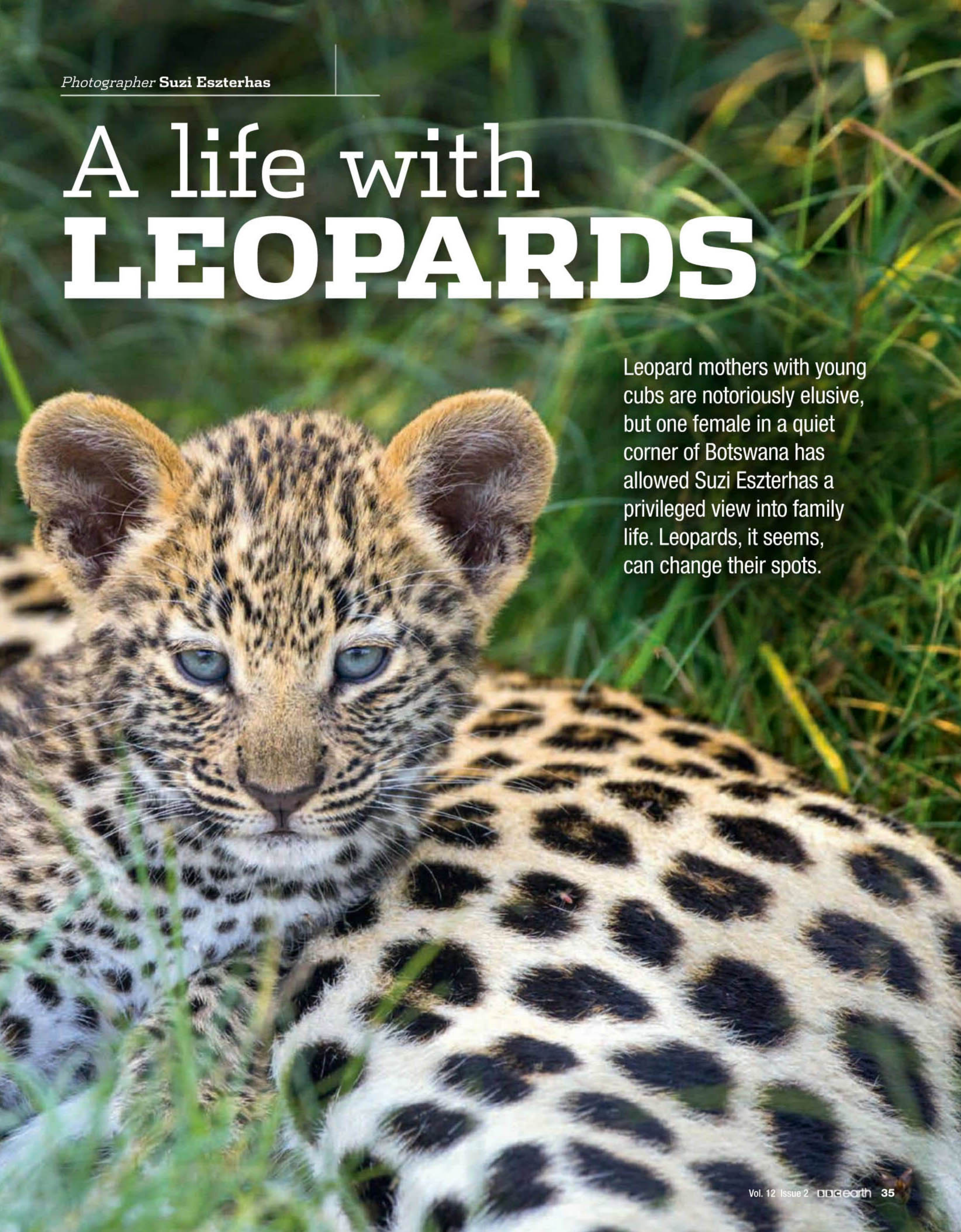
Whatever the case, life is most probably out there, many scientists believe. "Statistically, it's almost a certainty," says Fisher. And this means the search must go on, says Brinkman.

"We should continue to try – because if it were to get discovered, it would be the most important discovery humans have ever made." 🌍

by **MİČO TATALOVIĆ**
Mi'co is a science
journalist based
in London.



Despite spending many years photographing big cats, Suzi had always been eluded by leopards. Then she met an individual known as Camp Female, at Tubu Tree in Botswana's Jao Reserve. "The animals here live in a haven, protected from poachers, vehicle crowding and harassment," says Suzi. "Camp Female grew up around safari vehicles behaving responsibly and, as a result, is the most relaxed leopard I have ever known. Without such trust, these photos would not have been possible."



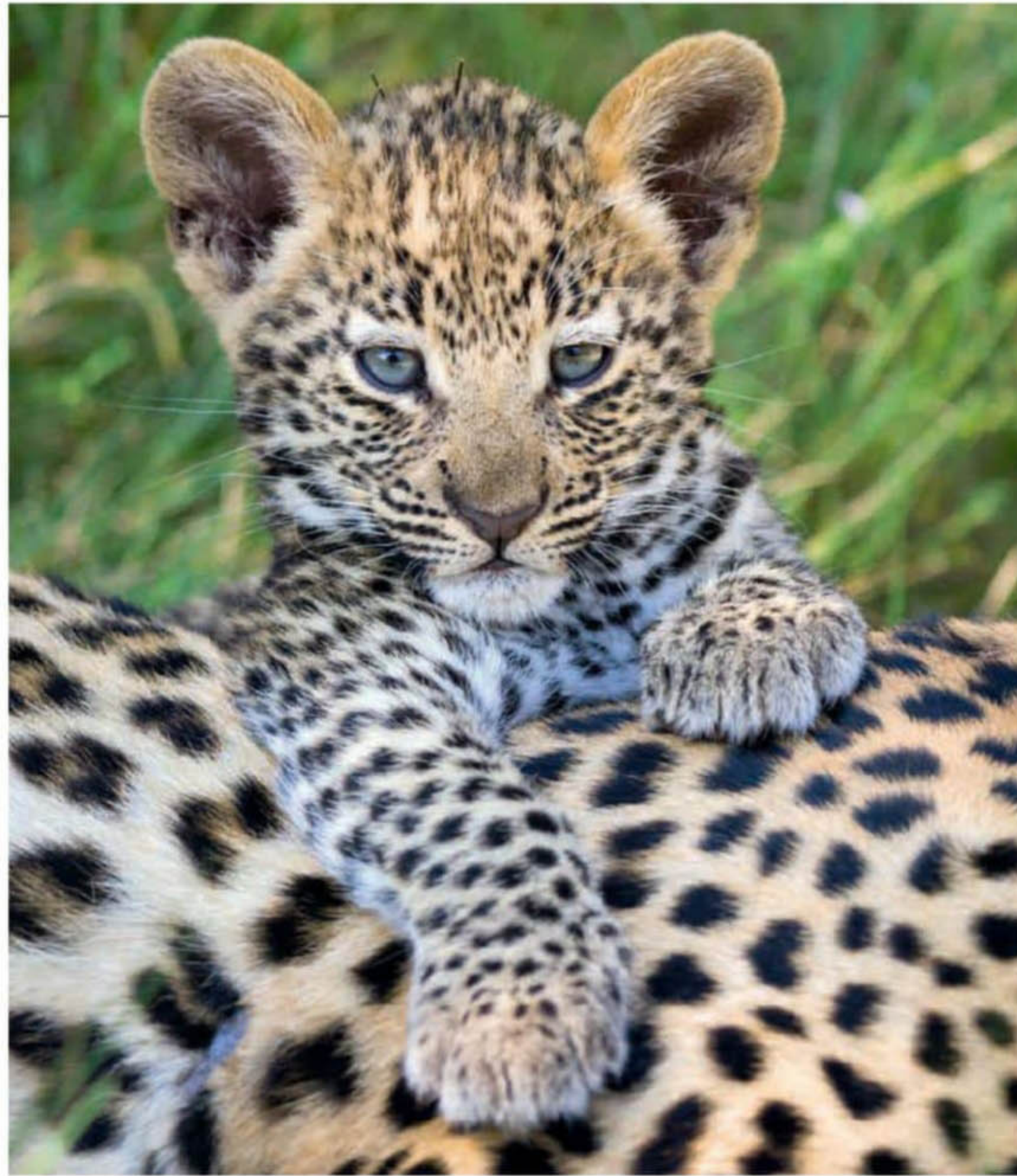
Photographer **Suzi Eszterhas**

A life with **LEOPARDS**

Leopard mothers with young cubs are notoriously elusive, but one female in a quiet corner of Botswana has allowed Suzi Eszterhas a privileged view into family life. Leopards, it seems, can change their spots.

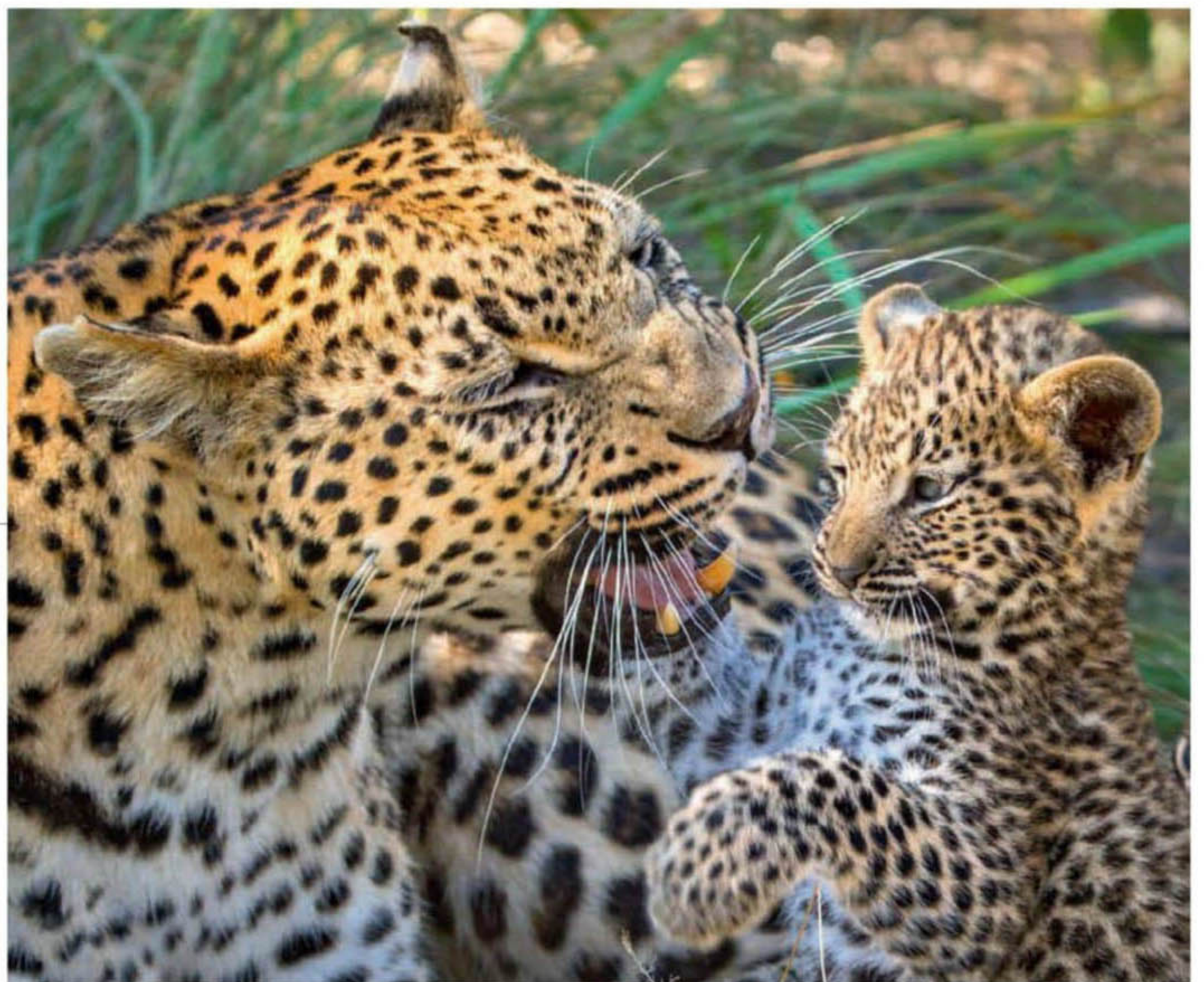
RIGHT Camp Female gave birth to two female cubs in March 2018. This was her third litter, and Suzi started photographing the youngsters when they were just five weeks old. Newborn cubs have blue eyes, a result of low levels of melanin at birth. As more melanin is deposited in the eyes and with exposure to UV light, the colour alters, fading to golden green by two months.

BELOW Leopard cubs are aggressive in play, and these siblings were no exception. If a skirmish was particularly intense, one of the pair would break off and return to its mother for a nuzzle before re-entering the fray. "There was a lot of snarling and growling," says Suzi. "If you heard the ruckus in the bushes, you'd be shocked to know it was coming from such young cubs."



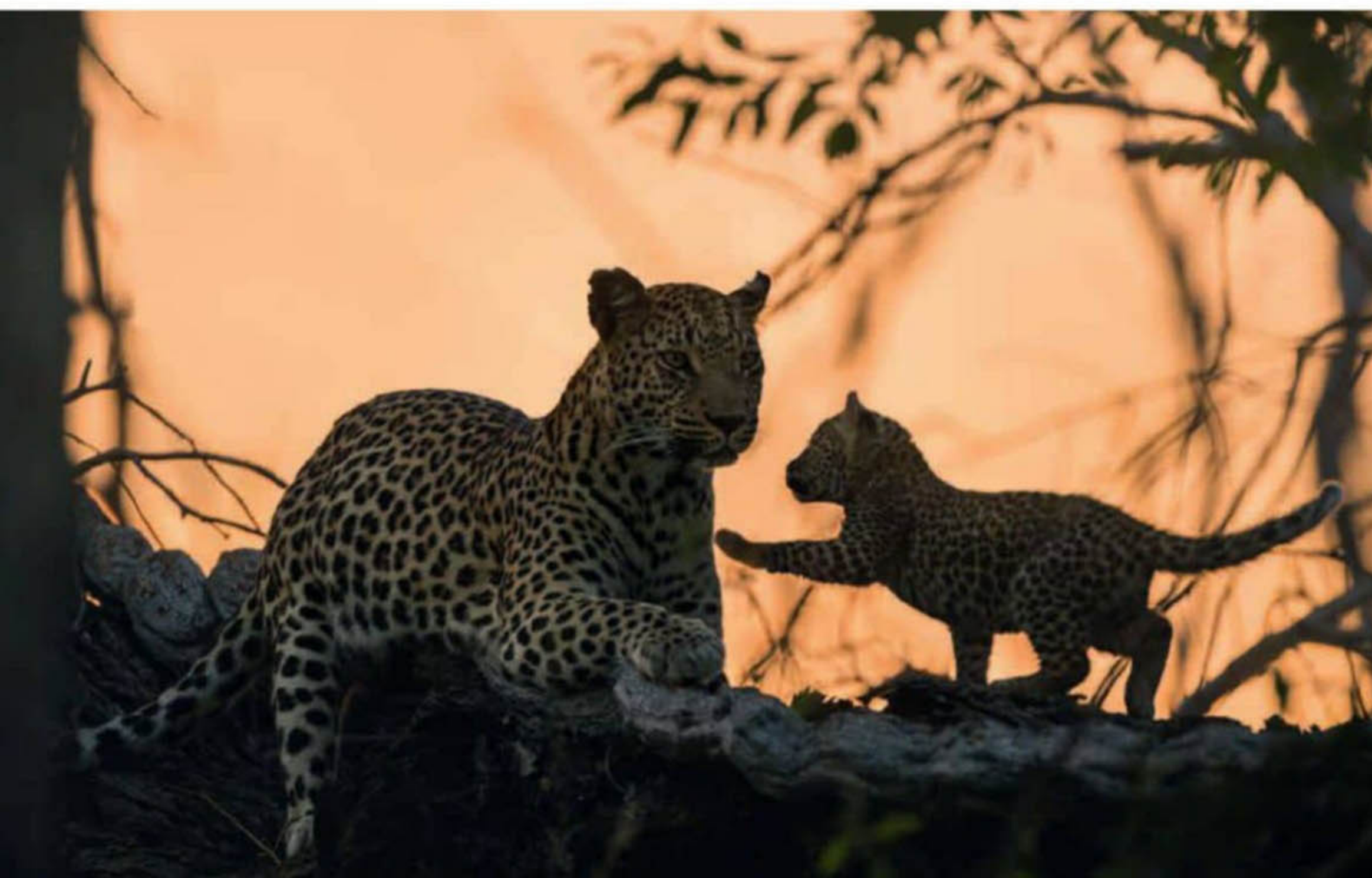
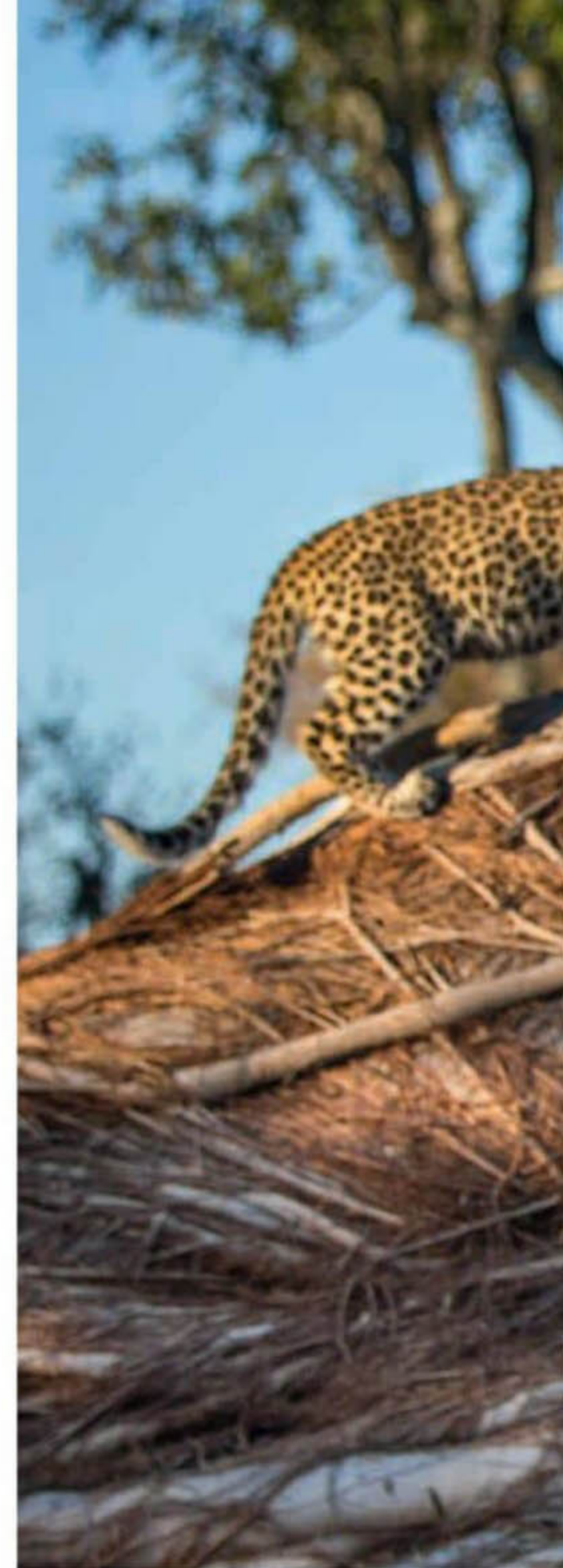
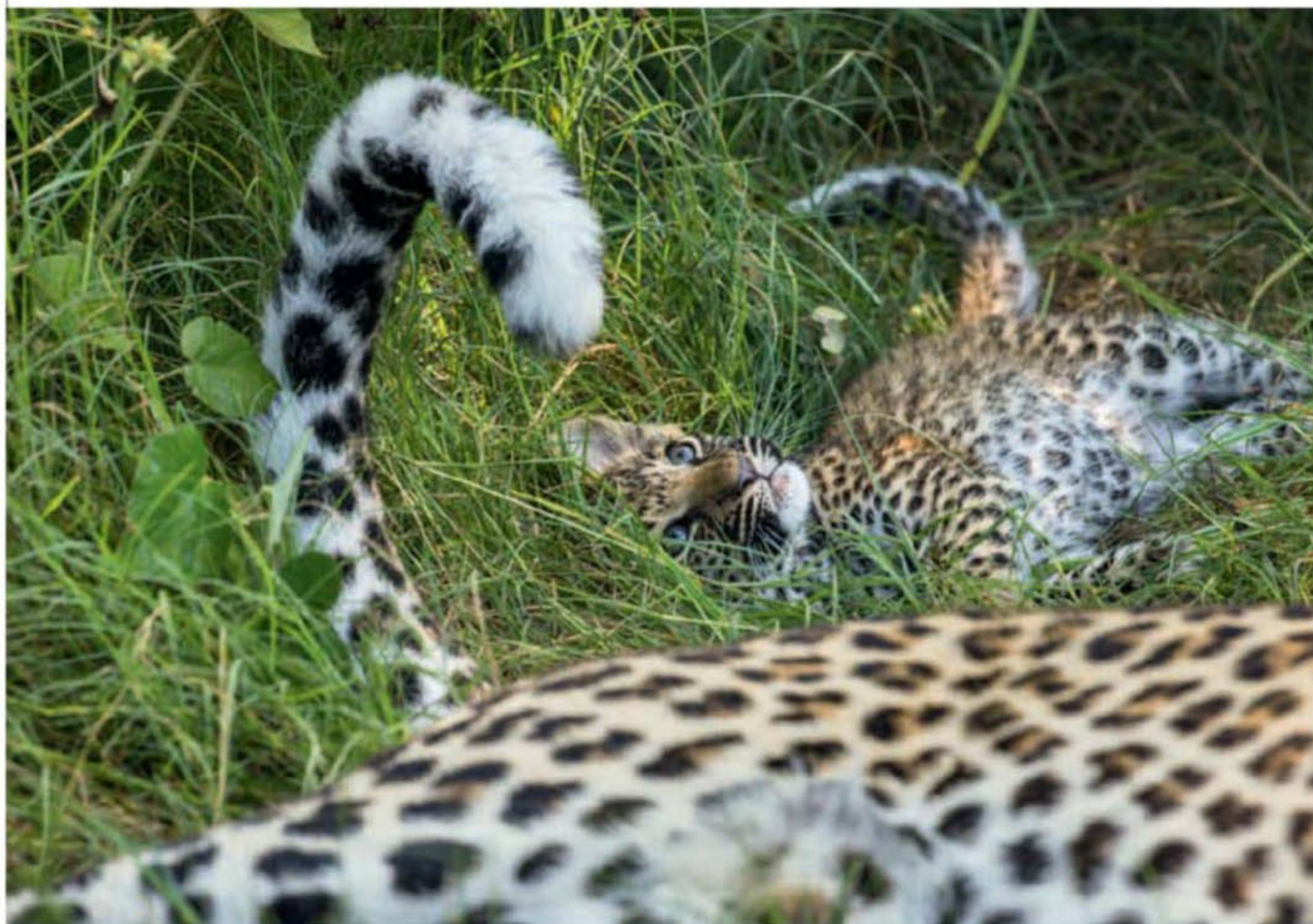


ABOVE Ever-watchful for predators such as baboons and lions, Camp Female scours the landscape from atop a dead tree. Leopards are thought of as nocturnal, but will hunt in the day if the opportunity arises. Cubs are stashed in a den – a hole in a log or the ground that’s too small for predators to access – until they are three or four months old.



RIGHT For leopard cubs, play is about practising their hunting skills and learning to defend themselves. Though these youngsters played excessively together, that did not mean their mother was off the hook. “They seemed obsessed with jumping on her head, and took any opportunity they could for ambush, making it rather difficult for her to rest,” says Suzi. “She would often actively engage in the antics, rather than just tolerate them.”

BELOW From a young age, leopards are fascinated by their mother's tail. Almost always in motion, flicking from one side to the other and adorned with a fluffy white tip, tails make ideal playthings. The youngsters would follow the movement of the tail, then pounce on it, seizing it in their mouths. "Mum's tail is their first 'kill'," says Suzi.



LEFT Returning at sunrise from hunting, Camp Female is greeted by one of her cubs. Mothers can leave youngsters for a day and a half when searching for prey. During this time, the cubs are starved of affection and milk, but this readies them for the feast-or-famine feeding style they'll endure as adults.

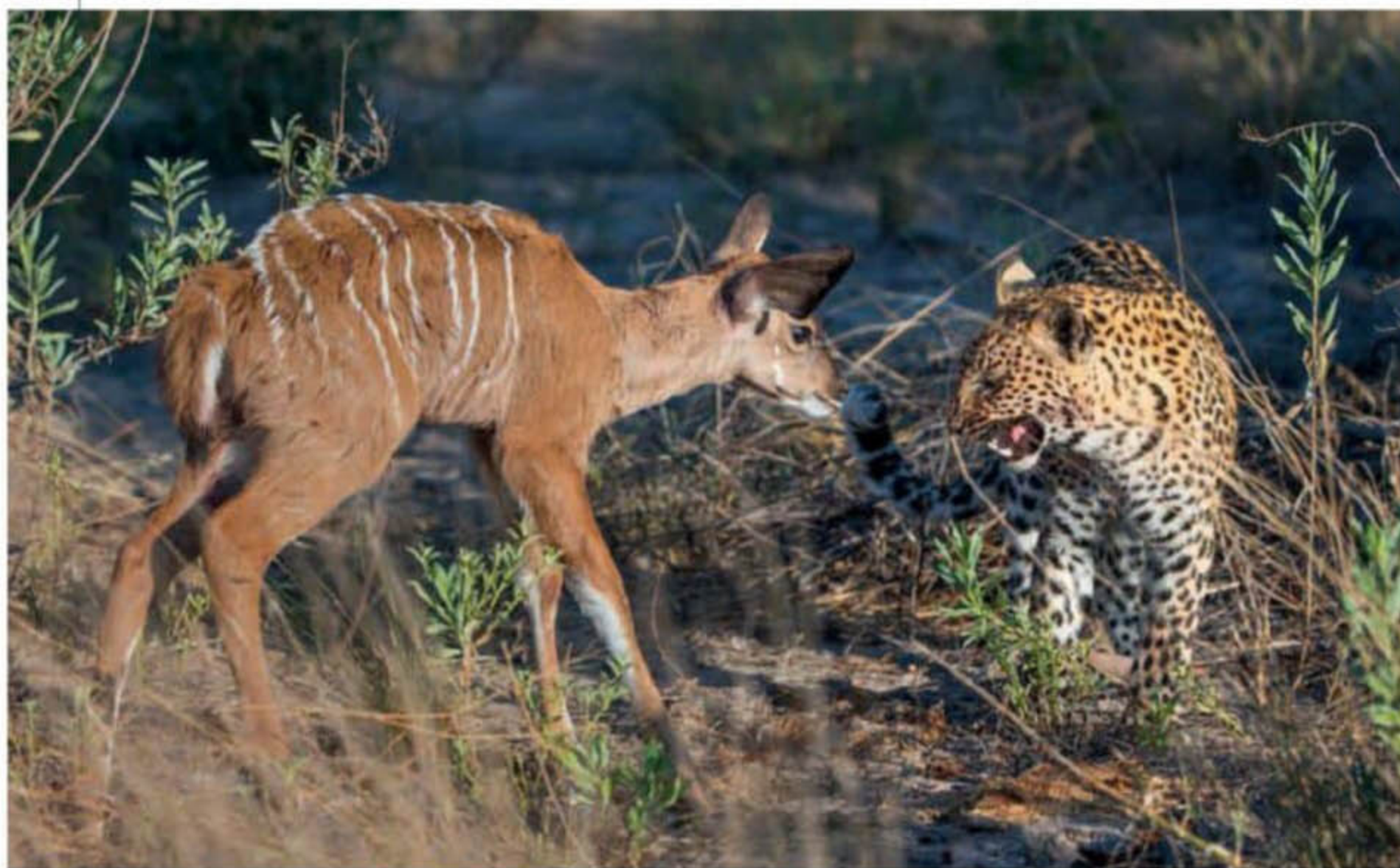
RIGHT Females may summon cubs from their hiding place with a faint call, if the coast is clear. Here, at four months old, the cubs appear delighted to see their mother, greeting her with exuberant nuzzles. Females will go to great lengths to protect their offspring, even leading predators away from where the cubs are stashed.



ABOVE Leopard cub mortality is high, with less than 50 per cent typically surviving to adulthood. Both of Camp Female's cubs thrived, however, and by the age of four months were noticeably bigger, stronger and more mobile. They had now left the den, but would still be hidden away when their mother was hunting. The trio rarely stayed in the same place for more than a few days – making Suzi's job more challenging.

RIGHT Even at a year old, the cubs are still very attached to the female. Leopards are solitary creatures, but the bond between mother and young is strong. Many cubs stay with their mothers for 12–16 months; some, as revealed in a recent study, even stick around for as long as 35 months. On average, males are tolerated for two months longer than females.

BELOW The cubs are now well practised in the art of hunting but still have much to learn. Here, Camp Female has cornered a kudu calf, but has intentionally not suffocated it, in order for her cubs to master the skill for themselves. On this occasion, they secured a meal, eventually.



SUZI ESZTERHAS is a photographer known for documenting newborn animals. She worked with tracker guide Kambango Sinimbo, at Tubu Tree Camp, to capture these images. suzieszterhas.com

RIGHT Having become proficient climbers, the young leopards doze away the midday hours in the cool and safety of the trees. In a few months, the siblings will be on the cusp of independence. With luck, they'll go on to rear cubs of their own.



Of all big cats, leopards are the most adept at climbing, with males famously able to drag carcasses three times their own weight up into the branches. These skills are learned through play, first scrambling around in small bushes, before graduating into big trees. Here, one of Camp Female's cubs chases her up a steep, sheer trunk.



In defence of Monty

For 50 years, historians have lined up to attack the architect of D-Day. But, writes **James Holland**, their criticisms are misguided

On Friday 30 June 1944, American general Omar Bradley visited Bernard Montgomery's Tactical HQ, near the village of Blay, a few miles west of Bayeux. He found the architect of the Allied assault on Normandy in a particularly spikey mood. "I say," he remarked to Bradley, looking at Chet Hansen, who had been recently promoted, "now do you have a major for an ADC [aide-de-camp]? Simply a dog's body, you know, a whipping boy. I would not have an ADC who is more than a captain."

What on earth compelled him to say such a thing? It was insulting to Bradley (commander of the US First Army), insulting to Hansen, whom Monty had seen many times before, and spectacularly rude and unnecessary.

"Messenger boys, simply messenger boys," added Montgomery. He then launched into a withering critique of the superbly designed American M1 steel helmet.

It is hard not to cringe recounting this outburst. Montgomery and Bradley needed to work hand in hand, side by side, with unity of purpose, mutual respect and fellowship. How much harder it was when a small Englishman in corduroys and a sweater was sitting there being so appallingly discourteous.

A MONSTROUS EGO

History has not been kind to Montgomery, particularly not over the last 50 years, as one historian after another has lined up to crucify both his character and his military reputation. To a certain extent, he brought it upon himself through his monstrous ego, the crass way in which he spoke to his peers and superiors, and the very large chip that remained planted on his shoulder.

Holding court Bernard Montgomery briefs reporters on progress in France, 1944



Montgomery never exuded the easy charm of many of his contemporaries. He also had a social inferiority complex, which he masked with haughtiness and arrogance – an arrogance that was supported by a growing self-belief. Discipline, clear thinking, preparation and sound, solid training were his watchwords, all of which had much merit. Yet he liked to impose himself by giving the impression of absolute self-assurance.

Montgomery wasn't the only senior commander with an ego. His great character flaw, however, was his social awkwardness. He simply did not know how to interact with others. He compensated for his lack of charm by talking entirely on his own terms, regardless of what offence he might be

Discipline, clear thinking, preparation and sound, solid training were his watchwords

causing. He lacked the ability to read the emotions of others very clearly – and that repeatedly got him into largely avoidable hot water. But these failings of character did not mean he was a bad general, and all too often since the end of the war successive historians have put their personal distaste towards his character ahead of sound historical judgment. The reality requires more nuance.

Tactically he was arguably not the most imaginative. But, at this stage of the war, sound strategic vision and operational skill were more important for the Allied armies.

Montgomery understood that, although most of the men under his command were now well trained, they were also reluctant soldiers, conscripts who were in uniform only because of a global war in which they had no choice but to participate. He also espoused the Allied mantra of ‘steel not flesh’, a strategy Britain had been determined to pursue long before war was declared and one to which the United States was equally wedded. This meant using their global reach, modernity and technological know-how to allow industrialised mass-production and mechanisation to do as much of the hard work as possible, thus limiting the number of those in the firing line to an absolute minimum. In the British Second Army in France, only 16 per cent of troops would be infantry and 7 per cent in tank units.

Britain and America were fighting highly complex, long-chain, industrialised war that harnessed air, land and sea power. It required a very effective operational commander, and Montgomery was certainly that.

PLAN UNDER ATTACK

Criticisms of Monty’s performance in Normandy usually begin with the plan. The thesis of Carlo D’Este’s 1983 book, *Decision in Normandy* – one that has largely held sway ever since – revolved around its perceived shortcomings. Montgomery was appointed Allied land commander at the end of 1943 and so had a big say in how the overall plan for Overlord (the battle for Normandy) looked. He rightly insisted on expanding the invasion beaches to five from three and also insisted on using airborne forces to help secure the flanks. However, it was a combined team that actually worked out the plan – albeit under his overall direction – and this was approved at an early stage by Dwight D Eisenhower as supreme Allied commander,

Monty rightly insisted on expanding the invasion beaches to five from three

and his chief of staff, General Walter Bedell-Smith. Monty presented the main plan for Overlord to all the senior commanders on 7 April 1944. It had to be this early to allow enough time for the naval plan, Neptune, to be prepared and organised, and for the component parts of Overlord to be worked out. It was not Monty’s job to oversee the detailed planning on each invasion beach.

At the 7 April meeting, he included a map, which showed ‘phase lines’ of where the Allies might be in the days and weeks that followed the invasion. On D plus 17, for example, the phase line suggested they would be 50 miles inland. Bradley cautioned against showing this; he felt it risked making them open to criticism if they did not achieve these predicted lines, which saw the Allies in Paris in 90 days.

Monty brushed aside such concerns. There was a palpable sense of doom among many of the Allied leaders, and he correctly sensed the need to present the invasion plan with confidence and with a clear sense of what was achievable. Based on German performance in previous campaigns in Tunisia, Sicily and southern Italy, his assumptions were entirely reasonable. It made no sense for the Germans to continue to fight close to the coast after a successful Allied invasion; their lines of supply would be over-extended and they would then remain within range of powerful and extensive off-shore naval guns.

Arguments about phase lines aside, the plan was accepted by all and reinforced again on 15 May when Eisenhower asked his commanders to speak up if any had any concerns about it at all. None did, because it was the best possible plan for the shipping available. Although there were 4,126 landing craft on hand, everyone wanted greater numbers, so that more men, more tanks, and more materiel could be delivered on D-Day.

As it was, fewer men were to be landed on D-Day than on the Sicilian beaches the

year before. Operations were ongoing in the Pacific, while a second planned invasion was to take place in southern France in August. In this still global war, there was much competition for landing craft and shipping.

Despite these constraints, the vagaries of the weather and the risks of mounting such a massive operation, D-Day was a huge success. The absolute priority was to ensure Overlord did not fail. That trumped everything else. Montgomery deserves credit for this.

Monty gave priority to securing the flanks, which was achieved, and to consolidating the bridgehead, which also followed in swift order. It’s true that British forces didn’t meet their objective of capturing Caen on the first day of the operation, but historians have become too fixated by this failure. This obsession is, in part, the result of criticism at the time by the air commanders. Both Arthur Tedder, the deputy supreme commander, and Air Marshal Arthur Coningham, the commander of the RAF’s 2nd Tactical Air Force, were anxious to capture the high ground south-east of Caen onto which airfields could be swiftly built. When this didn’t happen immediately, they blamed Montgomery for perceived sluggishness.

But Caen proved a tough nut to crack for a reason no one could have predicted: Hitler’s decision to keep his armies fighting as close to the coast as possible. This made no military sense – and Field Marshal Erwin Rommel, the commander of German Army Group B covering Normandy, pointed this out to the führer when the two met on 17 June. That Hitler refused to take Rommel’s advice – ordering his men to fight for every yard – was hardly Montgomery’s fault.

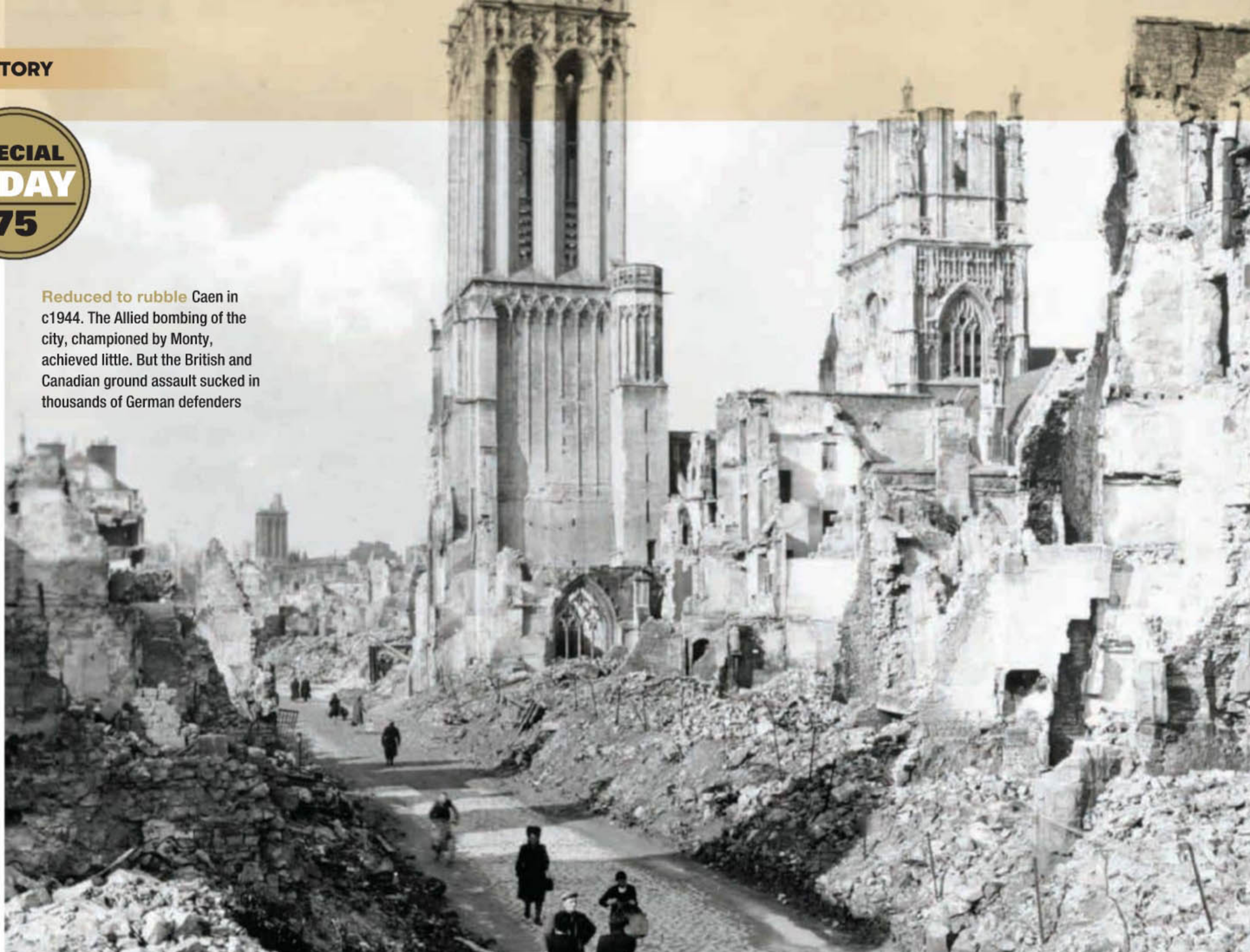
In fact, in many ways, Hitler’s tactics worked to the Allies’ advantage. By fighting close to the coast, they could indeed continue to benefit from the support of naval guns. And while it was true the bridgehead became congested by mid-July, the supply lines were shorter and a large number of airfields were swiftly constructed close to the coast.

SLOW PROGRESS

The Allies, and Monty especially, have been criticised for being heavy on their feet and risk averse. Neither of these accusations are fair. The terrain did not favour rapid exploitation. When the well-equipped and highly motivated 12th Waffen-SS Panzer Division counter-attacked on 7 June, they

SPECIAL
D-DAY
75

Reduced to rubble Caen in c1944. The Allied bombing of the city, championed by Monty, achieved little. But the British and Canadian ground assault sucked in thousands of German defenders



Fast forward An Allied tank passes German PoWs in July 1944. Montgomery's strategy was vindicated by the fact that the battle of Normandy was won ahead of schedule, argues James Holland



The top brass The Allied supreme command – including General Omar Bradley (far left), Dwight D Eisenhower (centre) and Bernard Montgomery (third from right) – discuss plans for the invasion of north-west Europe, February 1944

made little progress, despite coming up against just two Canadian infantry battalions and a few tanks shorn of fire support. It was the same story for the Panzer Lehr Division, arguably the best in the entire Wehrmacht, who threw themselves against British infantry and armour at Tilly, south of Bayeux and made no headway. Attacking in Normandy was tough.

What's more, the Allied way of war was to probe forward with infantry and armour, goad the enemy into a counter-attack, then hammer them with the full force of their immense firepower. Co-ordinating naval guns, artillery, tactical air forces, as well as armour, anti-tank units and infantry, took time. Replacements, ammunition stocks and reserves also had to be in place. These were the constraints of the Allies' materiel wealth.

GERMAN WEAKNESS

The Germans, by contrast, shorn of air support, with no naval firepower and more limited resources, could organise themselves far more swiftly into the tactically agile battle groups that have so impressed historians. These were enabled by the freedom of their poverty, however, and fundamentally were a sign of weakness. Tactical chutzpah was not enough to win the battle, let alone the campaign – and certainly not the war.

Monty's men – the British and Canadians – ground down the Germans very effectively. During the battle for Normandy, they

Montgomery's failing was his inability to explain the reality: that the Germans were being chewed up

came under attack from one of the largest concentration of panzer divisions of the war, and almost entirely destroyed them in the process, while pushing them back.

It is true that the bombing of Caen, beginning on D-Day and championed by Montgomery, achieved little. It is also the case that Montgomery allowed Eisenhower and Tedder to believe Operation Goodwood, Second Army's drive to capture the high ground south-east of Caen from 18–20 July, could achieve a decisive breakthrough when he himself had more limited and realistic aims. But Goodwood was General Dempsey's plan, not Monty's, and it did result in the Second Army advancing seven miles, to within reach of the Bourguébus Ridge.

Montgomery had always aimed to tie down the bulk of German armour in the British and Canadian sector and this is exactly what happened, albeit further north than originally expected. For those back in London and Washington, however, looking at a two-dimensional map, and with V1s now landing on England, it looked like the Allies were barely

making progress at all. Montgomery's failing in Normandy was his inability to explain the reality: that the Germans were being chewed up and that, soon enough, the floodgates would be open and the Germans would collapse.

British and Canadian efforts around Caen meant there were fewer panzer divisions facing the Americans, which in turn meant that when the breakthrough did finally arrive in the US sector, following the brilliantly executed Operation Cobra, the Germans were already on their knees, short of reserves, unable to move swiftly, and on the point of complete collapse. It was not long in coming.

In the end, the campaign in Normandy was won after 80 days, a week and a half ahead of schedule. Of the 2,500 German armoured fighting vehicles thrown into Normandy, barely two dozen escaped. Two armies were annihilated: by any reckoning it was a stunning victory. As the mastermind of that battle plan, Montgomery is owed far greater credit for his handling of this initial phase – and for his generalship throughout the campaign in western Europe. 🌐

James Holland's latest book, *Normandy '44: D-Day and the Battle for France*, was published by Bantam Press in May.





THE SHARPEST TOOLS

TOOL USE IS NOT RESTRICTED TO HUMANS AND IS FOUND THROUGHOUT NATURE. HERE ARE SOME OF EARTH'S MOST INNOVATIVE ANIMALS

Words: HAYLEY BENNETT

BRIGHT AS RAIN

← BORNEAN ORANGUTAN

When it rains, we humans get out our umbrellas. When it rains at the Camp Leakey research facility in Borneo, the orangutans make their own. Photographer Thomas Marent was observing this mother and baby when the skies opened. While taking out his umbrella to protect his camera, he saw the mother start to collect leaves from the tree. “She formed a kind of hat or shelter,” he says. “She was sitting this way for about 20 minutes.” Wild orangutans have also been observed using sticks to get seeds out of fruit and for measuring the depth of water to establish whether it’s safe to cross. However, researchers think we probably see even more innovative behaviours in captive orangutans, because in the wild they learn from their parents and rarely explore or come across new problems to solve. Orangutans at San Diego Zoo famously escaped from their enclosure nine times, once using a crowbar. If that’s anything to go by, they’re truly some of the smartest – and sneakiest – of the primates.

THOMAS MARENT/MINDEN PICTURES/FLPA

GRAB AND SMASH

ORANGE-DOTTED TUSKFISH ↓

Fish aren't generally known for their intellect. But the surprising behaviour of 'Percy', an orange-dotted tuskfish living in Australia's Great Barrier Reef (and star of 2017's *Blue Planet II*), has got scientists thinking. While not sophisticated enough to use a stone as a hammer, like some monkeys do, he did hold clams in his mouth and carried them to a hard coral. He then used the coral as an anvil to smash open the shellfish, releasing the food within. Experts are still debating whether or not this constitutes real tool use. Is an anvil a tool, or does a tool have to be a separate object that's held and manipulated, like the monkey's hammer? Either way, Percy has demonstrated some impressive cognitive abilities, consistently taking his clams to smash against the same, well-worn spot of coral.

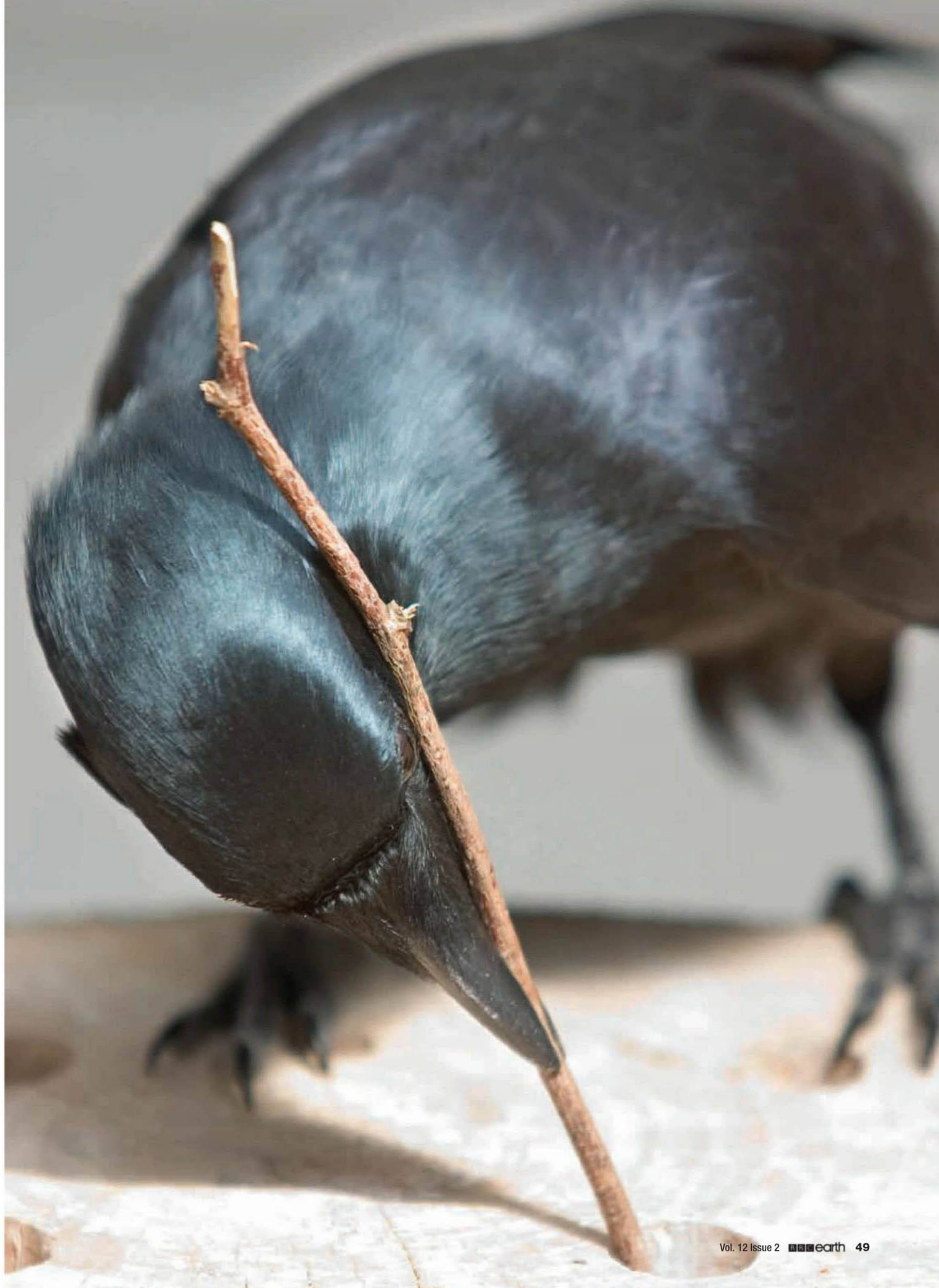
CREATURES OF HABIT?

NEW CALEDONIAN CROW →

In 2002, Betty the New Caledonian crow captured attention worldwide by bending a wire into a 'hook' and using it as a tool to extract food from a tube. Some scientists took this as a sign of superior intelligence, claiming Betty was problem-solving in a spontaneous way. However, further studies showed that wild crows – like the one in this photo – are just as adept at making hooks, but from twigs. Research suggests that the crows' tool use comes from watching other crows initially, but they also seem to commit the shape of the hooks to memory. "Like having a phone number in your mind and then using the memory of that phone number to make a call," suggests Dr Nathan Emery, a crow expert at Queen Mary University of London (QMUL). If this is what's happening, then crows are more creatures of habit than creative thinkers.



LUCY HOCKINGS/BBC, DR SIMON WALKER





SLICK AS A PARROT

GOFFIN'S COCKATOO ↑

A couple of years ago, biologists at the University of Vienna revisited Betty the crow's famous hook-making experiment with Goffin's cockatoos (seen here) and discovered that the birds could bend pipe cleaners to get food out of a tube, even though they'd never seen or used a hook tool before. What's more, Emery's team at QMUL had already shown the same was true of rooks that were given flexible wires. Neither bird is thought to be a toolmaker in the wild. So what's going on? "If they're making a hook on the first trial, there's no opportunity for them to learn to do it elsewhere," says Emery. "It may be that they're doing it by generalisation from things that they've learnt in the past." Sounds like smart thinking for a bird brain.

THE NUTCRACKER

BEARDED CAPUCHIN MONKEY →

Some bearded capuchins crack cashew nuts with rocks, placing the nuts on hard surfaces that they use as anvils. Primatologist Dr Lydia Luncz from the University of Oxford says it's a trick that's been passed from one generation to the next, although not all capuchin communities do it. Like in humans, tool use is cultural. Luncz studied a group of bearded capuchins at Brazil's Serra da Capivara National Park. Here, as well as using stones for nut-cracking, they use them as a shield against toxic substances that spurt out of the cashew shells. The monkeys also use stones to dig for tubers and spiders. In some groups, females use stones to flirt, throwing them at males that they want to mate with in order to get their attention. 🐒





Perfect Blend

Rather than clearing Colombian forests to make way for coffee plantations, merging the two could benefit migratory birds.

By James Lowen

Juan Pablo Echeverri hands me an espresso. “The coffee was cultivated and brewed right here,” he says. We’re at Hacienda Venecia, Juan Pablo’s family-run farm in Colombia’s Andean highlands. Inhaling the roast’s heady scent, I glance towards some tall, native trees. Binoculars raised, my vision suddenly fizzes with feather – a rainbow of birds nibbling fruit or gleaning insects. A sun-yellow flash announces a Canada warbler – an adult male judging by its ostentatious necklace and studious spectacles. The flock swirls onwards. As I prioritise café solo

over optics, I wonder whether growing coffee plants under the shade of rainforest trees might just stave off this migratory bird’s slump towards extinction.

The weight of an AAA battery, la reinita de Canada (Canada’s little queen) flies about 6,000km to spend seven months amid South American mountains before returning to North America to breed. Calamitous deforestation on its Andean wintering quarters is thought responsible for a 75 per cent population decline across four decades. Concern for the Canada warbler’s plight has galvanised “a multinational collaboration to co-ordinate recovery efforts,” ►

Caldas is part of Colombia’s Coffee Cultural Landscape, which made it onto the World Heritage list in 2011.



Scan this QR Code for the audio reader

The Canada warbler (pictured) and ovenbird (bottom left) are just two migratory species that have been spotted among the coffee farms of Central and South America.



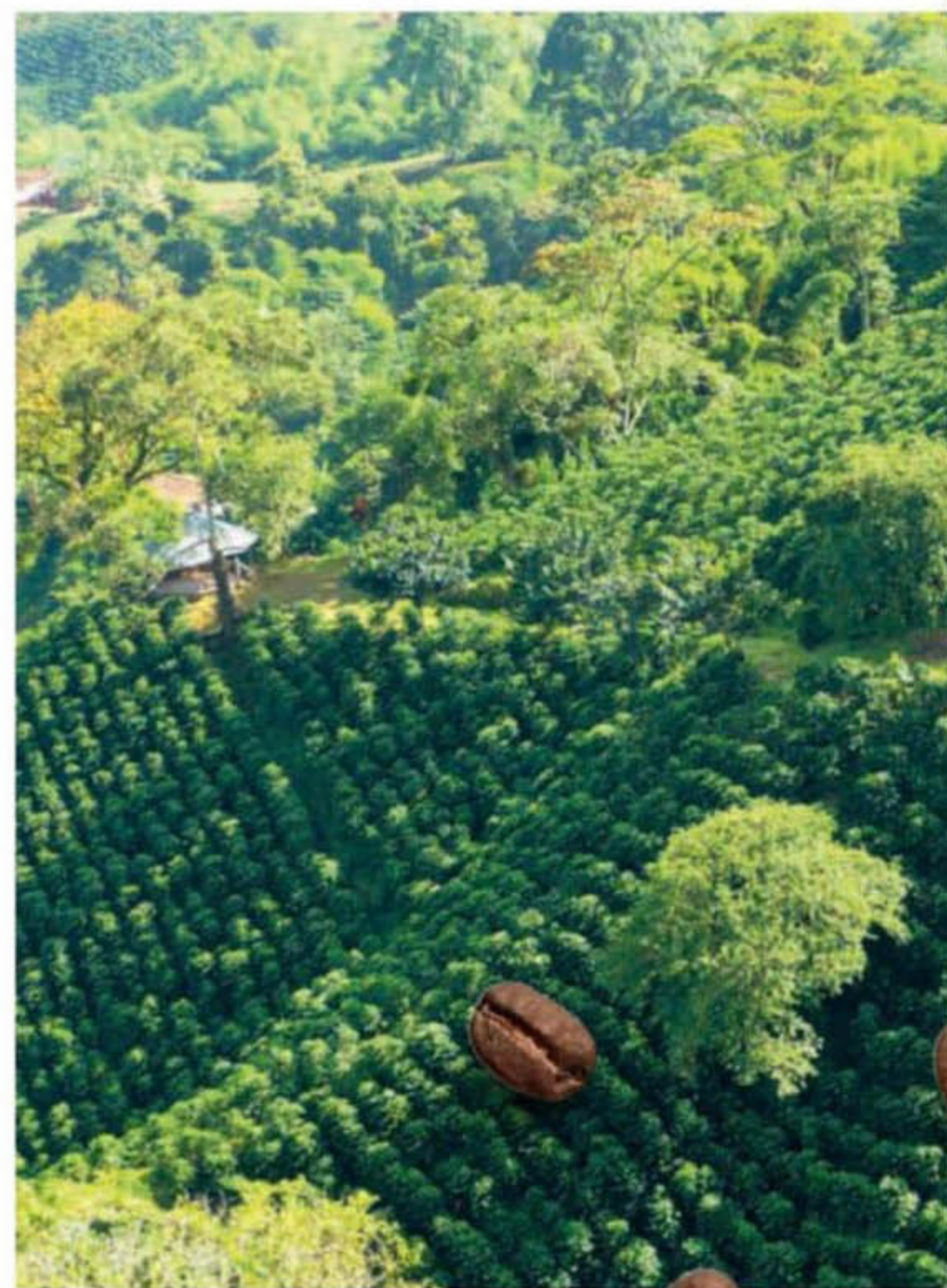
says Diana Eusse of Colombian wildlife charity Asociación Calidris. Joining forces with ProColombia (the national tourist board), Bird Studies Canada and BirdLife International's Preventing Extinctions Programme, Calidris is fighting to save migratory and resident species alike in the context of a 90 per cent reduction in Andean forest.

Getting tree cover back is key. "We have established 83 community nurseries for local vegetation and planted 80 hectares with native trees," Diana says. She also hails the "potential importance" of coffee grown in plantations

shaded by indigenous trees. "Shade-grown coffee can generate financial incentives" for landowners to retain or enhance forest. Ever the caffeine fiend, this intrigues me. Might savvy purchasing decisions help my addiction save tropical wildlife?

Among the world's most important commodities, coffee is big business in Colombia. Arábica exports are worth £2 billion and rose 20 per cent between 2013 and 2018 – only Brazil and Vietnam ship more. The Zona Cafetera of Caldas, Risaralda and Quindío employs 800,000 people. But coffee grows on hills from 900–2,000m, the same

At least 42 species of North American songbirds winter on Central or South American coffee farms.





Left: workers harvest young coffee plants before relocating them. Below: a bean damaged by coffee borer beetle. Bottom right: the Baltimore oriole favours coffee and cacao plantations where crops are grown under a shady canopy. Bottom: coffee plantations blanket hillsides in Colombia.



elevational band favoured by the Canada warbler and other migratory birds – and originally swathed in native forest. On Andean slopes, bean is battling bird.

PAST, PRESENT AND FUTURE

Coffee plantations were established here during the 19th century. The rainforest understorey was eradicated to make way for coffee bushes, but the canopy was retained to provide shade under which wild *Coffea arabica* naturally thrives. This approach persisted until late last century, when the race for higher yields led to inexorable clear-felling, so the crop could ripen in the sun. In Colombia, where Canada warblers mostly winter, the area of shade-grown coffee more than halved between 1997 and 2013. Worse, 69 per cent of Colombian coffee plantations now lack shading trees. Such 'sun-grown coffee' provides minimal service to wildlife.

In hot water: the extinction threat

It's not just migratory birds that may be on the way out – coffee itself is in trouble, say botanists at the Royal Botanic Gardens, Kew. Of 124 species of wild coffee plants, 60 per cent are now threatened with global extinction. These include one of the two cultivated species, *Coffea arabica* (below) – with disease, pests and climate change all taking their toll. Research published in January found conservation measures to be inadequate for wild coffees. "The worst-case scenario is that wild arabica could be extinct by 2080," says Kew's Justin Moat.



Concerned by this transformation, the US-based Smithsonian Migratory Bird Centre (SMBC) paved the way for researchers to investigate whether shade-grown coffee could help biodiversity. The ensuing body of evidence provides considerable hope.

The Cornell Lab of Ornithology calculates that at least 42 species of North American breeding songbird – warblers, tanagers, orioles and more – winter on



Central or South American coffee farms. Cornell's Amanda Rodewald found such migrants in the northern Andes to be more numerous in shade-coffee than natural forests – and, remarkably, those in shade-coffee improved their physical condition for their northbound migration. “With their nectar, insect and fruit resources, shade-grown coffee plantations can provide good foraging habitat for birds,” she says. Some birds like what they find so much that they return year after year. “One particular cerulean warbler even returned to the same farm for five consecutive winters.”

PAYING DIVIDENDS

Coffee isn't solely for the birds. Shade-grown coffee supports high levels of biodiversity, from insects to mammals, explains Ana González of Colombian research institute SELVA. Researchers in Mexico learnt that amphibians such as pygmy free-fingered frog and Mexican robber frog relished the higher humidity and denser leaf



litter found in shaded plantations. The equivalent landscape in Costa Rica was found to be home to 17 mammal species (including northern raccoon, grey four-eyed opossum and nine-banded armadillo). An Indonesian study counted 90 per cent more bees on shade-grown coffee farms than sun-ripened alternatives. But it's not just wildlife that benefits – coffee producers can, too. Nobody denies that sunny coffee plantations yield more beans than shady ones. But the latter's slower maturation imparts a deeper flavour that can garner higher prices. Leaf litter feeds plants, lowering fertiliser costs. Shade-grown coffee plants grow for twice as long – so need less frequent replacement. Birds naturally control pests such as coffee borer beetle. Overhanging trees reduce soil erosion, sequester carbon and offer the potential for harvesting other forest products – which SMBC's Robert Rice found “can potentially boost the value of coffee farmers' holdings by about 10 per cent”.

Top left: after planting, it can take up to four years for coffee trees to bear fruit. **Top right:** coffee cherries turn bright red when ready for harvesting – the beans are then separated from the fruit.

Above: the cherries are usually picked by hand. **Bottom left:** the wood thrush's wintering habitat is being lost to coffee plantations.

Then throw in the market premium that producers receive if their crop is independently certified as ‘shade-grown’. This uplift is feasible because coffee drinkers willingly pay extra to support good causes. In the UK, we are familiar with organic, Fairtrade and Rainforest Alliance coffee. Each certification scheme presses a different button to garner our custom. Organic labels confirm that crop and land have not been sluiced with chemicals. Fairtrade guarantees producers an equitable minimum price. Rainforest Alliance coffee promotes sustainable agriculture over biodiversity. ▶

Shade-grown coffee
supports high levels
of biodiversity, from
insects to mammals.



The fiery red plumage of the male
summer tanager makes it
relatively easy to spot amid the
greenery of the forest canopy.

Below: dried coffee beans. Right: more research is needed to determine if shade-grown coffee helps resident birds, such as sparkling violetear hummingbirds, as well as migrants.

Bottom left: the black-and-white warbler is one of the most common migrants to visit shade-coffee areas.

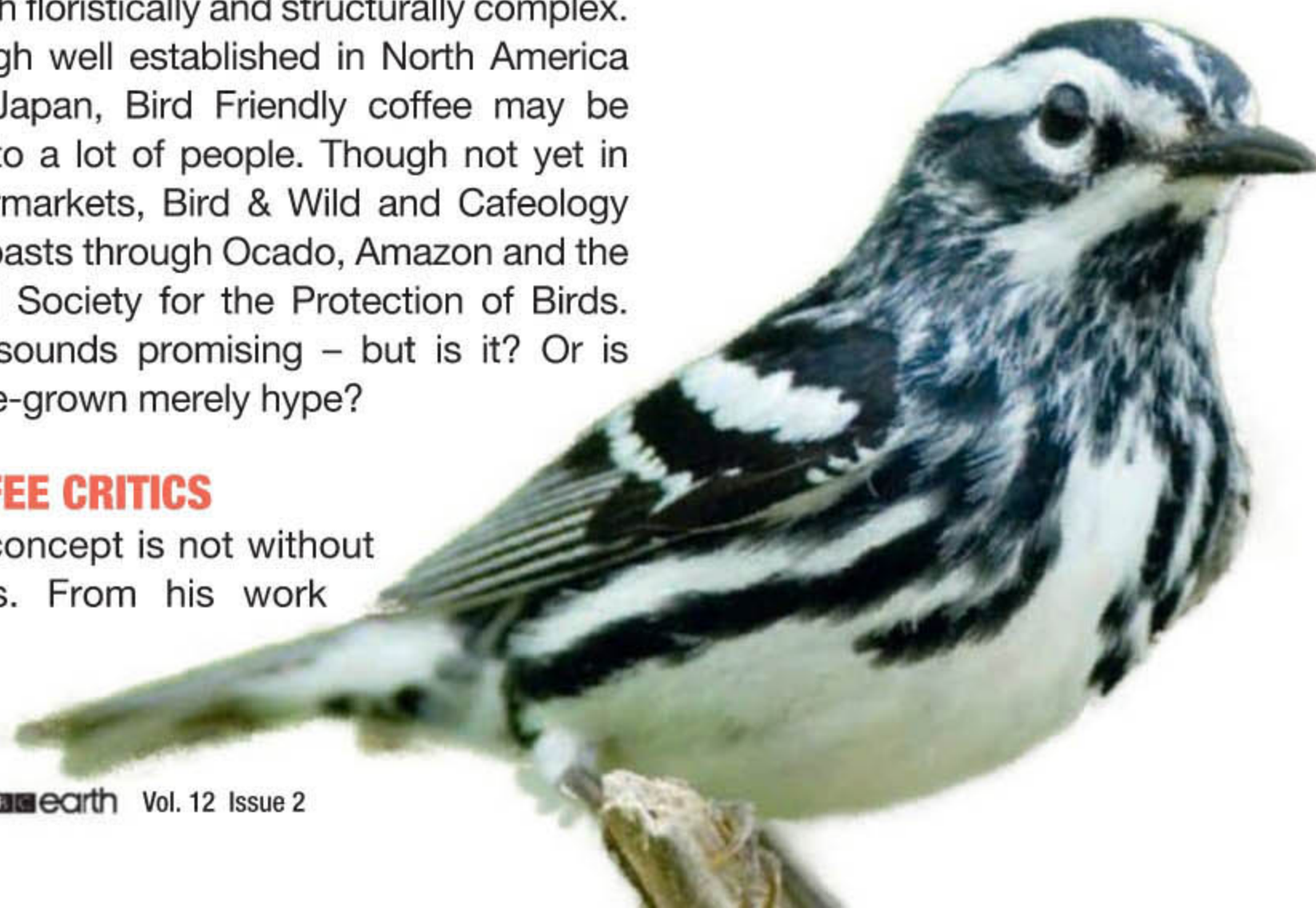


In 1996, SMBC launched the first – and, by all accounts, still best – certification scheme for shade-grown coffee. The primary goal of Bird Friendly coffee is avian conservation. Standards are ostensibly exacting: certifiers grant use of the label only if the canopy is 12m high or more, provides at least 40 per cent shade over the organic crop, contains native species and is both floristically and structurally complex. Though well established in North America and Japan, Bird Friendly coffee may be new to a lot of people. Though not yet in supermarkets, Bird & Wild and Cafeology sell roasts through Ocado, Amazon and the Royal Society for the Protection of Birds. This sounds promising – but is it? Or is shade-grown merely hype?

COFFEE CRITICS

The concept is not without critics. From his work

Consumers need more transparent information to guarantee they are making the right choices.



in Honduras, Samuel Jones (University of London) is concerned that “monocultures damage understorey habitat for scarce amphibians and birds.” Chris Sharpe of Venezuelan charity Provita has been unimpressed by shade-coffee farms in Costa Rica and Belize. “Only in Venezuela,” he says, “have I experienced plantations that provide what birds need – complex architecture with canopy layers comprising solely native species.” Ana is increasingly concerned that not all certified coffee is produced under as high standards as the Bird-Friendly label. “Some farms obtain certification without necessarily meeting shade-grown parameters,” she warns. “Consumers

Beans & hummingbird: James Lowen; warbler: Scott Leslie/NPL; armadillo: Carlos José Pacheco/Alamy; racoon: Ian Butler/Alamy



The nine-banded armadillo (right) and northern raccoon (far right) are among the mammals found in areas of shade-coffee in Costa Rica.

need more transparent information to guarantee they are making the right choices to protect wildlife habitat.”

Moreover, you need a lot of certified land to make a landscape-sized difference. As Colombia’s 300,000 producers typically run farms covering just 20,000–50,000m², the challenge is mighty. Encouragingly, both production and area certified have nearly tripled since 2008. Yet the US market share of Bird Friendly coffee remains tiny (less than 0.5 per cent) and the total land involved is little more than the size of Liverpool (128km²).

Nevertheless, advocates and sceptics have

found common ground on a few points. From a wildlife perspective, shade-grown coffee can never fully replace native forest. But it is better than no trees at all. In a sea of deforestation, any semblance of woodland helps buffer natural forest patches and enables animals to move between them. In the Colombian Andes, for Asociación Calidris and others, shade-coffee has become part of a pragmatic conservation mix whose mainstay is forest protection and restoration.

The world is not going to stop drinking coffee but we can select a less environmentally harmful roast. Back home, I brew a ‘conservation coffee’

from Colombia’s answer to Starbucks, Juan Valdez. A Canada warbler adorns the packet. Together, image and aroma transport me back to the Andes – and their hills of hope. ☕



JAMES LOWEN is an award-winning and espresso-loving author. He travelled to Colombia courtesy of ProColombia and BirdLife International.

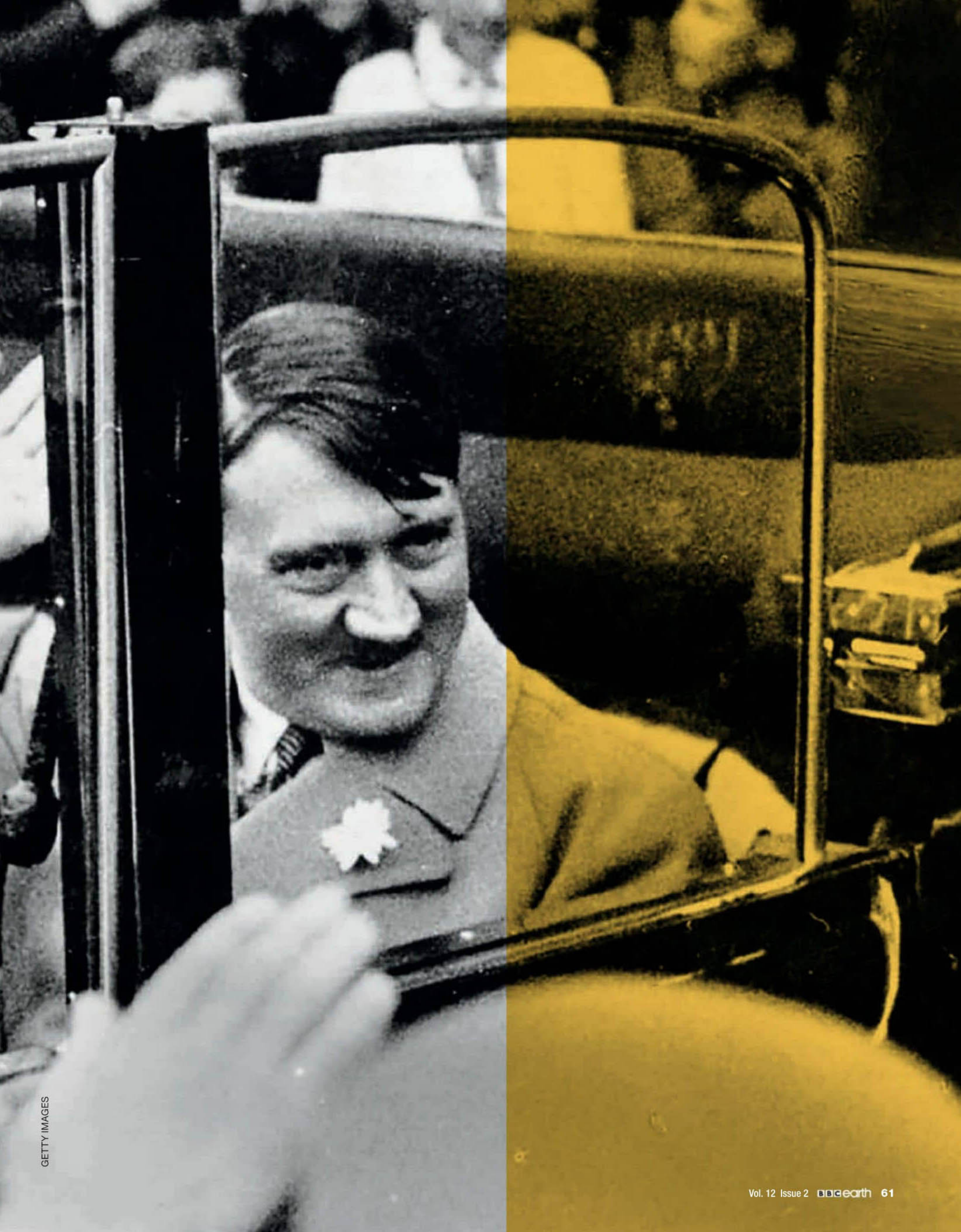
FIND OUT MORE Read about SELVA’s work: selva.org.co/en and BirdLife International’s Preventing Extinctions Programme: bit.ly/2UdsY0V.

Grave new world

Chancellor Adolf Hitler with President Paul von Hindenburg, Berlin, 1 May 1933. At this point, Germany's power elite believed Hitler could be controlled, but that illusion was about to be shattered

“The elites thought they could ride Hitler like a horse. But they soon discovered that they were the horse and that Hitler was the horseman”

Stephan Malinowski tells Rob Attar how a cocktail of naked opportunism and misplaced arrogance among Germany's most powerful men facilitated the rise of the Third Reich



It was late in the evening of 30 June 1934 when Kurt von Schleicher was disturbed from a telephone call by the arrival of a group of men at his house. According to one account, the men asked for von Schleicher to confirm his identity, and once he had done so – “Jawohl, ich bin General von Schleicher” – gunshots rang out. The man who

had been one of Germany's most influential army generals, and the last chancellor before Hitler, was dead – killed during the ruthless purge known as the Night of the Long Knives. Killed because it was feared he was conspiring against the Nazi regime that he himself had helped bring to power.

When the story of the Third Reich is told, several explanations are put forward for how a party that gained only 2.6 per cent of votes in the German elections of 1928 was able to establish a radical dictatorship just five years later: the Wall Street Crash, the legacy of the First World War and Hitler's charisma, to name a few. But one aspect that often receives less attention is the influence of Germany's elite on the events of the late 1920s and early 1930s. According to University of Edinburgh historian Stephan Malinowski, contributor to a new BBC Two series, *The Rise of the Nazis*, a small group of powerful actors played a critical role in the creation of the Third Reich.

BOOTS ON THE STREETS

Of course, there's no denying the importance of the economic collapse in helping to bring down the Weimar Republic. As Malinowski says, the world economic crisis “struck no other country as much as it did Germany, in terms of the economy falling apart: an unemployment rate around 30 per cent, people losing their livelihoods, and their life dreams falling apart”. And while there were many parties on the right and left of German politics seeking to exploit the economic catastrophe, it was the Nazi party that seemed to offer the boldest new direction. “Their voices; the sound of their boots marching on the streets; the oceans of flags and symbols and standards that they carried when they were marching through German cities and villages – this was all very different from what you would get from the conservatives and the more traditional rightwing parties. All of these parties and their leaders



Franz von Papen, below left, rides with state secretary Otto Meißner in 1932. Von Papen sought to co-opt Hitler, offering him the role of vice-chancellor



Germans consider their voting options ahead of the 1928 election, where the Nazis won just 2.6 per cent of the vote



GETTY IMAGES



Hitler greets Paul von Hindenburg after becoming chancellor in 1933. Soon, he had established a dictatorship

“The Nazis were a sharp break from business as usual. People could see this – they could smell it”

suddenly looked like fossils from a bygone age,” Malinowski explains. “The Nazis were a sharp break from business as usual. And people could see this, they could smell it, everybody was speaking about it.”

By the early 1930s, the Nazi movement was already marked by violence as political disputes were being fought out in the streets. Yet despite this, and the stark differences in style to the existing conservative parties, there was a surprising amount of common ground between the two. “There’s a grey zone between Nazi and non-Nazi, and if you look at the conservative elites, you will find that around 90 per cent of them share close to all the negative aims of the Nazis,” says Malinowski. “What the Nazis shared most with the power elites – be they military, industry, landowners, judges, university professors – is a language of fear, of hatred, of disdain for democracy, for the republic, communists, Jews, trade unions, modern art. It was a broad set of things that they did not want and I think it is important to understand that the basis on which the Nazis and conservatives met was a basis of negativity.”

DISDAIN FOR DEMOCRACY

The conservative elite’s hatred of democracy may seem surprising on the surface, considering they fared reasonably well under the Weimar Republic that replaced the kaiser after the First World War. As Malinowski notes: “German revolution and democracy had been extremely friendly with the conservative elites in and after 1918. The nobility kept their heads, their titles, their properties, their castles, and industrialists their factories.” So why then did the elite share the Nazis’ disdain for German democracy? Malinowski believes part of the answer may lie in democracy’s weak foundations in Germany. “The conservative elites in Britain and France had much more time to build compromises with democracies and parliaments than in Germany. There is probably no other country in Europe that has a higher stability of power than Britain.

An observer used to the highly unstable and fragile German conditions might even feel that it was basically the same people running the country since Hastings. Yet the German elite had often been challenged and smashed, exposed to political extremism, war, destruction and revolution: the First World War and the doom of the German empire in 1918 being the most important catastrophe before the Second World War and the Holocaust.

“There was a constant feeling of threat among the elites. And they felt that they were under attack from the communists and leftwing forces. Perhaps the most important element of all is that the elite had to accept political change in 1918 at a time of doom and catastrophe and absolute despair in Germany, which is infinitely more difficult than doing it from a position of triumph.”

In the German federal elections of 1932, amid ongoing economic crisis, the Nazis soared to 37 per cent of the vote – making them the biggest party in the Reichstag, though short of an overall majority. By this stage the Weimar Republic was already gravely weak, with power being exercised largely by members of the conservative elite, acting as advisors to the octogenarian war hero president, Paul von Hindenburg.

Rather than seeking to combat Nazism, the elite hoped to co-opt Hitler, with chancellor Franz von Papen offering him the role of vice-chancellor. “A metaphor these people used a lot – because most of them were noble horsemen – is that they wanted to ride the Nazi movement like a horse,” says Malinowski. “They would use the momentum and the political potential of the Nazi party but still keep it at bay. The idea of ‘framing’ – to control Hitler, to keep him in a conservative ‘frame’ – was the key concept in 1933. And it was a moment of deep misery in the history of German conservatism.”

Yet a coalition with the Nazis that members of the conservative elite favoured was ultimately rejected by Hitler. Lacking sufficient political support to govern, von Papen called another election in November 1932, which again saw the Nazis returned as the largest party, albeit with a smaller share of the vote. With no solution in sight, von Papen stepped down to be replaced by Kurt von Schleicher, but he also failed to create a workable administration.

On 30 January 1933, Adolf Hitler was sworn in as German chancellor by President von Hindenburg, with other options seemingly exhausted. It’s often forgotten now that the new regime was initially a ►

HITLER'S USEFUL IDIOTS

Five members of the elite who helped create the Nazi monster

Media mogul Hugenberg, pictured in c1930, served under Hitler before being marginalised



THE RABID ANTI-COMMUNIST

◀ Alfred Hugenberg (1865–1951)

Hugenberg was a major player in the German media during the Weimar years, and became leader of the rightwing German National People's party in 1928. A staunch opponent of communism, socialism and the Treaty of Versailles, he cooperated with the Nazi party, forming an alliance with them and other rightwing elements in 1931. He initially served under Hitler's chancellorship and believed the Nazis could be restrained, but was soon dissuaded of that notion as his party was dissolved a few months later.

THE AILING WAR HERO

▼ Paul von Hindenburg (1847–1934)

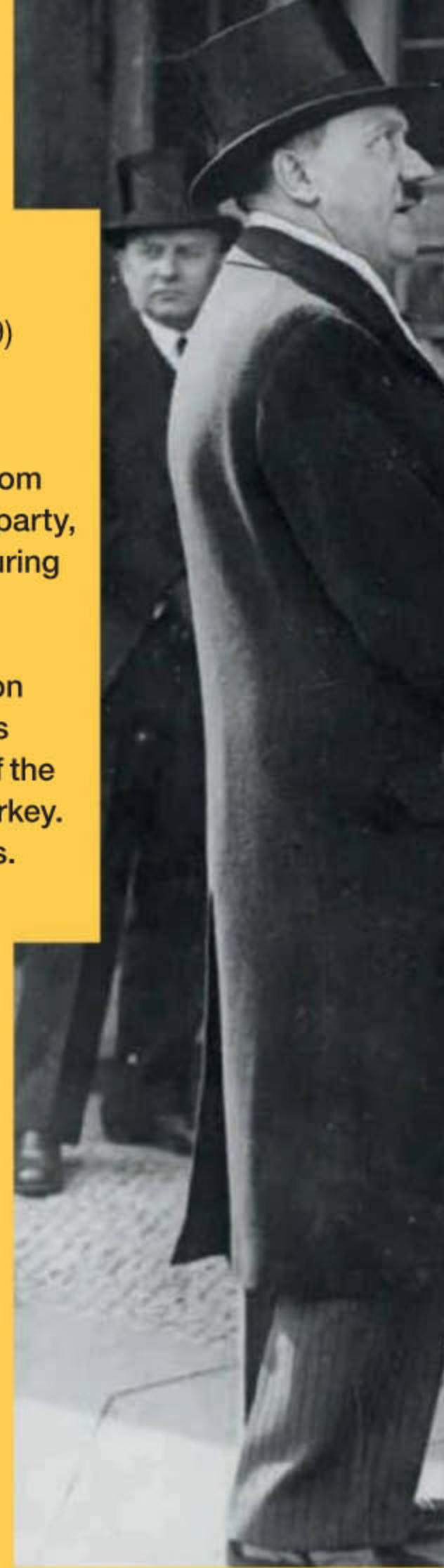
Born into the Prussian aristocracy, von Hindenburg came to prominence during the First World War, where he was one of the key protagonists of the German military campaign. His status as a war hero saw him elected president of Germany in 1925. Following the collapse of the German economy, from 1930 the government was largely operating under his decree. Re-elected president in 1932, von Hindenburg sought to keep the Nazis at bay but felt compelled to appoint Hitler chancellor in 1933. The aged president offered little opposition to the new regime and died in office the following year.



THE CATHOLIC FIXER

▶ Franz von Papen (1879–1969)

From a Catholic landowning family, von Papen held senior posts during the First World War. He served in the Reichstag from 1921 as a member of a Catholic political party, and was appointed chancellor in 1932 during the dying days of Weimar. He was later instrumental in persuading Paul von Hindenburg to make Hitler chancellor. Von Papen continued to hold senior positions during the Third Reich, spending most of the Second World War as ambassador to Turkey. He was acquitted at the Nuremberg trials.



Von Schleicher pictured in c1932, two years before he was murdered by the Nazis

THE ENEMY OF THE REGIME

▲ Kurt von Schleicher (1882–1934)

The last chancellor of Weimar Germany, von Schleicher spent most of his career in the army, until he switched to politics when the republic began to totter. As one of the key figures in German politics after 1929, he helped bring von Papen to power and then succeeded him in December 1932. He tried to make an accommodation with Hitler but was rebuffed and, following his replacement by the Nazi leader, came to be viewed as an enemy of the Third Reich. He was murdered during the Night of the Long Knives.

GETTY IMAGES





Franz von Papen with Hitler in March 1933 at a service to commemorate Germany's war dead

THE CAPTAIN OF INDUSTRY

◀ Fritz Thyssen (1873–1951)

One of Germany's wealthiest men during the Weimar era, Thyssen took over his father's steel and iron empire in 1926. He was an early supporter of the Nazis, providing them with funds and, crucially, working to arrange contacts with other leading industrialists, which ultimately helped fuel their rise to power. Thyssen eventually lost faith in the Nazis and fled the country during the Second World War, before being returned and spending time in the concentration camp system.

Fritz Thyssen, pictured in 1923, bankrolled the Nazis but was later sent to Dachau

conservative-Nazi coalition, with von Papen (who was vice-chancellor) and other senior figures serving alongside the Nazis and still believing Hitler could be controlled. As Malinowski explains: "Most members of this power elite, in particular von Papen, underestimated Hitler and saw him as you would see a servant. When questioned about the decision [to make Hitler chancellor] by another nobleman, von Papen famously said: 'But what do you want? We have hired him.'"

"Many members of the German elites thought he was going to be the useful idiot who was going to play their games. They thought he could be controlled. And I come back to this metaphor of the horseman riding the horse, except that within three or four months, they discovered that they were the horse and that Hitler was the horseman."

FATAL MISJUDGMENT

Less than two months after Hitler became chancellor, he introduced the Enabling Act that effectively marked the end of democracy and the start of the Nazi dictatorship. Measures rapidly followed that clamped down on political parties, trade unions and, of course, Jews. The elites that had hoped to control Hitler had misjudged him totally. Says Malinowski: "This was a bunch of powerful men overestimating their political intelligence and their capacities, and very much underestimating the technical intelligence of the Nazis and the ruthlessness and brutality with which they were going to dismantle and destroy the state, and use their power against their conservative allies."

Some of those conservative allies, like von Schleicher, met their end in the Night of the Long Knives of June 1934. This was a time of realisation for the German elite, as Malinowski says: "Now they understood that this monster they had helped create had come to a Frankenstein moment where it could no longer be tamed, and was redirecting its violence against its own creators."

This was a far cry from how 'hiring' Hitler was supposed to have turned out. "The elite had sought to tame political extremism by binding it into the system, softening it, giving it more responsibility. The understanding was that when Hitler and other Nazi leaders were ministers and responsible for steering part of the economy or universities or whatever part of society, they would somehow calm down and react like normal statesmen.

"Now they realised that this Nazi monster they had helped create could no longer be tamed"

"But this never happened. Hitler never reacted as a statesman in the traditional sense. The Nazis were playing an entirely new game in terms of ideology and of making the unfathomable fathomable. And the killing of 6 million Jews and millions of others in the Second World War can be seen as the darkest part of this."

In August 1934 von Hindenburg died, to be succeeded by Hitler himself. The last obstacle to total Nazi domination had been removed. But while the elite had been largely sidelined from political power, that didn't mean they were all suffering under Nazi rule.

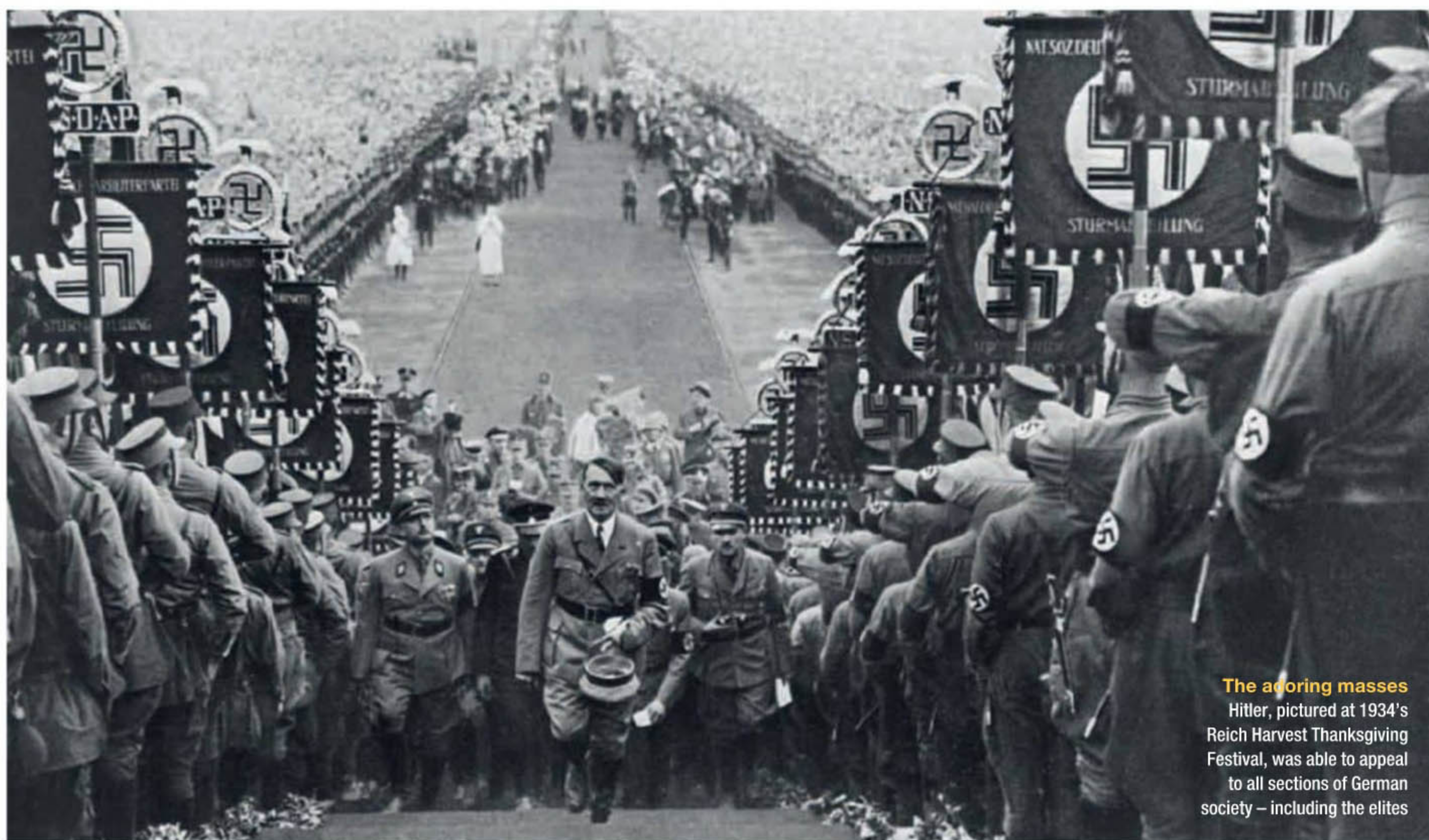
Aside, of course, from the many victims of Nazism, the early years of the Third Reich saw the majority of Germans thriving as the country's economy entered into what looked like a fantastic boom. "Many members of the elites were the great profiteers and beneficiaries of the Third Reich," says Malinowski. "The many examples of German army officers, armament industrialists or civil servants replacing sacked Jewish or socialist office holders in the state apparatus was just one aspect of this. It is often forgotten that the army, industry, universities and engineering were not necessarily directed and run by 'Nazis'. They were run by power elites. There was a power compromise between industrialists, landowners, civil servants, academics, judges and the Third Reich, and for a long time it seemed to be going very well."

So were the elite actually happy with how things turned out? "If you interviewed Germans in May 1945, you would always get the same story, which was: 'We didn't know, we didn't want this, we couldn't do anything, etc.' And some people, like Franz von Papen, were tried at Nuremberg and they would

say things like: 'We did not really collaborate, or we just did our duty, or we did not like this but we did collaborate in order to prevent even worse things from happening.' This is the main lie that conservative elites created after 1945, and it remains influential today. ►

MORE FROM US

For more content on the Third Reich, including podcasts and features, go to historyextra.com/nazi-germany



The adoring masses
Hitler, pictured at 1934's Reich Harvest Thanksgiving Festival, was able to appeal to all sections of German society – including the elites

“Within months of the Nazis’ rise to power, the wildest dreams of the conservatives had been exceeded”

“During the Third Reich itself, however, I think the views of most Germans were positive. They would say: ‘Well, this is deplorable and we do not like that they are beating up people, or the concentration camp of Dachau, the exaggerations; some of them are drunks and they’re not really cultivated; these are terrible people...’ But there was a general sense of admiration for what they were achieving. In two to three months, the leftwing parties had been broken; the communists and socialists had disappeared; the trade unions and parliament had been crushed. The wildest dreams of the conservatives had been exceeded.

“And then, if you go on a few years, Hitler seemed to be achieving everything that he tried. Poland was overrun in no time, and France – where a previous generation had

fought for three months to advance 500 metres – was crushed within six weeks. Summer 1940 was an unexpected moment of absolute triumph where Hitler got support from basically everywhere, including most of the German power elites. Of course, you had anti-Nazis. But if we speak about the majority of the power elites, then the story between 1933 and 1941 is one of stable support, and sometimes of enthusiastic support.”

It was only when the war began to turn against the Third Reich that the real rupture between the German elite and Nazism began – a rupture that culminated in the July 1944 von Stauffenberg plot, which was led by conservative officers who were now prepared to risk their lives to bring down a regime that so many of their fellows had acquiesced with. “Heroes, no doubt, but a tiny minority within their own milieu,” as Malinowski puts it.

Almost 75 years from the fall of the Third Reich, the role of the elite in facilitating Nazism remains a live topic. Recently, descendants of the former German royals have been in negotiations with state authorities to claim back their historic property, and the decision could hinge on the extent to which the Kaiser’s son, Crown Prince Wilhelm, may have supported the Nazis in the 1930s. “It seems historians, lawyers and journalists will go back to

questions that are still not entirely answered: who was responsible for January 1933 and what was the role of Germany’s elites in this process?” comments Malinowski.

Meanwhile, the far right is on the march again – in Europe and beyond. So what warnings might this history have for us today? Says Malinowski: “The most important lessons of 1933 and the Third Reich are about the dark sides of modernity and the general vulnerability of democracy. It’s a fragile system. Any democracy losing the support of the people will fail and a democracy losing the support of its elites will fail too – especially if these elites are working against the democracy and trying to find an ‘alternative’.

“This was the specific situation of the Weimar Republic, and it is the specific historical responsibility of the German power elites that they never came to any kind of peace treaty with the idea of a republic and democracy before 1945.”

Stephan Malinowski is a historian at the University of Edinburgh. His book *Nobles and Nazis: The History of a Misalliance* is due to be published by OUP in 2020. Words: Rob Attar



Scan this QR Code for
the audio reader

SNIFFING OUT DISEASE

In just a few years, we could all be carrying a device in our pocket that detects the aroma of diseases like malaria or cancer before we even realise we're ill

by **Rosie Mallett**

Picture a world where you no longer have to run a gauntlet of tedious, invasive tests when you suspect that something is amiss with your health. Instead, your smartphone or wearable device tells you that there's something wrong before you have any symptoms, and suggests that a trip to the GP might be in order, gaining you precious time to beat the illness. One day, perhaps you could be warned by a sensor that's implanted inside your body to keep tabs on your health.

Such a world may not be that far into the future. Most of the technology already exists, and it has been right under our noses all along. It relies on a resource that has been with us since the dawn of humanity: the power of smell. Scientists

believe that tapping into this hidden world of odours could pave the way to a major shake-up in our approach to healthcare.

MAKING SCENTS

We constantly emit an aura of hundreds of volatile chemicals from our skin, our breath, and potentially even our gut microbes. Every smell is made up of a complex cocktail of compounds – like a recipe with multiple ingredients. Generally, these scents are too faint for us to detect, but to animals we're clouds of smells on legs, and they can detect when our odour is different from usual. This is vital, because scientists suspect that when we're unwell, our unique aroma changes; each disease could even have its own signature pong. ►

"THE MOSQUITO HAS A HIGHLY SOPHISTICATED SENSE OF SMELL"

► "If we can figure out these chemical signatures and mimic the animals' smell-power, then we can use them to achieve earlier diagnosis and perhaps save lives," says Prof James Logan, head of disease control at the London School of Hygiene and Tropical Medicine. And that's exactly what he and his colleagues have been doing for one killer disease: malaria.

GETTING BUGGED

The search begins with the mosquito. Although unpopular, it has one important asset: a highly sophisticated sense of smell, which it uses to hunt us down. It's this efficiency that makes it a threat to human life in those parts of the world where it carries the malaria parasite, *Plasmodium*.

Red blood cells infected with the malaria parasite (yellow). Generally, symptoms appear once the red blood cells are affected

Progress in the fight against malaria has stalled, partly because some people don't realise they have the infection, and can pass it on when they're bitten again. But Logan and his team of researchers discovered that when someone is infected by a malaria-carrying mosquito, they produce chemicals that change their smell, making them even more attractive to other mosquitoes. "So the malaria parasite is manipulating the human body to boost its chances of being transmitted," says Logan. In a double-whammy, malaria also supercharges a mosquito's sense of smell – all the better for sniffing out its human victims.

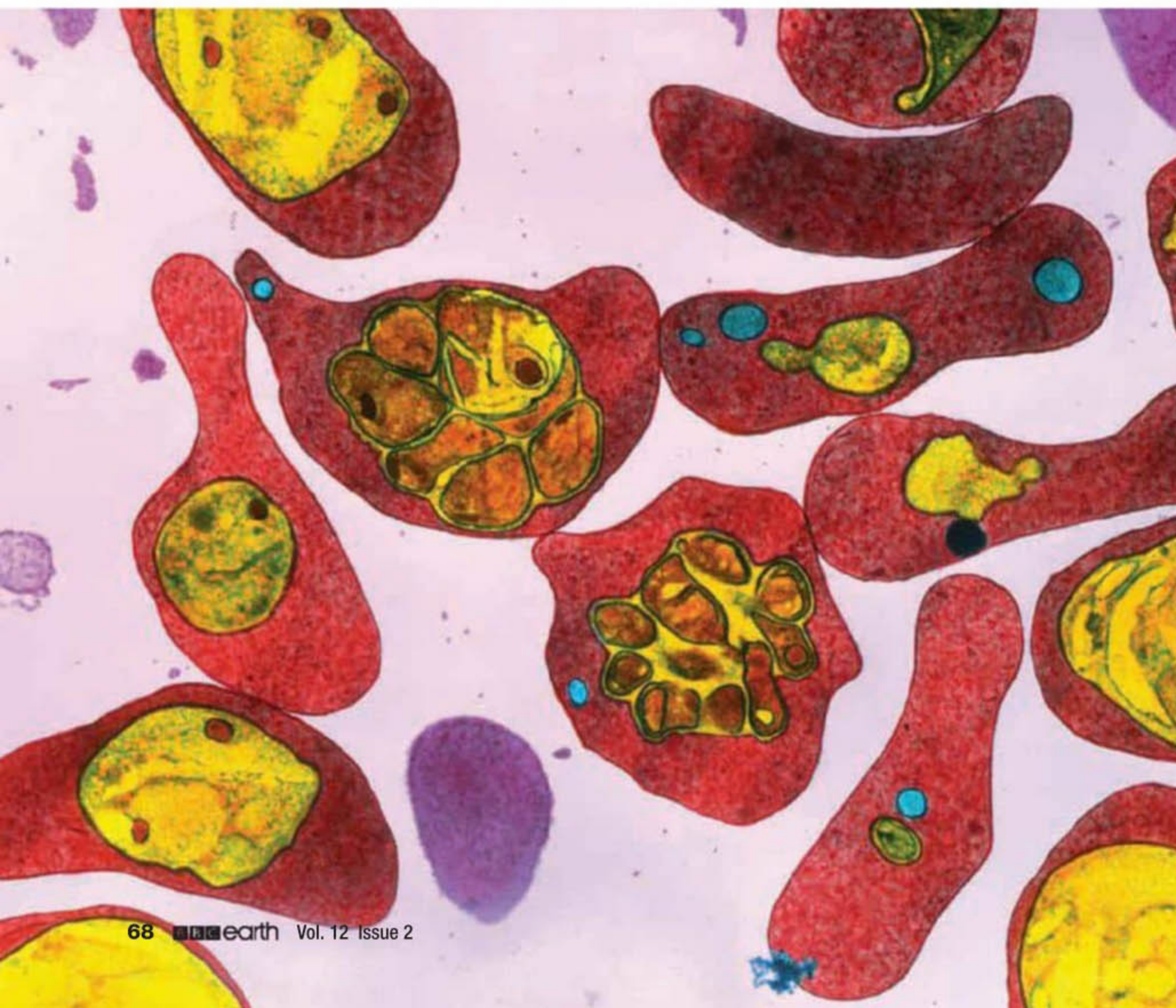
The researchers resolved to find out exactly what chemicals were attracting the mosquitoes. They collected odour samples from the

feet of children with malaria, and separated these odours out into their component parts. Tiny electrodes were attached to mosquitoes' antennae, which they use for detecting smells. They then exposed the mosquitoes to the different components, and measured the electrical responses of the smell receptors in the antennae. The culprits that triggered the highest response turned out to be mainly chemicals called aldehydes. These could be synthesised in the laboratory and kept in a bottle. More on that later.

But how do we turn a mosquito into a diagnostic tool? "It would be lovely if we could put a leash on a mosquito and take it round a community to find people infected with malaria. Not possible. But there is an animal we can do that with," says Logan. Enter the dog – arguably the world's best and most enthusiastic sensor.

LAB REPORT

A dog's nose has 300 million receptors compared with our 5 million. In the same way as they point out illegal drugs in



TAKING THE SMELL TEST

Five diseases with telltale odours

airports, dogs could be trained to sniff people's ankles for malaria, says Prof Steve Lindsay of Durham University's biosciences department.

The team worked with researchers in the Gambia to collect body odour samples from schoolchildren, asking them to wear nylon socks overnight. They also carried out blood tests to see which of the children had the malaria parasite: 30 of 175 children tested positive. None of the children had symptoms.

Then they presented the socks to two dogs trained to recognise malaria at the UK charity, Medical Detection Dogs (MDD). The dogs correctly detected the smell of malaria in 80 per cent of the samples from children who were positive for the infection. Among those who did not have the infection, the dogs got 91 per cent right.

"We think the malaria odour is so strong that the dogs can probably pick someone out from a crowd. So we're looking at using the dogs at ports of entry to countries to detect people carrying the malaria parasite," says Lindsay.

Once they're spotted, they can be treated before they spread the infection. "If it works well, we have a fast, non-invasive and affordable test to help keep countries malaria-free," he explains. "It might even be possible to eradicate malaria."

Other than detecting malaria, dogs are already known for their skill in sniffing out cancers, and are being studied for several other conditions. But they aren't the perfect answer for all our medical woes. They're not likely to be installed in every GP surgery, for instance. And you can only work with a dog for a short time before it loses concentration. In contrast, a machine can keep going forever.

That's where Logan's bottled malaria smell comes in handy. The chemicals can be used to develop a device that mimics what the dogs do: an artificial nose. And malaria may just be the tip of the iceberg. "We know that other diseases have smells. If we can use the animals to help us pick out the right smells then we could develop diagnostics for any of these diseases," says Logan. ►

Joy Milne is a 'super-smeller'. These people have a superior sense of smell and are sometimes sought after by perfume or wine manufacturers.

For Joy, however, her sensitive nose meant that she detected an unusual odour on her husband, Les. Initially she thought that perhaps he wasn't showering enough, but 12 years later he was diagnosed with Parkinson's disease. She only made the connection between the condition and the aroma after noticing the same smell on people at a Parkinson's disease support group. She has since worked with scientists at the University of Manchester to identify the chemicals underlying what she says is the characteristic smell of the condition, which could help lead to earlier diagnosis. Joy is now the linchpin for ongoing smell research. This is what she says about some common diseases:

1. PARKINSON'S DISEASE

This is a musky smell. It can become acrid due to a build-up of bacteria and yeasts in the sebum, the greasy substance that is secreted by our skin and overproduced in Parkinson's.

2. ALZHEIMER'S DISEASE

This has a milder human musk, like rye bread. The skin has a creamy yeast smell which can become stronger as the disease progresses.

3. TUBERCULOSIS (TB)

TB has an odour like stale beer. The smell is present in the breath, and changes as the disease progresses. The skin smells like "wet brown cardboard and brine".

4. DIABETES

Diabetes has a sweet smell with the combination of citrus and creamy pineapple. The smell can vary throughout the day, reflecting fluctuations in glucose levels and how well the diabetes is controlled.

5. CANCER

This smells of yeast or fungi, and different types of cancers have their own smell. It may also be possible to smell the difference when a patient is in remission following treatment.



Joy, who can smell Parkinson's disease, meets a rat that can sniff out tuberculosis



► ON THE NOSE

In the future, an artificial nose might be as simple as a patch that you wear on your skin like a plaster, or a wristband that changes colour when it detects the chemicals in your sweat, or it could be a smartwatch. It might even be a handheld electronic nose – an e-nose – tailored to sniff out the signature smell for the disease. Prof Krishna Persaud, a chemoreception expert at the University of Manchester, has developed an e-nose that's about the size of an early mobile phone, and brings us a step closer to what has until now been science fiction. According to Persaud, we haven't quite managed to develop a tricorder like the one used by Star Trek's Dr McCoy yet, "but we are looking at a set of tools right now being developed by researchers around the world, which will help to transform medicine for the future," he says.

The e-nose works by producing a chemical fingerprint after processing signals from its 'nose' – the sensor. When an odour hits the sensor it changes the electrical signal. One type of sensor uses a small quartz crystal that oscillates at a frequency that depends on its mass. Incoming odour molecules change the mass of the crystal and the resulting change in frequency is measured.

Persaud and his team, however, are developing a new type of sensor – one that more closely mimics what an animal's

nose can smell. Using molecular biology, they've synthesised proteins that are naturally present in the mucus of animals' noses, where they bind to odours and carry them to the smell receptors. The result is a super-sensitive bioelectronic nose that has to learn to detect changes in chemicals that happen when we get sick.

But another scientist wants to take it a step further, by putting a nose in your phone. Dr Andreas Mershin, director of the Label-Free Research Group at the Massachusetts Institute of Technology in the USA, says we live with our smartphones 24/7 so it makes sense to use them to keep tabs on our health.

His vision is to create an artificially intelligent, dog-like nose. This 'nano-nose' would constantly monitor your smell from your phone.



Above left: This very good girl is being trained to identify the smells of diseases

Left: Dr McCoy could wave his tricorder over a patient to diagnose their ailments. We're not quite there yet, but the device is becoming closer to reality

Above right: Dr Andreas Mershin with his prototype device he's developing that fits in your phone and sniffs out cancer

It could even save your life. “Eventually it might even be something you install inside your body so you never lose it,” he says.

Mershin has been learning how to perfect his nano-nose from the Medical Detection Dogs in the UK, and he and his colleagues have created a device even more sensitive than the dog’s nose. But the e-nose has a fundamental flaw: it doesn’t have a brain.

“We made a big mistake when we thought the dogs are so good just because their nose is so sensitive,” he says. “A dog can learn to detect a type of cancer in a sample. Then that dog, without additional training, can spontaneously recognise other types of cancer – even though they have no identical molecules. So the dog



“BY UNDERSTANDING
YOUR OWN BODY SMELLS,
YOU WILL BE IN CHARGE
AND THE DOCTOR WILL
BE THE LAST PERSON
YOU TURN TO”

understands something more than just the volatiles that are flying around. No machine can achieve that.”

The key, he believes, is in how the handler trains the dog. “I want the phone to be your dog and you to be the handler – it learns your personalised scents so when they change, it can warn you,” says Mershin. It will alert you, for instance, if a mole becomes malignant. “Maybe your phone says, ‘you know what, you should probably see a dermatologist, something is smelling iffy’.”

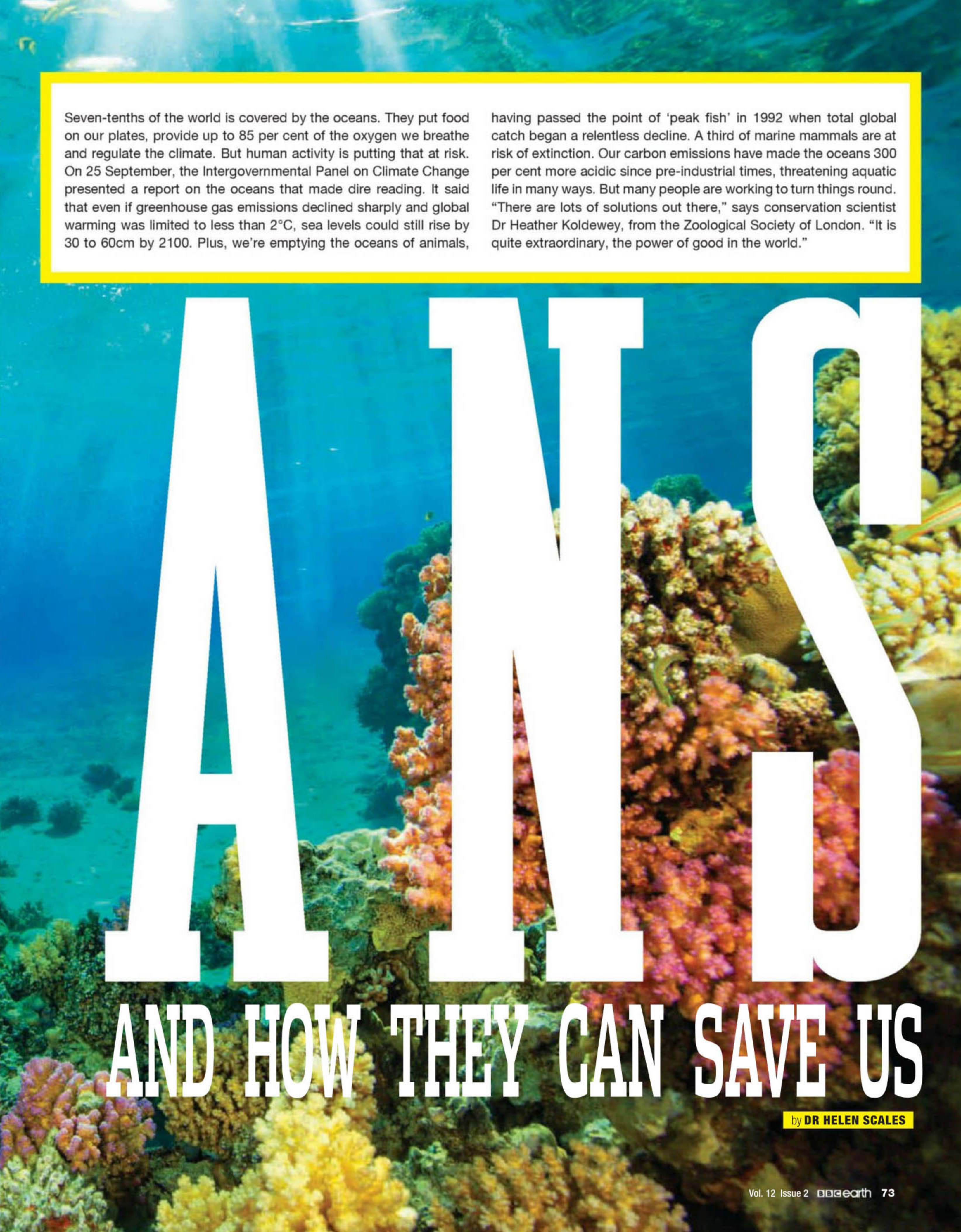
The e-nose could become the most powerful diagnostic tool developed to date. It will allow us to flip the responsibility for healthcare on its head, Mershin predicts. “By understanding your own body smells, you will be in charge and the doctor will be the last person you turn to.” 🌐

by **ROSIE MALLET** (@RosieMallett)
Rosie is a freelance science writer, who specialises in health and medicine.

HOW WE CAN SAVE THE

OCEAN

ALAMY/GETTY IMAGES

A vibrant underwater photograph of a coral reef serves as the background for the entire page. The water is a deep blue, and the coral is a mix of bright orange, yellow, and pink. Sunlight rays filter down from the surface, creating a shimmering effect.

Seven-tenths of the world is covered by the oceans. They put food on our plates, provide up to 85 per cent of the oxygen we breathe and regulate the climate. But human activity is putting that at risk. On 25 September, the Intergovernmental Panel on Climate Change presented a report on the oceans that made dire reading. It said that even if greenhouse gas emissions declined sharply and global warming was limited to less than 2°C, sea levels could still rise by 30 to 60cm by 2100. Plus, we're emptying the oceans of animals,

having passed the point of 'peak fish' in 1992 when total global catch began a relentless decline. A third of marine mammals are at risk of extinction. Our carbon emissions have made the oceans 300 per cent more acidic since pre-industrial times, threatening aquatic life in many ways. But many people are working to turn things round. "There are lots of solutions out there," says conservation scientist Dr Heather Koldewey, from the Zoological Society of London. "It is quite extraordinary, the power of good in the world."

ALMS

AND HOW THEY CAN SAVE US

by **DR HELEN SCALES**

PART ONE

HERE ARE SOME OF THE
BRIGHTEST AND BEST
INITIATIVES THAT HOPE
TO SAFEGUARD OUR
OCEANS' FUTURE

THE SMART MACHINE THAT CATCHES PLASTIC AT THE SOURCE

Plastic particles have become ubiquitous in our seas. They have been spotted in remote areas of the poles and in the deepest ocean trenches.

While a number of projects focus on removing plastics from the seas, tech start-up Ichthion is developing a system for extracting plastic waste from rivers. Rivers play a big part in the plastic problem in the oceans, because they sweep tonnes of waste from land out to sea. "What we're doing hundreds of thousands of miles inland really does have an impact," explains conservation scientist Dr Heather Koldewey, who recently took part in an expedition that tracked plastic waste along the River Ganges.

Ichthion's Azure device sits on a river's surface and diverts floating objects towards the river banks, where a conveyor belt lifts them up and runs them past a camera. An artificial intelligence algorithm then recognises the shapes and colours of different plastics and packaging brands. This enables researchers to pinpoint where rubbish is coming from and what types of plastics are most common. "Without data, it's like fighting against a problem that we don't understand,"

says Inty Grønneberg, CEO of Ichthion. The recovered plastic, up to 80 tonnes a day, is then sorted and sent off for reuse and recycling.

The first Azure systems are due to be installed next year in rivers in Ecuador, where it's hoped they will stem the flow

of plastic heading towards the Galapagos Islands.

Another device that the Ichthion team is working on will attach to ships and filter plastic particles from the water, an idea inspired by basking sharks that sieve plankton through their gills.

Inty Grønneberg with part of the Azure system, which will sweep plastics from rivers without harming wildlife



UK RESEARCH AND INNOVATION, CAMERON LAIRD X2



BREEDING TOUGHER REEFS

Coral reefs are thriving ecosystems, with one-quarter of all marine species calling them home. But if average temperatures rise by 2°C by 2100, most of the world's reefs will be destroyed. Breeding 'super corals' could be one way of saving them from the climate crisis. In Australia, Prof Madeleine van Oppen is continuing the work she began a few years ago with coral biologist Ruth Gates, who died in 2018. She, and other teams of researchers, are trying different techniques that fall under the umbrella of 'assisted evolution', ranging from selective breeding to gene editing.

Some species of coral are naturally better able to cope

with heat, and there are already promising results from cross-breeding these tougher corals with other species to produce heat-tolerant hybrids. Meanwhile, scientists are hunting for the genes that give some corals their heat tolerance. Ultimately, the aim could be to replant reefs with hardy, lab-grown corals.

Conservation scientist Dr Heather Koldewey, from the Zoological Society of London, warns that we don't have time to conduct decades of research but urgently need to assess which solutions are most viable, so we're ready to act. But until countries cut greenhouse gas emissions, "everything else we're doing for coral reefs is just buying time," she says.

ABOVE Prof Madeleine van Oppen (right) and Line Bay are creating tougher corals that could cope with changing ocean conditions

RIGHT A researcher prepares coral samples in the lab



SHARK EYE IN THE SKY

In Australia and South Africa, shark nets are often deployed in coastal regions to reduce the likelihood of shark attacks – not by putting a barrier between humans and sharks, but by deliberately killing thousands of sharks a year. The theory is that fewer sharks mean fewer attacks. However, as top predators, sharks are an important part of the ecosystem, and many species are already threatened. The nets can also trap other vulnerable marine life, including stingrays, dolphins and turtles.

Project Airship could provide a cost-effective, zero-impact alternative means of keeping bathers safe. Project Airship uses tethered blimps that are equipped with motion-sensitive cameras to keep an eye on coastal waters. According to founder Kye Adams, these blimps will keep going all day, as opposed to coastguard-driven drones that can only run for around 20 minutes.

During two test seasons in Australia, Adams deployed 'analogue sharks', otherwise known as human freedivers, into the sea. He was pleasantly surprised by how well the camera detected the divers swimming underwater with their arms stuck out to imitate a shark's pectoral fins. The next step will be to use artificial intelligence to automatically detect real sharks. Ultimately, the airships could be an option to reassure swimmers and surfers that it's safe to go into the water, rather than killing sharks by launching culling campaigns and setting up shark nets.

Kye Adams hopes that his Project Airship will stop shark culling and the deployment of shark nets

PAUL JONES/UNIVERSITY OF WOLLONGONG, GETTY IMAGES



POLICING POACHERS FROM SPACE

Until a few years ago, it was almost impossible to track illegal fishing activity that was taking place out in the open ocean. What happened beyond the horizon stayed beyond the horizon.

Since 2016, the Global Fishing Watch has been keeping an eye on the oceans from space. The collaboration between internet giant Google, the conservation group Oceana and satellite technology experts SkyTruth, makes it much harder for vessels to hide what they're up to.

The technology is based on the tracking devices that large boats must carry to broadcast their location, speed and course in order to avoid collisions with other vessels. The Global Fishing Watch team used this publicly-available information to teach computer algorithms what different types of fishing looks like. For example, long-lining boats work

over and over straight stretches of water, while trawlers crawl around more haphazardly. Now, the system analyses 60 million data points each day to identify the telltale fishing patterns of more than 65,000 vessels. The fishing activities are then posted in near real time on an interactive, online map that anyone can access and download. Already, governments are using the data to combat illegal fishing inside marine reserves, while researchers are drawing up strategies for making legal fishing more sustainable.

The system can even identify fishing vessels that are trying to dupe the system. The algorithms detect when several vessels use the same identification number, or when someone tampers with the onboard GPS and the vessel's broadcast location doesn't match the whereabouts of the satellite that received the data.



SEND IN THE ROBOTS!

The deep sea is the planet's biggest habitat, but we still know so little about it. With emerging threats such as deep-sea mining, it has become increasingly urgent to study this habitat so we can find out what species live down there and what impact our actions will have.

The problem is, it's incredibly difficult to explore the ocean depths, but technological innovations, including fleets of diving robots known as autonomous underwater vehicles or AUVs, are helping us make this a possibility. Equipped with high resolution cameras, AUVs are the powerful eyes that allow us to glimpse the environment beneath the surface. The only snag is that somebody has to pore through the footage afterwards. "It's astronomical how long it takes to analyse imagery," says Prof Kerry Howell, a marine ecologist from Plymouth University. Howell leads the Deep Links project, which recently tested artificial intelligence as a way of speeding up the process.

Her team took a dataset of 150,000 images collected by one of the UK's AUVs, called Autosub6000, from a dive it made to more than a kilometre deep on the Rockall Bank in the Atlantic Ocean. PhD student Nils Piechaud got the unenviable job of examining 1,200 of those images

and identifying 40,000 animals from more than 100 species. Using those images, he then trained Google's TensorFlow – a deep learning algorithm – to identify deep-sea animals. The algorithm's performance was then tested using other images it hadn't already seen. "For some species, it does very well," says Howell. Over 90 per cent of the time, the algorithm correctly spotted xenophyophores, organisms that look like croquet balls made of honeycomb.

It's early days, but Howell is convinced that algorithms will assist researchers with mind-numbing tasks and help unlock the potential of autonomous technologies. "The brilliant thing about artificial intelligence and computer vision is that it's consistent," says Howell. Unlike humans, algorithms don't get tired, or make unpredictable mistakes.

Of course, machines aren't always right, but their bias can be quantified and removed from the data – something that's impossible with the wandering minds of humans.

ABOVE Boaty McBoatface is a AUV that explores the deep sea with the British Antarctic Survey

BELOW This deep-water starfish was spotted by Plymouth University's AUV and has only been seen a handful of times



UNIVERSITY OF PLYMOUTH X2, ALEX MUSTARD/NATURE PICTURE LIBRARY

NASA X2, SCIENCE PHOTO LIBRARY

PART TWO

DRUGS, FOOD AND OXYGEN... HERE IS WHAT WE STAND TO LOSE IF WE FAIL TO PROTECT OUR OCEANS

Corals, like the ones spawning here, are a promising source of new drugs

AN UNOPENED MEDICINE CHEST

Modern medicine is becoming threatened by antibiotic-resistant infections such as MRSA. With lifesaving drugs losing their efficacy, some experts warn of a return to the Dark Ages if this continues.

As a consequence, an urgent search is underway for new medicines to battle against resistance, and one place people are looking is in the oceans. "Sponges and corals are the most promising sources of natural products that have medical properties," says Prof Kerry Howell, a marine ecologist from Plymouth University. That's because these animals are commonly colonised by bacteria that

have evolved chemicals to defeat and kill each other, making the ideal basis for antibiotic drugs.

As a deep-sea biologist, Howell is among the first to know about any new molecules discovered in the oceans. Howell and her colleague Mat Upton, a microbiologist also at Plymouth University, have already uncovered at least one molecule extracted from deep-sea bacteria that seems to be effective against MRSA.

Howell admits that she originally became interested in bioprospecting as a way of persuading people to care

about deep-sea species. "If you don't care about the deep sea just because it's wrong to destroy species and habitats, then at least care about it because it might actually save your life," she says.

It's not only antibiotics that are being found in the oceans. Painkillers have been produced that are based on the toxins of deadly, tropical cone snails. Meanwhile, a Caribbean sponge has yielded various antiviral and anti-cancer drugs, including cytarabine to treat lymphoma and leukaemia, and aciclovir used against shingles, chickenpox, cold sores and herpes.

OCEANS THAT SOAK UP HEAT AND CO₂

Without the oceans, the climate crisis would already be far worse. This huge volume of water has absorbed more than 90 per cent of the heat from the warming atmosphere, and soaked up many gigatonnes of carbon dioxide (one gigatonne = a billion tonnes).

A recent study calculated that between 1994 and 2007, the oceans absorbed close to one-third of all the CO₂ emitted by human activities. "The oceans have shielded us from the heat, they've shielded us from the carbon dioxide," says Dan Laffoley, from the International Union for the Conservation of Nature. "If the ocean hadn't been there, global surface temperatures would be over 30°C warmer."

He describes the oceans as a comfort blanket that has been keeping conditions just right for life on Earth. But while their colossal absorption of carbon and heat helps to stave off the climate crisis, it causes other problems beneath the waves. The oceans themselves are noticeably warming and are becoming more acidic, and as temperatures rise the oceans are losing oxygen.

And this spells bad news for all sea life, which will find it harder to breathe and survive. The shifting chemistry of the oceans makes life especially tough for corals, clams, plankton and other organisms with shells or skeletons made of calcium carbonate which begins to dissolve as pH drops.

The oceans protect us from heat and CO₂ generated by human activity. But for how long can this continue?



GETTY IMAGES, SCIENCE PHOTO LIBRARY, FESTO

THE LUNGS OF THE PLANET

We should all be thankful for the existence of phytoplankton. Multitudes of these tiny organisms float through the oceans, harnessing energy from the Sun via photosynthesis, and in the process producing roughly half of all the oxygen in Earth's atmosphere (the rest comes from land plants).

Especially important is a type of cyanobacteria, or blue-green algae, called *Prochlorococcus*. What they lack in size – 10 of them could fit across the width of a red blood cell – they more than make up for in numbers, and are probably the most abundant photosynthetic organisms on the planet.

"They exist in such numbers that they're measured in octillions, which I think is 10²⁷, a ridiculously massive number," says Dan Laffoley, from the International Union for the Conservation of Nature.

Prochlorococcus specimens were first isolated from water collected from the Sargasso Sea in 1986, by oceanographer Sallie Chisholm from the Massachusetts Institute of Technology. This year, she was awarded the \$750,000 Crafoord Prize for her ground-breaking discovery and ongoing study of the vitally important cyanobacteria.



Enjoy breathing? You can thank these *Prochlorococcus* specimens



THE TECH INSPIRED BY SEA CREATURES

This robot built by German company Festo was inspired by octopus tentacles

Many scientists and engineers have been inspired to develop useful new materials, structures and technologies based on the things that live in the oceans. For example, instead of clunky, metal robots, we could one day see soft-bodied machines inspired by the flexible arms of octopuses. Octopuses' amazing ability to change the colour and texture of their skin to instantly match their surroundings is also being investigated for use as military camouflage.

Inspiration from the oceans can come from the humblest animals. For example, researchers wanted to know how mussels stay attached to rocks, even when they are wet and being pounded by waves. It turns out that the molluscs secrete a special type of waterproof glue, which medical researchers are now using to develop surgical adhesives to use in intricate procedures, such as operating on unborn babies.

A relative of mussels – the limpets – posed another question that was only recently answered: how do these common shoreline molluscs spend so much time scraping algae from rocks without smashing their teeth? Their secret lies in the intricate nanostructure of their gnashers, which makes them the toughest known biological material. If a limpet wanted to, it could chew its way through a bulletproof vest. Their tiny, resilient teeth could be replicated and used to our advantage for manufacturing tough materials.

Sea urchins take the concept of impressive dentistry a step further with their self-sharpening teeth. Their teeth are made of layers of calcium carbonate crystals and organic material with specific weak points that snap, leaving a razor-sharp edge. If materials scientists can mimic that ability, we could find ourselves using urchin-inspired, self-sharpening scissors and knives.



AN IRREPLACEABLE SOURCE OF FOOD

According to the World Wide Fund for Nature (WWF), approximately three billion people rely on seafood as their number one source of protein. Just under half of the fish we eat comes from wild animals caught in the oceans, with the rest coming from fish farms. Besides the familiar fish and shellfish, the oceans provide something else that reaches into our diets and daily lives, often without us knowing it. Each year, at least 25 million tonnes of seaweed are farmed.

Sometimes you'll see it as the nori wrapped around your sushi rolls, but a lot of it is used to make industrial products, including alginates and carrageenans, which end up in all sorts of items. Shampoo, toothpaste, pet food, ice cream, processed meats, vegetarian hot dogs, beer, shoe polish, air fresheners and fire extinguishers can all contain chemicals derived from seaweed.

Seaweed farming has traditionally been carried out in Asia, and now other countries

including the UK and US are catching onto the benefits. Not only is seaweed considered a 'superfood' that's rich in iodine, calcium and amino acids, but it can be sustainably farmed and is carbon-neutral, absorbing carbon dioxide and mopping up excess nutrients from the sea. Seaweed can be used to create biofuels, while research suggests that cattle reared on seaweed-based feeds produce less methane, a potent greenhouse gas.



Seaweed offers a sustainable, carbon-neutral way to feed a growing population, without emptying the oceans of wildlife

IT'S TIME FOR ACTION

Given everything they provide and all the ways they make planet Earth habitable, it's crystal clear that the oceans urgently need safeguarding. Establishing marine reserves where all damaging activities are off limits – particularly fishing – is a major win-win for the oceans and for us: ecosystems become healthier and potentially more resilient to climate change, while fishing is boosted by the eggs and larvae of species that spill out from these thriving oases.

Currently, around 8 per cent of the world's ocean area has some level of protection inside marine reserves, although many are considered to be good on paper, but not well-enforced.

The European Commission claims that 10.8 per cent of European seas are protected, but a recent World Wide Fund For Nature (WWF) report concluded that properly managed reserves only cover 1.8 per cent. A global target to protect 10 per cent of the oceans by 2020 looks to be within reach, but

conservationists and scientists are demanding more. In 2016, members of the International Union for the Conservation of Nature (IUCN), including 1,400 governments, NGOs and indigenous communities, voted overwhelmingly in support of a new target: protect 30 per cent of the oceans by 2030. This will help support fisheries, encourage biodiversity and safeguard traditions linked to the oceans.

"There's no scientific publication that supports the current policy of protecting 10 per cent," says the IUCN's Dan Laffoley. Science is telling us that the minimum needed is one-third protection of the oceans, or more. And it's not just about marine reserves but also what happens outside them. "If we are to have a sustainable ocean," says Dr Heather Koldewey, a senior advisor at the Zoological Society of London. "It has to be a combination of protection combined with sustainable management of the rest." 🌊



It's vital that a large percentage of our oceans are protected in marine reserves

GETTY IMAGES, NATURE PICTURE LIBRARY

by **DR HELEN SCALES**
(@helenscales)

Helen is a marine biologist and science writer. Her latest book is *Octopuses*, from the Ladybird Expert Series.

PRIMER

Neuralink

WITH TESLA AND SPACE X, ELON MUSK MADE ELECTRIC CARS AND PRIVATE SPACEFLIGHT UBIQUITOUS. NOW, HE HOPES HE CAN DO THE SAME FOR MIND-MACHINE INTERFACES...

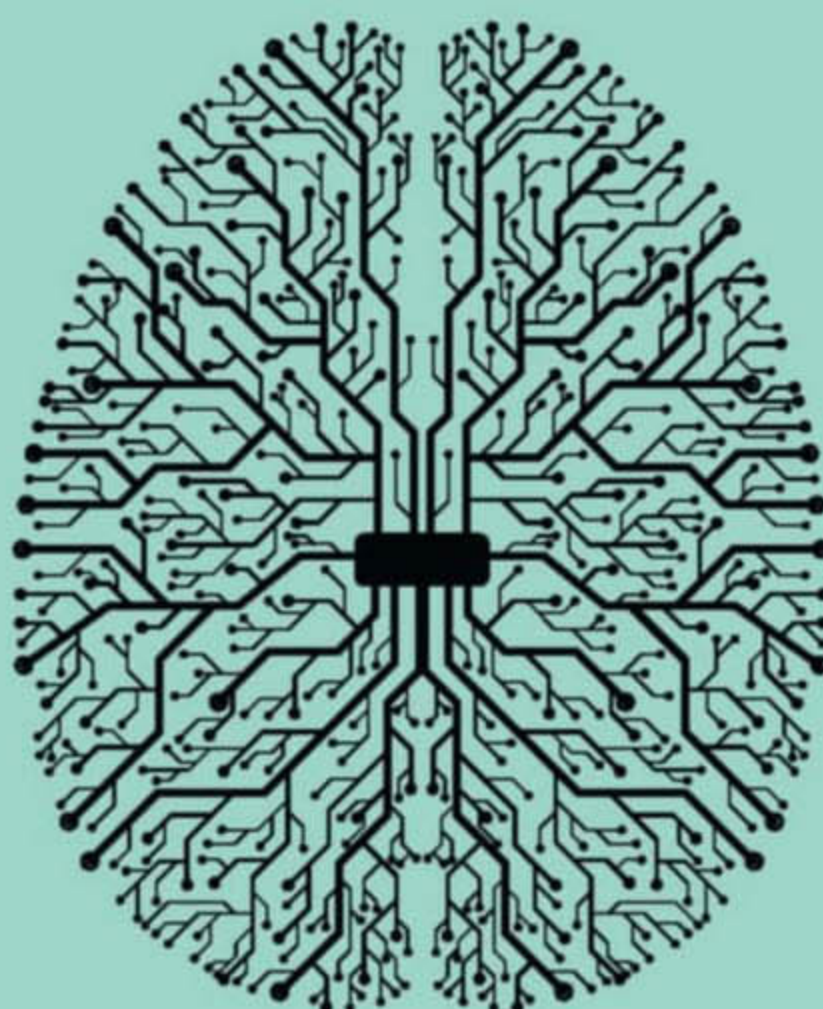
WHAT IS NEURALINK?

Elon Musk wants to control machines with just the power of thought. To that end, last month Musk and his team revealed that they had developed ultrafine 'threads' that can be woven into your brain to listen in on your neurons. The company has also built a robot that can perform the delicate surgery, under the supervision of a neurosurgeon. When the company was first launched in 2016, Musk said he wanted to help humans compete in a world where artificial intelligence had surpassed them – to give us more 'bandwidth'. But with this new announcement the researchers have turned their attention to helping those with brain-related disorders.

HOW DOES IT WORK?

The N1, a 4mm-square chip, is implanted into the skull. Attached to the chip are wires thinner than a human hair, which reach out into the brain. These threads are placed close to important parts of the brain and are able to detect messages as they are relayed between neurons, recording each impulse and stimulating their own. Neuralink says the N1 is able to connect with 1,000 different brain cells, and that a patient might have as many as 10 N1 chips implanted.

The chips connect wirelessly to a wearable device that hooks over the user's ear, much like a hearing aid, and



“What are the ethics behind monitoring someone’s every thought, deed and emotion?”

contains a Bluetooth radio and a battery. Neuralink says the first devices will be implanted via traditional neurosurgery, but eventually the chips will be inserted safely and virtually painlessly through small incisions by a robot surgeon.

WHAT KIND OF CONDITIONS COULD BE TREATED USING THIS TECHNOLOGY?

The technology could help with neurological disorders, which are rooted in the inability of the brain to connect with nerves around the body. These include epilepsy and Parkinson's disease, but also paraplegia and quadriplegia following injuries to spinal nerves.

DOES IT HAVE TO BE STUCK INSIDE MY BRAIN?

Unfortunately, the technology needs to be close to each nerve in order to pick up signals – anything further than 60 microns wouldn't be able to detect individual impulses (1 micron = 0.001mm).

WHAT ARE THE RISKS?

Neuralink will need to learn from the successes (and failures) of existing brain-computer interface technologies. The threads connecting electrodes to the chip need to be flexible, to minimise the damage to surrounding brain tissue. And if this technology is to be given to patients with pre-existing conditions, there are also risks associated with operating on those whose immune systems may be compromised.

Musk reassured the audience that implanting the device would be as safe as having laser eye surgery, but the company is yet to seek FDA approval, which it will need to market the device.

There aren't just health risks, either: society will need to consider what to do with the data recorded by the N1. What are the ethics behind monitoring someone's every thought, deed and emotion?

SO WHEN COULD IT BECOME A REALITY?

Musk hopes for human studies to begin as early as 2020, a date some say is wildly optimistic. At the launch, Neuralink's CEO Max Hodak stated that the first patients would be those with quadriplegia due to spinal cord injuries. These patients will have four chips implanted, connecting with up to 4,000 different neurons.

The benefits extend beyond the disabled. Musk hopes that the technology will become commonplace, turning the humans into cyborg beings that can achieve a symbiosis with artificial intelligence – something he believes will be essential to the survival of our species.

Q
&
A

ALL YOUR
QUESTIONS
ANSWERED

GETTY IMAGES

THIS ISSUE'S EXPERTS

DR ALASTAIR GUNN

Astronomer,
astrophysicist

ALEX FRANKLIN-CHEUNG

Environment/
climate expert

ALOM SHAHA

Science
teacher,
author

DR PETER J BENTLEY

Computer
scientist, author

DR HILARY GUTE

Former GP,
science writer

CHARLOTTE CORNEY

Zoo director,
conservationist

DR HELEN SCALES

Oceans expert,
science writer

DR CHRISTIAN JARRETT

Neuroscientist,
science writer

DR EMMA DAVIES

Chemistry expert,
science writer

LUIS VILLAZON

Science/tech
writer

JULES HOWARD

Zoologist,
science writer

PROF ROBERT MATTHEWS

Physicist,
science writer

ANNA BRIGGS, PLYMOUTH

HOW FAR FROM EARTH COULD ALIENS DETECT OUR RADIO SIGNALS?

While commercial radio broadcasts began around 100 years ago, these early transmissions used frequencies that were either mopped up by the atmosphere or drowned out by radio emission from the Sun. In contrast, military radar transmissions set up during the Cold War to detect incoming ballistic missiles have the power and frequency characteristics to be detected over hundreds of light-years – and have already broadcast our existence to any aliens within around 60 light-years of the Earth. **RM**





JESSICA HOWARD, INVERNESS

WHAT WOULD HAVE HAPPENED IF WE'D CARRIED ON USING CFCs?

In the late 1970s, scientists noticed levels of ozone gas (O₃) dropping in the ozone layer, a region of the stratosphere some 15 to 30km above our heads. The ozone here absorbs most of the Sun's damaging ultraviolet (UV) radiation, shielding us from UVB and UVC rays. The culprit for the disappearing ozone? Chlorofluorocarbons (CFCs), which were used in fridges, aerosols and air conditioners. As CFCs entered the atmosphere, they released chlorine atoms which broke down ozone and allowed more UV radiation through.

As rates of ozone depletion accelerated, the international community sprang into action. Effective from 1989 and signed by 197

countries, the Montreal Protocol has now phased out 99 per cent of CFCs and other ozone-depleting chemicals, with ozone levels predicted to make a full recovery by the 2050s. Without this treaty, CFCs would have continued to rise, with disastrous consequences for life on our planet.

In humans, heightened exposure to UVB radiation would have triggered a surge in incidences of skin cancer and cataracts. According to one estimate, there would have been an extra two million cases of skin cancer worldwide by 2030. By 2065, UV radiation at the planet's surface would have reached three times its current strength, making any Sun exposure dangerous.

Overexposure to UVB radiation stunts the growth of many plants, and the resulting decline in agricultural productivity could have triggered food shortages. The radiation harms phytoplankton, too – the tiny organisms that form the basis of marine food webs – with untold consequences for wider ecosystems. CFCs are powerful greenhouse gases, and US researchers have calculated that there would have been an additional 2°C of global warming by 2070 if CFCs had been left unchecked. This would have fuelled extreme weather such as floods, droughts, hurricanes and heatwaves.

Fortunately, this disaster scenario was averted, and today the Montreal Protocol is often heralded as the most successful piece of environmental legislation in history. **AFC**



HENRY BUTLER, CANTERBURY

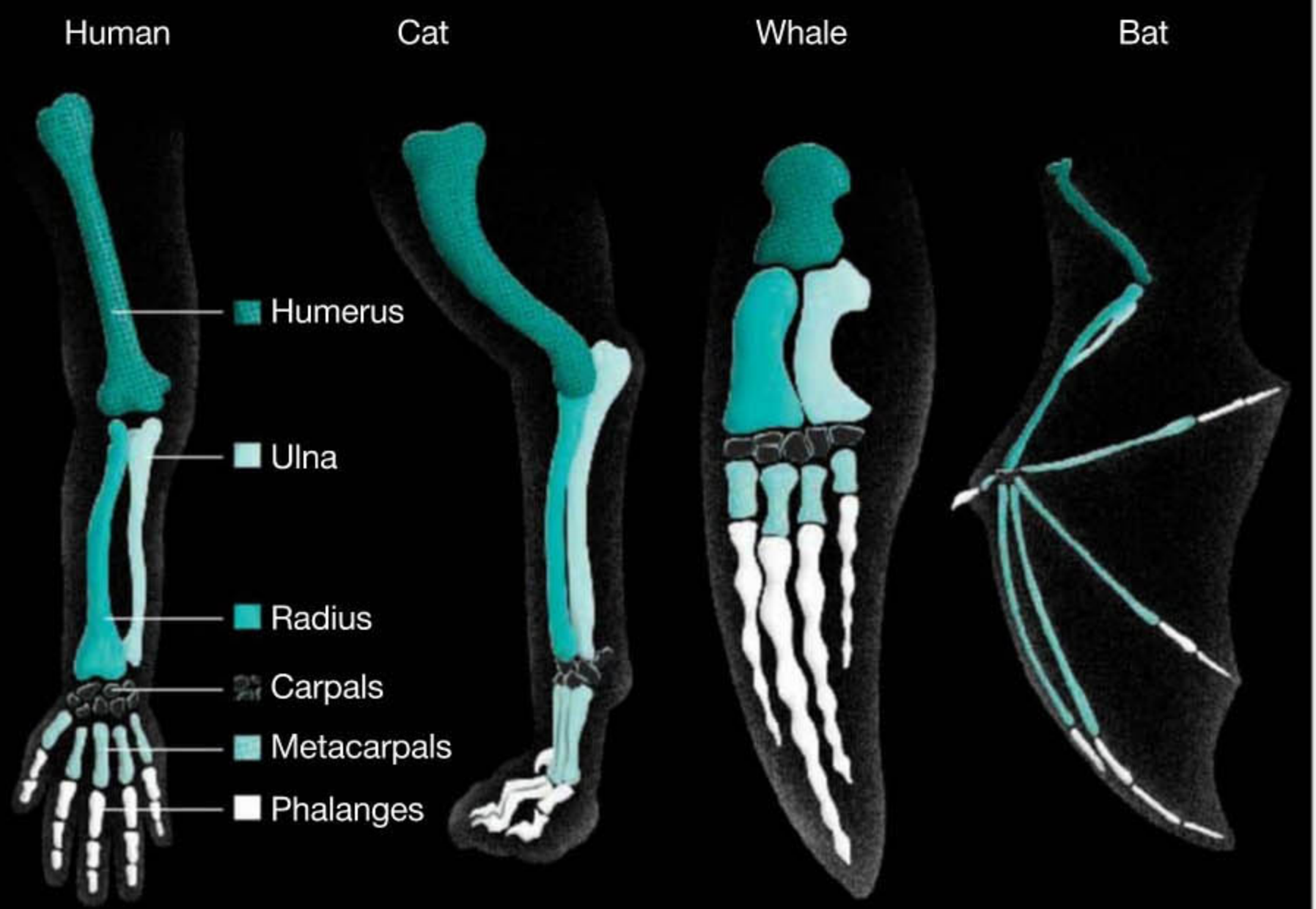
WHY DO MILLIPEDES HAVE SO MANY LEGS?

Though no known millipede species has 1,000 legs, common species of this burrowing arthropod have between 40 and 400 legs – more than enough to move the millipede forwards with impressive heft. Like an army of tiny soldiers running a giant battering ram into a wall, this adaptation allows the millipede's head to be forced into the cracks between lumps of soil where the most delicious leaf matter often resides. These crevices also offer excellent protection from predators. **JH**

EDWARD SEYMOUR, HOVE

ARE HUMAN AND ANIMAL BONES THE SAME?

Humans and other mammals share the same distant ancestors, so our bones are almost identical to theirs in form and function. The bones in your hand have the same layout as those in bat wings and in the fins of whales, for instance. What differs most between species, however, is the thickness, size and density of minerals that provide strength to bones. This is what scientists are most interested in when trying to determine the origin of mysterious bones. Even today, mistaken identifications of human bones from animal remains can occur. To the untrained eye, the bones within the paw of a bear, for instance, look very similar to the bones within the human hand. **JH**





GEEK_KID, VIA TWITTER

DOES EATING BLUE CHEESE CONTRIBUTE TO ANTIBIOTIC RESISTANCE?

Discovered by Alexander Fleming in 1928, the antibiotic properties of penicillin, derived from a species of *Penicillium* fungus, are still widely used today, though many bacteria have become resistant to the drug over time.

Antibiotic resistance occurs when bacteria are regularly exposed to doses of antibiotic that are not quite strong enough to kill all the bacteria. In these situations, the antibiotics only kill off the weakest bacteria, which leaves the slightly stronger ones to multiply and spread their more resistant genes.

Blue cheese does contain cultures of *Penicillium* mould. You might therefore think that eating too much blue cheese could have a similar effect to antibiotic resistance, by overexposing the bacteria in your body to *Penicillium*. However, the strains of *Penicillium* that are used in cheesemaking are different to the ones in the drug, and don't have any significant antibiotic properties to begin with. Besides, they are destroyed by your stomach acid anyway. **LV**

SIMON BARTLETT, VIA EMAIL

IS 'SNAKEBITE' JUST A MIXTURE OF LAGER AND CIDER, OR A CHEMICAL REACTION BETWEEN THE TWO?

There's no chemical reaction, because the main ingredients are the same: water, alcohol and carbohydrates. So the drinks just mix together. Despite the fact that some bars refuse to sell snakebite, the beverage is actually no more deadly than a pint of beer or cider alone – both drinks tend to have a similar alcohol content, so mixing them just produces a drink of a similar strength. The feeling of getting drunk quicker is likely to be purely psychological. **ED**



KEITH ANDERSON, BRADFORD

DO FISH FEEL PAIN?

It's an old adage that fish don't feel pain. Their brains are too small and simple – or so the story goes. But evidence is stacking up to the contrary. In 2003, researchers at the Roslin Institute near Edinburgh discovered sensory nerves in bony fish that allow them to detect pain in a similar way to birds and mammals, linking their skin and other areas of the body to the brain. The same team went on to find that, when injected in the lips with mild acid or bee stings, rainbow trout rocked their heads and rubbed their lips against the aquarium tank. Given painkillers, the trout behaved normally again. Many other studies reveal aspects of fish suffering, including in cramped fish farms where some salmon stop feeding and show signs of depression, such as high levels of the stress hormone cortisol. **HS**

Hidden figures

ABU YŪSUF YA'QŪB IBN 'ISHĀQ AS- SABBĀH AL-KINDĪ

THE MAN WHO BROUGHT SCIENCE
OUT OF THE DARK AGES

For centuries following the collapse of the Roman Empire in the 5th Century, texts by key thinkers from Ancient Greece, India and elsewhere became lost to the world. The texts still existed physically, but during the Dark Ages very few scholars could read them in their original language. That changed in the 9th Century, with the work of the Arabic polymath Al-Kindi.

Born around 800 in what is now the Iraqi city of Kufa, Al-Kindi became the leading scholar at the House of Wisdom, a grand library created by the ruling caliphs of Baghdad. He led a team of translators working on ancient texts by the likes of Hippocrates and Aristotle. Over the decades, manuscripts on everything from astronomy to medicine and logic were brought back into circulation by being rewritten in contemporary Arabic, and in a newly available format: paper, imported from China. A brilliant academic, Al-Kindi also contributed his own insights in fields as diverse as pharmacology and code-breaking. He is regarded as one of the greatest scientific polymaths of all time. **RM**



OLD WIVES' TALES...

CHEWING GUM TAKES SEVEN YEARS TO DIGEST

The digestive system isn't like an in-tray, where everything remains until fully processed: it's more like a conveyor belt. Whatever you eat moves through your intestines at roughly the same speed, and anything that doesn't get broken down and absorbed into your bloodstream passes out the other end. This usually takes one to three days. Chewing gum can't stick to the wet intestinal wall, so a single piece of swallowed gum normally gets swept along with everything else. There are a few cases in the medical literature of small children swallowing many pieces of gum that formed a lump too large to pass. But this quickly caused severe constipation and pain, and needed surgery to remove.

But supposing some gum did somehow get trapped, would it take seven years to digest? Chewing gum is 70 to 85 per cent sweeteners, flavourings and starch, all of which are digestible. But the remaining 15 to 30 per cent is a blend of synthetic polymers, often including butyl rubber. This rubber is also used to make the seals on chemistry lab flasks, and is rated as suitable for storing hydrochloric acid that is 30 times more concentrated than the acid in your stomach. So if you could somehow withstand the severe constipation, the gum would likely last at least seven years. **LV**



EMRE YORGANCIGIL, ISTANBUL, TURKEY

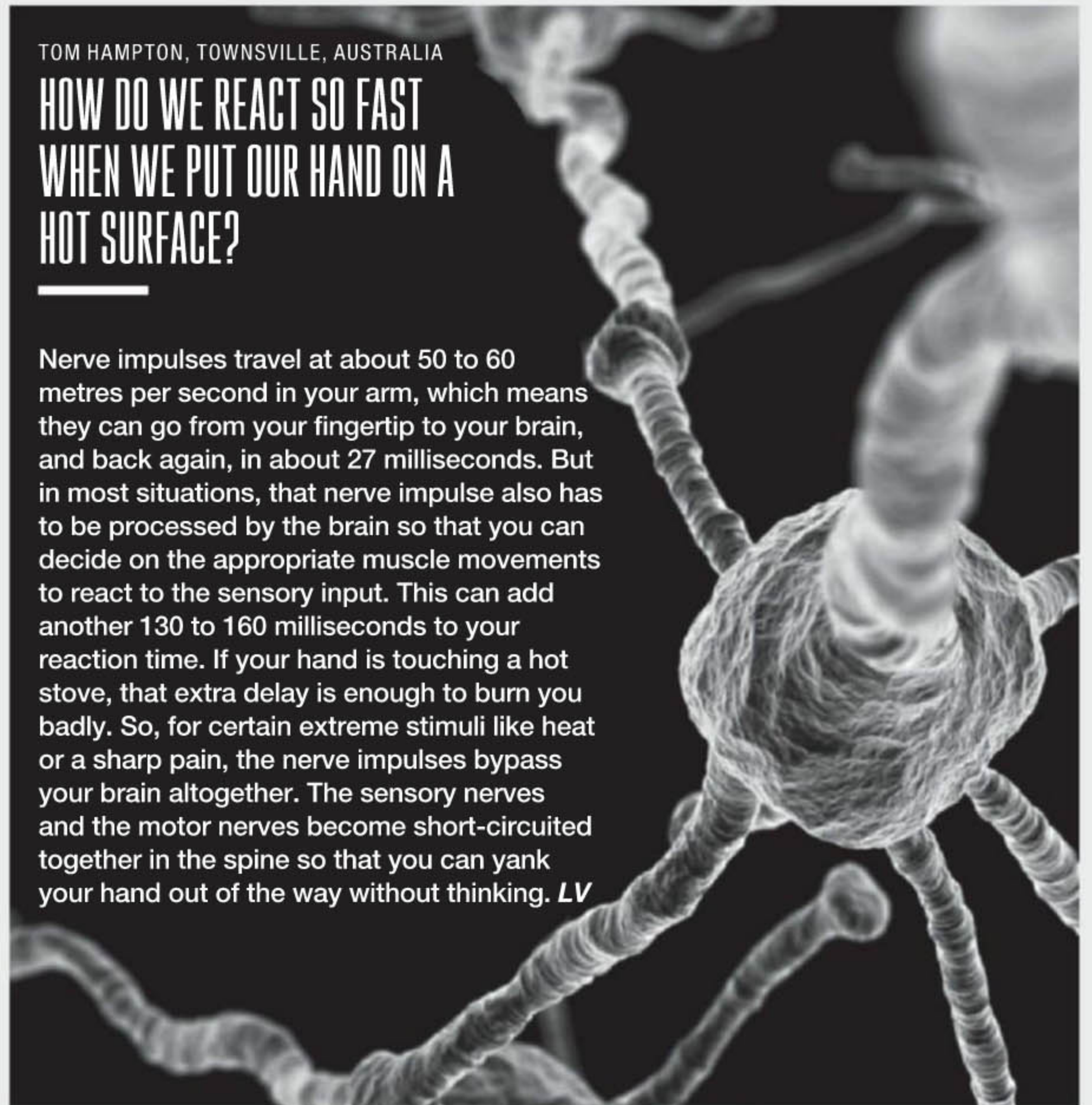
WHY CAN'T WE CLOSE OUR EARS LIKE WE CAN CLOSE OUR EYES?

We have evolved eyelids to protect our eyes from drying out or getting scratched. When you are sleeping, it is dark anyway, so there's not much point in your eyes being open. But your ears have evolved as an important early warning mechanism, allowing you to wake up if, say, there's a tiger growling in the undergrowth. Some animals, including seals, otters and hippos, can close their ears, but this is to keep water out while swimming. **LV**

TOM HAMPTON, TOWNSVILLE, AUSTRALIA

HOW DO WE REACT SO FAST WHEN WE PUT OUR HAND ON A HOT SURFACE?

Nerve impulses travel at about 50 to 60 metres per second in your arm, which means they can go from your fingertip to your brain, and back again, in about 27 milliseconds. But in most situations, that nerve impulse also has to be processed by the brain so that you can decide on the appropriate muscle movements to react to the sensory input. This can add another 130 to 160 milliseconds to your reaction time. If your hand is touching a hot stove, that extra delay is enough to burn you badly. So, for certain extreme stimuli like heat or a sharp pain, the nerve impulses bypass your brain altogether. The sensory nerves and the motor nerves become short-circuited together in the spine so that you can yank your hand out of the way without thinking. **LV**

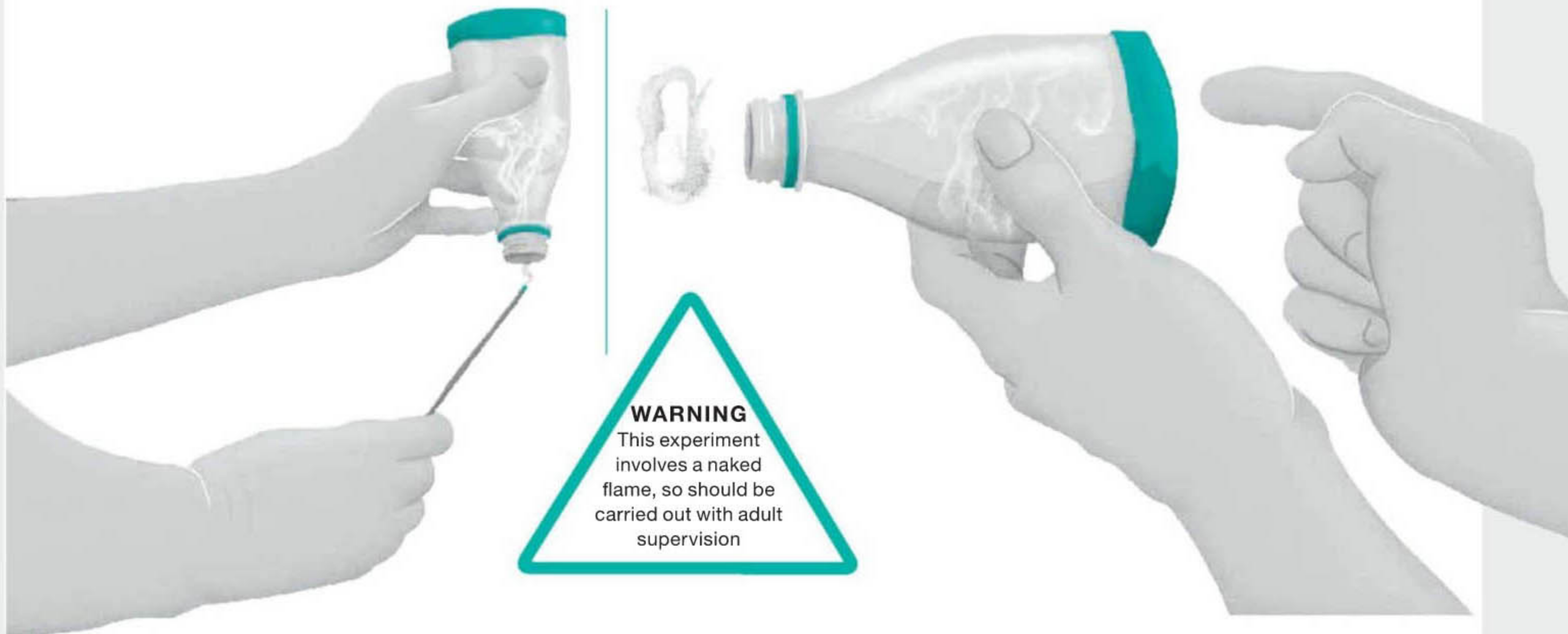


DIY SCIENCE

SMOKE RING CANNON

WHAT YOU'LL NEED

- One-litre plastic bottle
- Scissors
- Rubber balloon
- Sticky tape
- Incense stick
- Matches



WARNING

This experiment involves a naked flame, so should be carried out with adult supervision

WHAT TO DO

1. Use scissors to cut off the bottom third of the plastic bottle.
2. Cut the balloon at the base of the neck. Discard the neck and keep the main round section.
3. Stretch the balloon over the open bottom of the bottle, so that it forms a tight 'skin'.
4. Secure the balloon to the sides of the bottle with sticky tape.
5. Light an incense stick.
6. Hold the open neck of the bottle directly above the burning incense stick until the bottle is full of smoke.
7. To make smoke rings, tap or poke the balloon skin with your fingers. Varying how hard you tap or poke will give different results.

WHAT'S HAPPENING

Tapping or poking the balloon skin exerts a force on the smoky air in the bottle, making a puff of smoke move out of the hole in the neck.

The smoke on the outside of the puff experiences more friction than the smoke in the middle, because it's in contact with the edges of the bottleneck, and the air outside the bottle, as it emerges. This results in the smoke on the outside moving slower, then it starts spinning as it's simultaneously dragged forwards by the faster smoke in the middle and pulled backwards by the frictional forces. The spinning smoke forms a doughnut shape, also known as a 'toroidal vortex'.

The smoke in the ring stays together because of the law of the conservation of angular momentum, which means that spinning objects tend to stay spinning unless an external force is applied. If the smoke wasn't spinning, it would disperse as smoke ordinarily does when it mixes with air. **AS**



DEAR DOCTOR...

DELICATE ISSUES DEALT WITH BY SCIENCE FOCUS EXPERTS

I LOVE THE TASTE OF CURRY, BUT I CAN'T STAND THE BURN. CAN I BUILD UP A TOLERANCE TO IT?

The heat in a curry comes from the capsaicin compound in chilli peppers. This causes the pain receptors in your mouth to release a molecule called PIP2, which creates a burning sensation, even though there's no actual tissue damage. Your genes control how tightly PIP2 is bound to the pain receptors, which in turn determines how sensitive you are to the spice, but repeated exposure to chilli will reduce the effect quite quickly. A 1991 study at Yale University found that daily exposure over six days was enough to significantly reduce the perceived burn. So it's possible to build up a tolerance, but even true 'chilli heads' will always feel the heat from a vindaloo – they just relish the extreme sensation. **LV**



I'M ADDICTED TO THE GYM, BUT I HAVE A COLD. CAN I STILL EXERCISE?



A good rule of thumb is the 'above-the-neck test', which says that if your cold symptoms are all in your head – such as a runny nose, sneezing or a sore throat – then it's safe to do some light to moderate exercise. Last year, health scientists at the University of Bath published a paper arguing that even vigorous exercise is okay, citing evidence that it can

boost immune system functioning. Take it slowly, though, and tone down your session if you're feeling weak or uncomfortable. And if you have below-the-neck symptoms such as a high temperature or chest congestion, it's best to rest up completely, as exercising will raise your temperature even higher and stress your body, leaving you feeling rotten. **HG**

I'VE BROKEN UP WITH MY EX. WHY IS LISTENING TO SAD SONGS MAKING ME FEEL BETTER?

You're far from alone. Surveys have shown that many of us like listening to sad music when we're feeling down. In fact, the tendency is strongest in people who are clinically depressed. It seems paradoxical – surely we'd be better off listening to jolly music – but when we're in a low mood, hearing a jingly track like Happy by Pharrell Williams can irritate us and accentuate our sense of isolation. In contrast, listening to sad music can help us to feel like we're not suffering alone. In research by the University of Limerick

published in 2013, people talked about sad music being like a friend and triggering a sense of shared suffering (after all, as REM put it, Everybody Hurts). The participants also mentioned how sad music could trigger memories of loved ones, often making them feel better. This year, a team at the University of Florida found that even clinically depressed people feel happier and calmer after listening to doleful ditties – which somewhat disproves the theory that depressed people listen to sad music in order to exaggerate or perpetuate their low mood. **CJ**

LAURIE WALKER, GUERNSEY

CAN ANYTHING BE DONE TO STOP CAR HEADLIGHTS BLINDING ME?

The glare from headlights causes accidents, and the problem is getting worse as bulbs get brighter. One way to cut out glare is with a polarising filter that only lets light through that travels in a single direction, cutting out all the other light waves wiggling in random directions. Back in the 1930s, the ingenious idea of using polarised headlights and a polarising filter in windscreens was suggested. Unfortunately, because of regulations, costs and the fact that polarising filters cut out too much light, the system was never introduced. Instead, the dimming rearview mirror was created, which can be flipped between a normal and dim reflection. Today, automatic dimming mirrors are available, as well as special polarised driving glasses, which both help to cut down glare. **PB**



Deep-sea invertebrates, like this sea cucumber, could be good candidates to live on Jupiter's moon Europa

ANDREW CIREL, CORSHAM

COULD WE GENETICALLY MODIFY AN ANIMAL SO THAT IT COULD LIVE UNAIDED ON ANOTHER PLANET OR MOON?

There may already be microbes on Earth that could survive on Mars. Bacteria from the Dead Sea and the Arctic tundra have been shown to survive in a simulated Martian atmosphere. Venus would be trickier, even in its cooler upper atmosphere, because this planet has no ice or water. Alien life might have its own completely different biochemistry, but we couldn't genetically engineer it, because DNA molecules themselves require water.

For more complex, multicellular life, the lack of atmospheric oxygen on Mars would probably rule out this planet. Earth organisms that don't need oxygen

are almost all single-celled because anaerobic metabolisms produce much less energy. But Jupiter's moon Europa has a liquid water ocean underneath its icy crust, and in 2009, researchers at the University of Arizona suggested that there might be oxygen too. How survivable this ocean is for Earth life will depend on what other toxins and nutrients are dissolved in it. Deep-sea fish and invertebrates would be good colonisation candidates, though, and genetic engineering might be useful to give them improved cold and pressure resistance. *LV*

SAMUEL MURPHY, NOTTINGHAM

WHAT PROPELS THE 'SAILING STONES' ACROSS THE CALIFORNIAN DESERT?



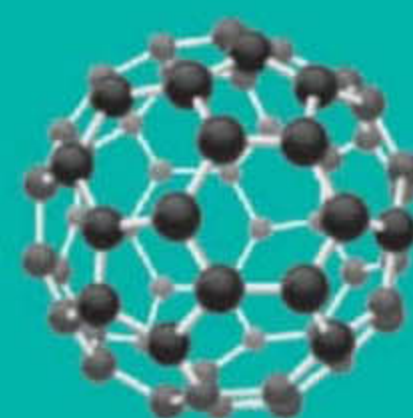
Reports of rocks apparently moving across dry lakebeds in Death Valley, California, have been circulating for over a century. With some 'sailing stones' weighing over 300kg and leaving trails hundreds of metres long, scientists have long struggled to find a plausible explanation. That changed in 2014, when researchers led by Richard Norris at Scripps Institution of Oceanography showed that during the winter, rain turns to ice on the lakebeds, which then cracks during the daytime, forming large panels. These sometimes catch the wind, lift up and start moving – shoving even large boulders ahead of them across the soft mud. But conditions must be just right: if the ice is too thick, it doesn't break into panels; too thin, and it can't shove the rocks. *RM*

WHAT CONNECTS

THE HUBBLE TELESCOPE AND CORNWALL?



1. The Hubble Space Telescope was used to detect the largest electrically-charged molecule found so far in the interstellar medium of deep space. The molecules form hollow spheres, called 'buckyballs'.



2. Buckyballs are a form of carbon, like diamond or graphite. Properly known as buckminsterfullerene, the molecule consists of 60 carbon atoms bonded together into a shape that resembles a geodesic sphere.



3. They are named after the American futurist and architect Robert Buckminster Fuller. In the 1940s he popularised the use of geodesic domes. These are enclosed structures, made up of triangular elements.



4. Geodesic domes are lightweight, strong, and enclose a large volume, making them the ideal design for the two huge greenhouses at Cornwall's iconic Eden Project, built in 2000.



TERESA HENDERSON, BLACKPOOL

IS IT POSSIBLE TO HATCH A CHICK FROM A SUPERMARKET EGG?

It's unlikely, but not impossible. Most commercial egg farms have strictly all-female flocks because male chickens aren't needed for egg production and aren't suitable for meat either (chickens raised for meat are a different breed). Without a rooster in the flock, the eggs will never be fertilised and can't develop

into a chicken embryo. With other poultry species though, such as quail or duck, the males and females aren't segregated so strictly, and ducks can also come into contact with wild males and mate with them. There have been a few reported cases of supermarket duck and quail eggs being successfully incubated. **LV**

EVERETT LOWENSTEIN, PORTLAND, USA

WHY IS IT BETTER TO STORE WINE HORIZONTALLY?

A horizontal bottle keeps the cork moist, so it doesn't dry out and shrink. At least that's the theory, but the science says otherwise. The air gap in a wine bottle has almost 100 per cent humidity, so the cork will never dry out as long as there is wine in the bottle. In 2005, the Australian Wine Research Institute tested this and found that the orientation of the bottle makes little difference to the wine's keeping qualities. **LV**



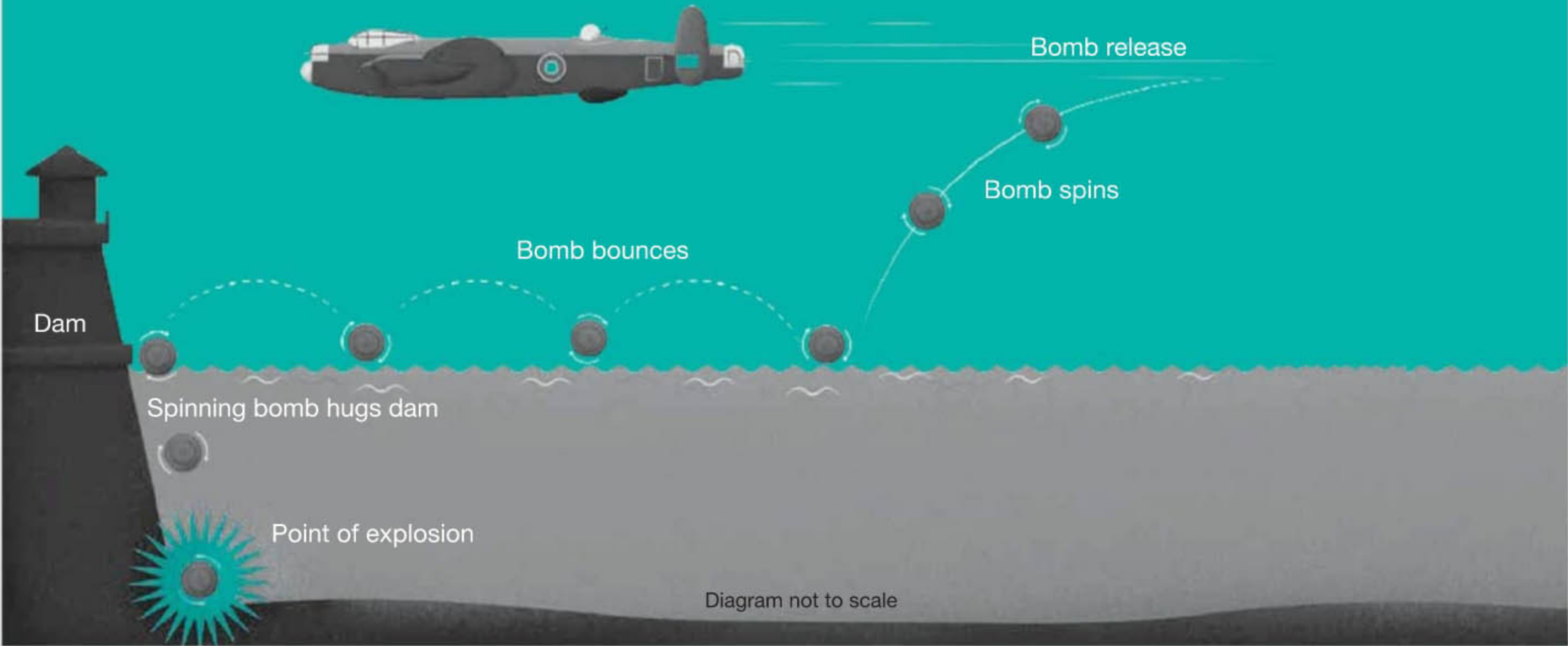
QUESTION OF THE MONTH

ABBEY-LEIGH THOMPSON, LEEDS

HOW DID THE BOUNCING BOMB WORK?

There's some nifty physics behind the dam-busting bombs that were used by the British in WWII. Just like skipping stones, to make a bomb bounce off water you need to have enough speed and a perfect angle (about 7° in the case of the bomb). If you get these just right, conservation of momentum means that the water pushes back on the bomb and kicks it up in the air. For multiple bounces, the magic ingredient is spin. Spin the bomb and you

stabilise its motion, like a frisbee or a gyroscope. The designers of the bouncing bomb made use of these principles, with the aim of saving the British bombers the tricky task of hitting a German dam bang on target. The cylindrical bombs were spun on launch, making them bounce several times, and as the bombs completed their final bounce, the spin even made them sink in a curved trajectory towards the dam. **PB**



GETTY IMAGES X3, FLPA ILLUSTRATIONS: DAN BRIGHT



ANNA DACA (LEICESTER) AND CALVIN TOMSIC (EVERETT, WASHINGTON, USA)

WHY DO CLOTHES GET DARKER WHEN WET?

As water is transparent, it seems odd that it makes clothes look darker. After all, it doesn't have that effect on, say, a hard plastic surface. Surprisingly, the science behind the phenomenon was only fully investigated around 30 years ago. Physicists John Lekner and Michael Dorf at the Victoria University of Wellington, New Zealand, showed that the darkening effect is the result of fabric being both rough and absorbent. When light strikes any surface, some of it is reflected back into our eyes. But damp clothes have a thin layer of water on their surface (held in place by the material's roughness), which leads to more of the reflected light rays being bent – 'refracted' – off-course. Some of the light also gets reflected back into the film of water, or scattered off the tiny water-filled holes in the fabric. The combined effect is a reduction in the amount of light reaching our eyes, which makes the fabric look darker. **RM**

FATIMA, MANCHESTER

WHY IS THE MOON SOMETIMES VISIBLE DURING THE DAY?

In fact, the Moon is visible in daylight almost every day. The Earth's daily revolution on its axis means that the Moon is actually above the horizon for about 12 hours out of every 24. Usually, some portion of that time will be during daylight – you just need to look carefully, because its brightness is so much less than the Sun's. The only times you won't be able to see it during the day are near a new Moon, when it is positioned too close to the Sun in the sky to be seen, and near a full Moon, when it rises at sunset and sets at sunrise, so is only visible during the hours of darkness. **AGu**

40

The percentage by which giraffe numbers have fallen in Africa over the last 30 years. In response to this, the animals and their body parts are now regulated under the Convention on International Trade in Endangered Species (CITES).

NATURE'S WEIRDEST CREATURES...

THE PINK FAIRY ARMADILLO

The pink fairy armadillo is mostly an apt name. After all, this is a species that spends most of its time in a subterranean neverland and whose pink armour, sitting atop silky white fur, gives it an almost magical charm. However, it also has some rather unfairy-like qualities. Fairies, for instance, do not have robust digging claws. And fairies do not use their enormous bottoms to firm up the soil as they dig to strengthen the walls of their tunnels.

This species of armadillo is found only in the deserts and scrublands of central Argentina. To limit the likelihood of heat exhaustion during the warm season, it

uses its leathery shell as a cooling aid. By pumping this thin layer of armour with blood, the pink fairy armadillo can flush away heat from its body's core. This is an organism that doesn't spare its blushes. It depends upon them for survival.

Like all fairies, the pink armadillo is hard to see. The only time these animals surface is when heavy rain forces them out of their burrows, often into the mouths of introduced predators such as domestic cats and dogs. The species is likely to be declining in the wild, so this is one fairy that's in need of a godmother. **JH**



RECOMMENDED

FIND OUT WHAT'S CAUGHT OUR ATTENTION THIS MONTH



WHAT I'M READING

Amy Barrett
EDITORIAL ASSISTANT

ANATOMICUM

CURATED BY KATY WIEDEMANN AND
JENNIFER Z PAXTON



This is a museum quite unlike any other. The incredible world of the human body is displayed in print across six 'galleries'.

A favourite page of mine shows the bust of a woman with a diamond-shaped section of

skin cut away from her abdomen, revealing the wonder of the urinary system underneath. The Cardiovascular and Respiratory Systems gallery features a detailed dissection of the heart, where I can identify the valves, open and closed. The lub-dub, lub-dub of each heartbeat is almost echoed in the turning of the large, thick pages.

This is a book I would be proud to put on my coffee table. I can imagine inviting guests to sit, step inside the Anatomicum and choose their favourite image after much consideration. Just be careful – no food or drink near the museum, please.



WHAT I'M PLAYING

Daniel Bennett
EDITOR

TELLING LIES

AVAILABLE VIA STEAM, ON MAC & PC



If you love a whodunnit, try out a game called Her Story. It's not a traditional video game. You don't shoot anyone, smash anything up or jump on any turtles, instead, Her Story mimics an old police computer that you search through to investigate a cold case. You use search terms, like 'murder' to dig up old interrogation footage of live actors and piece together a story told out of order. The trick is to identify what's important, and what's not, and use your guile to recreate the timeline of events. The beauty of this formula is that every player enjoys a different experience.

In Telling Lies, Her Story's creator Sam Barlow expands on this format, replacing the police computer with an NSA database that the player uses to spy on four characters embroiled in a deadly incident. This time, the game has bigger scope, recognisable actors and more drama. It's a thrilling experiment in story-telling that pays off and invites you back even after you've finished the game. I can't wait to see what Barlow does next.



WHERE I'M VISITING

Sara Rigby
ONLINE ASSISTANT

THE ART OF INNOVATION: FROM ENLIGHTENMENT TO DARK MATTER

SCIENCE MUSEUM, LONDON

We tend to think of science and art as polar opposites, but that certainly hasn't always been the case. Arguably, they share a common goal: understanding our place in the Universe.

The Art Of Innovation exhibition at London's Science Museum is an exploration of how the two fields have developed over the last 250 years: how is scientific discovery represented in art, and how has art driven scientific exploration? The exhibition features the work of artists such as Barbara Hepworth and David Hockney alongside objects of scientific discovery.





While experts usually encourage us to avoid blue light at bedtime, Dodow claims that its light is too dim to disrupt sleep



The painting Coalbrookdale By Night symbolises the start of the Industrial Revolution, and is currently on display at the Science Museum



WHAT I'M TESTING

Alice
Lipscombe-Southwell
PRODUCTION EDITOR

DODOW

Do you often lie in bed, staring at the ceiling, desperately trying to nod off? Or do you wake up at 3am with your mind racing at a million miles an hour? Dodow promises to get your sleeping back on track by encouraging deep breathing techniques to help you unwind. The discreet, wireless device sits on your bedside table and with a tap of your finger it projects a gentle beam of blue light that contracts and expands for eight minutes. The idea is that you breathe in rhythm with the light: inhaling on the expansion; exhaling on the contraction. Dodow claims that this gradually slows your breathing to six breaths per minute, therefore putting you in a relaxed state, while fixating

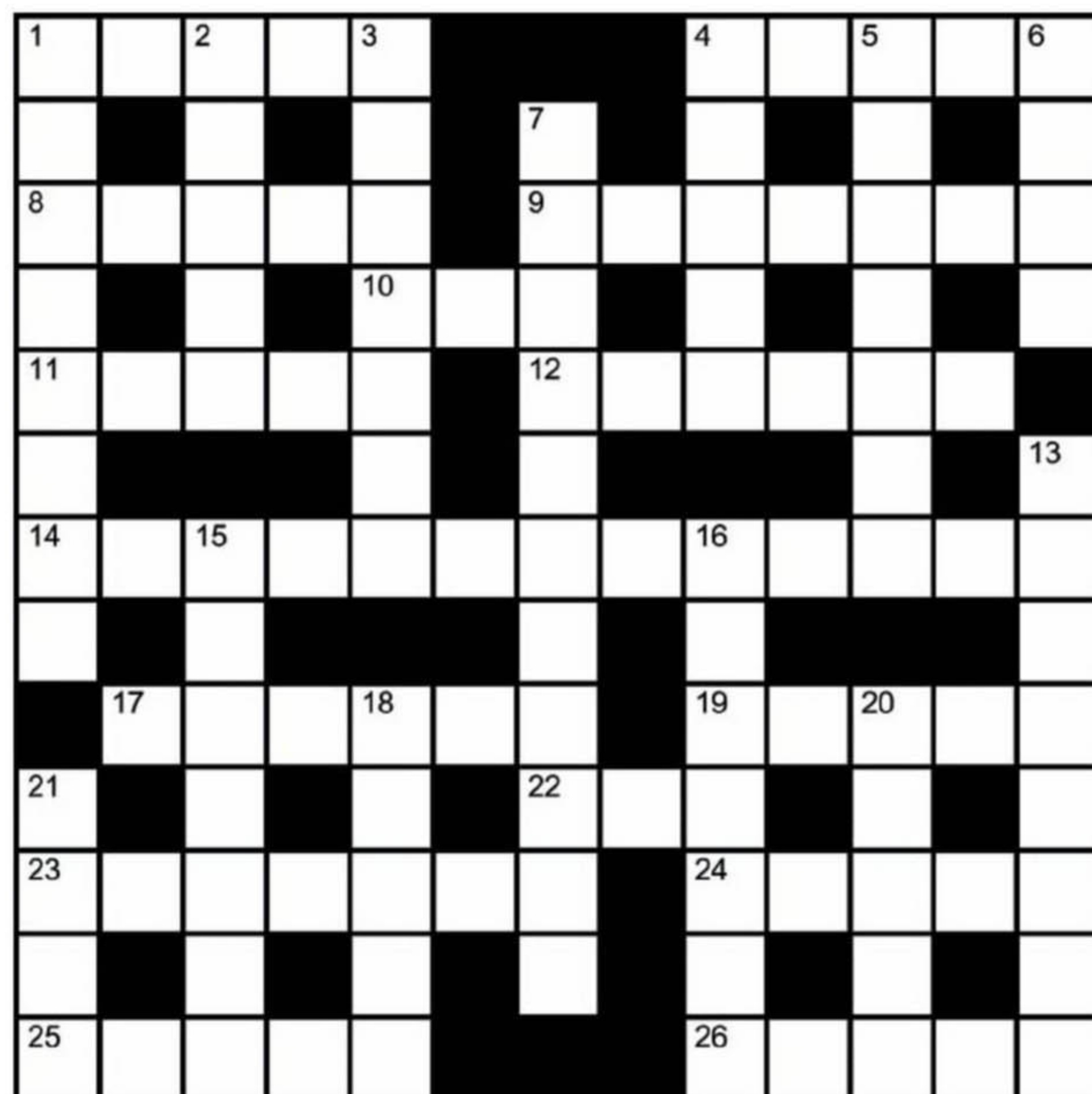


on the hypnotic blue light helps to calm any mental chatter. But does it work? After waking up in the all-too-familiar early hours, I turned the Dodow on. As promised, it helped me chill out, but I was still lying awake two hours later.

Still, it comes with a 100-day money-back guarantee if you aren't satisfied, so perhaps it's worth a try if the lavender baths and mugs of warm milk just aren't cutting it.

CROSSWORD PUZZLE

GIVE YOUR BRAIN A WORKOUT



ACROSS

- 1 Attracted to get registered in the morning (5)
- 4 Reported location for one of the senses (5)
- 8 Sign fluctuates without starting (5)
- 9 Almost like a horse and a bull for a day in March (7)
- 10 Element from continent's heart (3)
- 11 Animal less cold in the East End (5)
- 12 Ship wasted energy in some water (6)
- 14 Claimed my sets used were in base ten (7,6)
- 17 Aim: move around – rule country (6)
- 19 Thing got broken in darkness (5)
- 22 Choke on a joke (3)
- 23 Crib transformed with time into vital frame (3,4)
- 24 Cat flap nearby (5)
- 25 Courage to get a transmitter (5)
- 26 It happened in the Seventies (5)

DOWN

- 1 Maid nods about suit (8)
- 2 Advertisers initially lean on top celebrities (1-4)
- 3 Negative way with strange patent medicine (7)
- 4 Ability, swapping one with universal bone (5)
- 5 Libertine captures a French and British naval ship (7)
- 6 Cricket team volunteers first to get transport (4)
- 7 Boy and girl row about girl's first cat (6,5)
- 13 Teams played with your old stone (8)
- 15 Cleaner accepts award, showing a bit of heart (7)
- 16 Get any excursion around unknown river (7)
- 18 Agricultural leader donated a tropical plant (5)
- 20 Part of wall bolstered top in storm (5)
- 21 Bishop managed to get some roughage (4)

ANSWERS

Solution to crossword in the previous issue



A SCIENTIST'S GUIDE TO LIFE

PRIDE AND SHINE

IN THE MORNING, DO YOU CRAVE A BIG FRY-UP, OR PREFER TO JUST RUN OUT OF THE DOOR? WE GET THE COFFEE BREWING AND TALK ABOUT BREAKFAST WITH NUTRITIONIST **LEONIE RUDDICK-COLLINS**



IS BREAKFAST REALLY THE MOST IMPORTANT MEAL OF THE DAY?

Despite the media hype, the benefits are not as obvious as you might think. There's no clear-cut link, for example, between breakfast and body weight, blood pressure or cholesterol. That said, studies have shown that having breakfast can help concentration and memory, and it also plays a key role in blood glucose regulation.

IS IT POSSIBLE TO HAVE A HEALTHY FRY-UP?

Absolutely. It's about how you cook it. Use a healthy oil, or grill it, and don't go overboard on portion size. A bit of bacon every now and then is fine, just remove as much fat as you can. Baked beans are fantastic in the morning, so are eggs, mushrooms and tomatoes.

WHAT CEREAL SHOULD I PICK?

Many breakfast cereals are laden with sugar. For some, sugar makes up more than a third of the total content. Look carefully at the labels. A low-sugar product contains less than 5g of sugar per 100g. Go for low-sugar, fibre-filled cereals, like Weetabix, oats and bran flakes. Be aware that although it's healthy, muesli is calorie-dense, so watch the portion size. Have a small bowlful with yoghurt, to help you get the right balance of fibre, iron and calcium.

TEA OR JUICE?

Go easy on the fruit juice. Many juices contain the same amount of sugar as cola, but we don't realise this. My advice is to go for tea and a piece of fruit, like an orange.

IS IT TRUE THAT BREAKFAST KICK-STARTS YOUR METABOLISM?

People cite this as a reason why we should eat breakfast but it's not exactly true. Metabolism increases naturally when you get up in the morning and after you eat any meal. It doesn't have to be breakfast.

SHOULD I BREAKFAST LIKE A KING AND DINE LIKE A PAUPER, AS THE OLD ADAGE GOES?

The typical UK style of eating is to consume 48 per cent of your calories at dinner, and just 16 per cent at breakfast, but studies suggest that if we eat more in the morning, and less later in the day, it can help with weight loss. This makes sense because the body is primed to eat early in the morning to give us energy to get through the day. In the evening, the body prepares itself for an overnight fast. It breaks down its stored energy, like fat and glucose, to use as fuel while we sleep. Late eating may interfere with this process. So, if you're trying to lose weight, maybe a bigger breakfast is the way to go.

IS SKIPPING BREAKFAST BAD FOR YOU?

It's not great. Skipping breakfast has been linked to an increased risk of type 2 diabetes. This could be because breakfast skippers tend to eat more later in the day when our bodies are more glucose intolerant.

Also, compared with breakfast eaters, people who skip breakfast tend to be lacking in key nutrients, such as fibre, iron and calcium. These are the sorts of things that are frequently found in breakfast foods, so the morning meal is an ideal opportunity to stock up on them. 🍌

NEED TO KNOW...

1

Read the labels of cereals, and check portion sizes.

2

If you love a fry-up, use healthy oils and fill up on tomatoes, baked beans, mushrooms and eggs.

3

Your mum was right – it's good to breakfast like a king.

DR LEONIE RUDDICK-COLLINS

Leonie is a nutrition researcher at the Rowett Institute in Aberdeen.

Interviewed by Dr Helen Pilcher.

ILLUSTRATION: THOMAS HEDGER

GUT FEELINGS

Listen carefully, the gurgles of a grumbling belly could be a cry for help

One of my medical heroes is Prof Barry Marshall of the University of Western Australia. We met in the 1990s when I made a documentary about him and his colleague, Robin Warren. I created the film, *Ulcer Wars*, because they had a great story to tell: they had identified and grown a species of bacteria they called *Helicobacter pylori* and had become convinced that it was responsible for the majority of cases of gastric cancer and gastric ulcers.

As a film-maker, it appealed to me that in the 1980s Barry had drunk from a beaker containing *H. pylori*. He became ill and a biopsy of his gut revealed that the *H. pylori* had indeed begun colonising his stomach lining and the upper part of his small intestine, causing inflammation, or gastritis. He took antibiotics, his symptoms improved and biopsies confirmed the *H. pylori* had gone.

When I made *Ulcer Wars* there was widespread scepticism about their claims about *H. pylori*. That changed when the pair won the Nobel Prize in Physiology or Medicine in 2005. It was thanks to Barry's example that I embraced my policy of on-screen self-experimentation.

I caught up with Barry recently and he showed me his latest project, which may again change our understanding of a common gut problem. His team is investigating irritable bowel syndrome (IBS). IBS is incredibly common, affecting about 10 per cent of the world's population. Symptoms include pain, bloating, diarrhoea and constipation. There is no simple, reliable test and many people either go undiagnosed or are dismissed as overly anxious.

"We're using sensing technology originally created to track the munching sounds of termites"

So there is a lot of interest in a test that Barry's team is developing. It uses a belt that is strapped to a patient's stomach, encasing a small, sensitive microphone. The research is called the Noisy Guts Project.

"We wanted to find a way to listen to the rumblings and grumbings of the gut, to identify patterns that characterise chronic gut conditions like IBS," Barry says. "We're using

acoustic sensing technology that was originally created to track the munching sounds of termites."

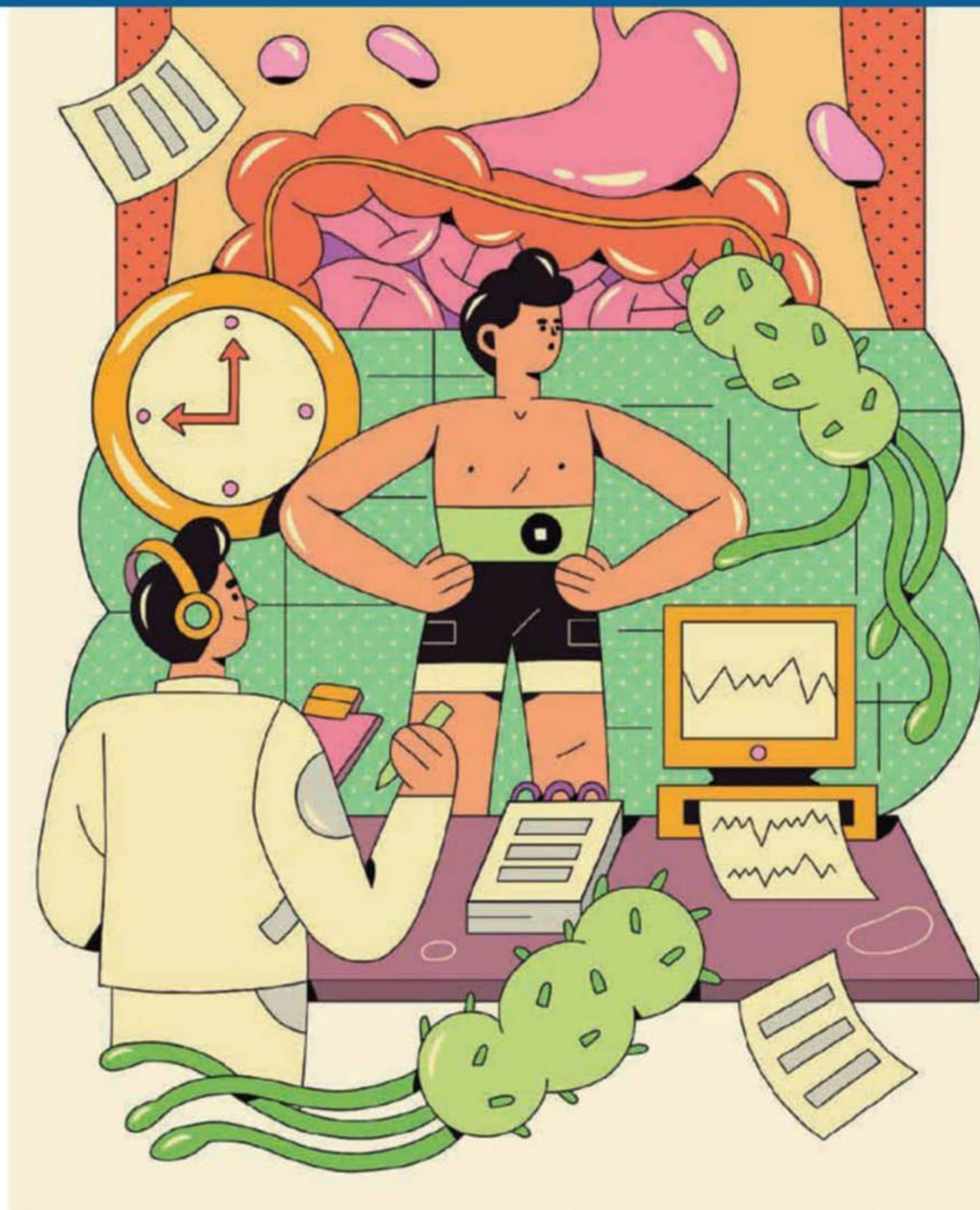
They recruited volunteers, some with a diagnosis of IBS, others with healthy digestive systems, and asked them to wear the belt and have their gut sounds recorded for two hours post-fasting, and then for 40 minutes after a standardised meal.

Their gut sounds were uploaded into a computer that used machine-learning to identify differences between healthy and unhealthy guts. They then tested their system on a similar range of people, this time mixed up so the researchers didn't know their medical histories. The system worked well, accurately detecting IBS 87 per cent of the time, with few false positives. The team is now testing the system with large numbers of patients before bringing it to market. 🌐



MICHAEL MOSLEY

Michael is a writer and broadcaster, who presents *Trust Me, I'm A Doctor*. His latest book is *The Fast 800*



*Asia Pacific's ultra luxury magazine with a focus
on private jet aviation and the bespoke lifestyle*

LIFE BEYOND FIRST CLASS

JETGALA

ISSUE 43 / NOVEMBER - DECEMBER 2019



**LEXUS
LUXURY**

Launch of the
new LY 650

**BOMBARDIER
DNA**

Expanding the
Global jet family

**SKY
TAXIS**

VoloPort's Singapore
debut

www.jetgala.com



Jetgala Magazine



@Jetgala

EARTH'S TROPICAL ISLANDS

Premieres Monday 30th March at 8:05pm

BBC
earth

www.bbcasia.com

[f /bbcearth](https://www.facebook.com/bbcearth)

[t @BBCEarthAsia](https://twitter.com/BBCEarthAsia)

BBC Earth is available in Hong Kong, Indonesia, Laos, Malaysia, Mongolia, Myanmar, Philippines, Singapore, South Korea, Taiwan, Thailand and Vietnam. Please call your cable operator for more details or check out our website at www.bbcasia.com

Also available on

BBC iPlayer



www.bbc.com/earth

Available on the
App Store

Available on
Google Play