

INTERVIEW
**LIZ BONNIN TALKS BIG CATS
AND PLASTIC POLLUTION**

FOCUS ON
**THE NEXT GENERATION
OF CANCER VACCINES**

NEUROSCIENCE
**THE STRANGENESS OF
'UNCONSCIOUS VISION'**

THE **Biologist**

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FROM EVIDENCE TO ART

How palaeoartists bring the ancient world to life

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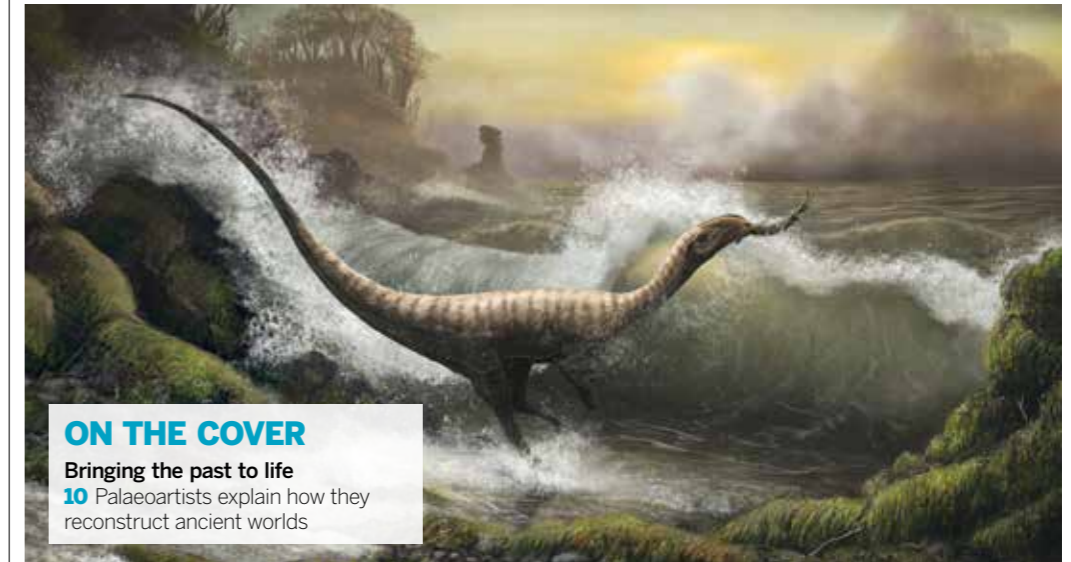
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Cover image: *Balaia bondoc* by Emily Willoughby

David Lindsay: Atlantic Productions (Liz Bonnin), Sarcosaurus by Mark Witton

CONTENTS

 Volume 65 No 4 August/September 2018

ON THE COVER

Bringing the past to life
10 Palaeoartists explain how they reconstruct ancient worlds



16

UP FRONT

04 Society News

Parliamentary Links Day; RSB chief executive honoured; Biology Week 2018

06 Policy, analysis and opinion

The influence of scientific instrument makers, and new thinking on science investment

FEATURES

16 Interview

Liz Bonnin on big cats, biochemistry and taking responsibility for our planet

20 Out of sight

The patient who could grasp what she couldn't see and how it helped us understand how vision works

24 By degrees

David Coates on accrediting courses in the biosciences

REGULARS

26 Focus on...

Therapeutic cancer vaccines – are they finally showing promise?

30 Members

Meet RSB members on the lake and in the lab; plus membership training and events

34 Book reviews

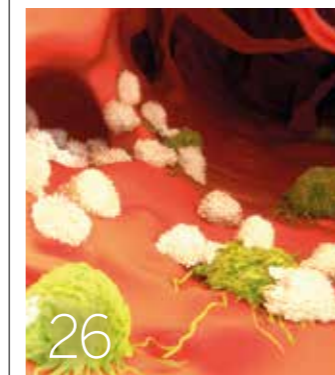
40 Regional grant reports

42 Branches

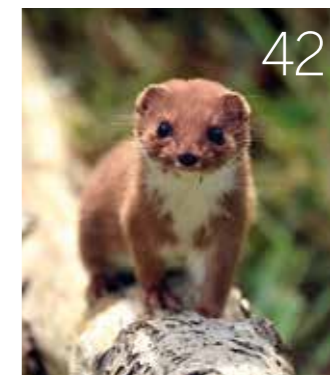
47 Crossword

48 Museum piece

Objects built by nature at the Leeds City Museum



26



42



48



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Palaeoartists bring the past to life

I'm writing this editorial at 37,000 feet en route to New York, celebrating my 50th birthday in style with my oldest friend. Fifty! How did that happen? It's all relative, of course: we humans are but a nail filing on the outstretched arm of life, so reading about palaeoart (page 10) has cheered me up somewhat. What cool jobs our featured palaeoartists have, bringing ancient life to art – an increasingly data-led venture that sparks collaboration between artist and scientist, blurring the distinctions in order to celebrate and represent some of the billions of life forms that had their day in the sun millions of years ago.

Now back to the present day and more worries about our capacity to destroy our wonderful planet in the incredibly short time we have inhabited it. Wildlife and science broadcaster Liz Bonnin is our interviewee (page 16) and her new BBC film is about plastic pollution. Bonnin thinks a call to arms is needed – not so much targeted at individuals making small-scale changes, such as using cardboard straws, but focused on governments driving step-change across societies. No time to waste? No time *for* waste! Away from the gloom and doom, be inspired by Bonnin's fascinating career journey (she used to present *Top of the Pops!*) and see if you agree with her refreshingly honest views about zoos.

Now here's a weird story. Regaining consciousness after being poisoned by carbon monoxide about 30 years ago, a woman known as 'patient DF' discovered she couldn't see. As her sight returned over the next few days, she regained the ability to perceive colour and texture, but not shape or form. She knew a pencil was yellow, but couldn't describe its orientation when it was held in front of her. But although she couldn't describe its orientation, she had no trouble orienting her grasp to pick it up. Basically, she could act on visual information that she couldn't perceive. Taken together with DF's brain scans, the case led neuroscientists Melvyn Goodale and David Milner (writing on page 20) to propose that there are two visual streams operating quite separately in the brain, one to control visual perception and the other for visual control of our actions. Modern functional MRI studies have been able to shed even more light on how these parallel visual streams interact in order to maximise the visual awareness that most of us take for granted every second of every day.

In this issue, we also look at the exciting developments in cancer vaccines (page 26) and, finally – look at that BioPic – have you ever seen anything like it? This extraordinary photo, sent in by a reader, attracted thousands of shares on Twitter and ended up being featured on *Springwatch*. All power to the readership – please keep your pictures and article ideas coming!



The scientists proposed that there are two visual streams operating quite separately in the brain, one to control visual perception and the other for visual control of our actions

Al Woollard

Alison Woollard FRSB
Chair, Editorial Board of
The Biologist



BioPic

COOT DROWNING
A BUZZARD
By Naomi Portnoy

This extraordinary picture was sent in by member Alexander Waller, whose friend Naomi Portnoy photographed a coot drowning a buzzard while she was walking in woodland in Alblasserwaard, the Netherlands. The image amazed ornithologists from around the world when posted by *The Biologist's* editor, Tom Ireland, on Twitter and was discussed on the BBC's *Springwatch* programme soon after.

Portnoy reports that the buzzard had been attacking the coot's young before it was forced backwards into the water by the coot. "The buzzard was waterlogged quite quickly, and the coot made sure it drowned completely – and even when it was, the coot stood on it and continued pecking for some time," she writes. "It was very violent and moving in many ways, including the sound of the buzzard drowning."

RSB

More than 500 degrees given RSB accreditation

Over the last year 17 more institutions' degree programmes have been recognised by the Society's accreditation scheme, taking the total number of degrees accredited by the Society to more than 500.

A parliamentary reception celebrating the latest cohort of accredited institutions took place in April, with academics, industry representatives and bioscience students invited to attend.

The RSB Accreditation programme champions excellence in the biosciences, not only recognising degree programmes that offer a high standard of teaching and practical skill development, but also those that enhance graduate employability.

Almost 300 programmes across 38 UK institutions have now received Accreditation, and more than 200 programmes at 23 UK institutions have been awarded Advanced Accreditation.

See page p24 for David Coates' article on the need for accreditation in the biosciences.



Dame Jean Thomas and dignitaries celebrate with representatives from accredited institutions

EVENTS

Standing room only as scientists gather for 30th Parliamentary Links Day



Packed house for annual event

Prime Minister Theresa May sent a message of thanks to the RSB and the wider scientific community as part of the 30th Parliamentary Links Day.

The annual meeting of scientists and MPs is the largest science event in the parliamentary events calendar. Organised by the Society, the event allows hundreds of scientists and representatives from the science and engineering community to engage with MPs, peers and policymakers in the Houses of Parliament.

This year appeared to be the most well-attended Links Day on record, with Speaker of the House of Commons John Bercow commenting that he had "never seen so many people" in the parliamentary conference room.

Keynote speakers included Claire Perry,

Minister for Business, Energy and Industrial Strategy; Dr Patrick Vallance, the Government's chief scientific adviser; and Rebecca Endean, UKRI's director of strategy. Two panel discussions, chaired by the BBC's science correspondent Pallab Ghosh, focused on the Government's Industrial Strategy and how its ambitious aims could be achieved.

The next Parliamentary Links Day will be on Tuesday 25th June 2019.

A more detailed report from the event can be found at bit.ly/RSB_LINKS

AWARDS

Society's chief executive wins national award



RSB chief executive Mark Downs FRSB has been recognised for outstanding leadership and the lasting and positive

impact of his work during nine years at the helm of the Society.

Downs won the Louis Armstrong Leadership Award, which recognises outstanding performance and impact, at the Memcom Awards, which celebrates the work of membership organisations.

Chief executive of the RSB since its formation in 2009, Downs has overseen the growth of individual membership to more than 18,000, a doubling of annual turnover, and the Society's receipt of its Royal title in 2015. Since 2009, the RSB has also submitted more than 100 policy positions to Government and others, accredited more than 500 educational programmes across more than 50 higher education institutions, and reached nearly 500,000 pupils and many more members of the public through its competitions and outreach activities.

Lucy Coia, membership and marketing officer for the RSB, was also shortlisted for a Memcom award for her work in supporting the Society's membership.

AWARDS

Bioscience and RSB membership recognised in latest Queen's honours list

A number of RSB Members and Fellows have been recognised in this year's Queen's birthday honours list, including one of the Society's trustees.

Professor Julia Buckingham FRSB, a founding trustee of the RSB, was made

In case you missed it...

The editor's pick of biology stories being shared online

IRISH 'GIANT' COULD BE BURIED AFTER 200 YEARS ON DISPLAY

The Hunterian Museum in London has said it may release the skeleton of Charles Byrne, which has been displayed for more than two centuries against his final wishes. Byrne, who suffered from gigantism and reached 7 feet 7 inches tall, asked friends to ensure he was buried at sea to prevent his remains being sold to the medical establishment, but his skeleton was acquired by surgeon and anatomist John Hunter, and has stood as a centrepiece in the museum for more than 200 years. The museum, which is closing for refurbishment until 2021, said its board of trustees will now consider allowing the remains to be given a respectful burial during the closure.

THE GUARDIAN

bit.ly/Irishgiant

FAMED SIGNING GORILLA, KOKO, DIES AT 46



Koko with animal psychologist Francine Patterson

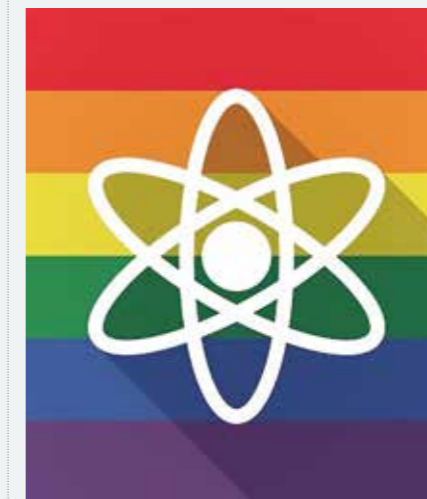
Koko, a western lowland gorilla known for her ability to communicate in sign language, has died at the Gorilla Foundation in California aged 46. Koko helped scientists make new discoveries about animal sentience and communication and, according to The Gorilla Foundation, had a

vocabulary of more than 1,000 signs and the ability to understand 2,000 words of spoken English. Koko's apparent ability to hold conversations with humans, and care for cats, made her the subject of numerous documentaries, although some scientists have raised doubts about some of the claims of her communication abilities.

NATIONAL GEOGRAPHIC

bit.ly/Koko-dies

5TH JULY BECOMES LGBT IN STEM DAY



This July saw the first international LGBT+ STEM day to recognise the contribution of LGBT scientists and increase awareness of issues they face. Under the hashtag #LGBTSTEMday, scientists from around the world shared their experiences online and celebrated diversity in science with rainbow-themed scientific images.

A blogpost on the day by the RSB's science policy officer Alessandro Coatti can be found at bit.ly/LGBTinSTEM

THE BIOLOGIST'S COOT PICTURE SPARKS TWITTER DEBATE

Ornithologists and bird-watchers from around the world have shared and commented on the stunning image of a buzzard being drowned by a coot, featured on page 3 of this issue. The coot's aggressiveness surprised many on Twitter and attracted hundreds of comments, including from Steve Dudley, editor of *IBIS* (the International Journal



Charles Byrne's skeleton on display at The Hunterian Museum

of Avian Science), who wrote: "Wow. I have heard of coots being aggressive, but personally have never heard of them drowning something as large as a buzzard." Another Twitter user called the image "unforgettably haunting".

VIA @TOM_J_IRELAND

bit.ly/CoottoBuzzard

SCIENTISTS REACH UNDISTURBED RAINFOREST IN AFRICAN VOLCANO

A team of international scientists have found a 'wealth' of new species after scaling Mozambique's Mount Lico to reach what is thought to be Africa's only known undisturbed rainforest. Professor Julian Bayliss used satellite technology to find the hidden forest, and a team of biologists were supported by free climbers in order to scale the volcano's sheer 125m side to reach the lush vegetation at the top. Pictures published online by *The Guardian* show a range of unusual caterpillars and other animals discovered in the area.

THE GUARDIAN

bit.ly/MountLico

Hiding in plain sight

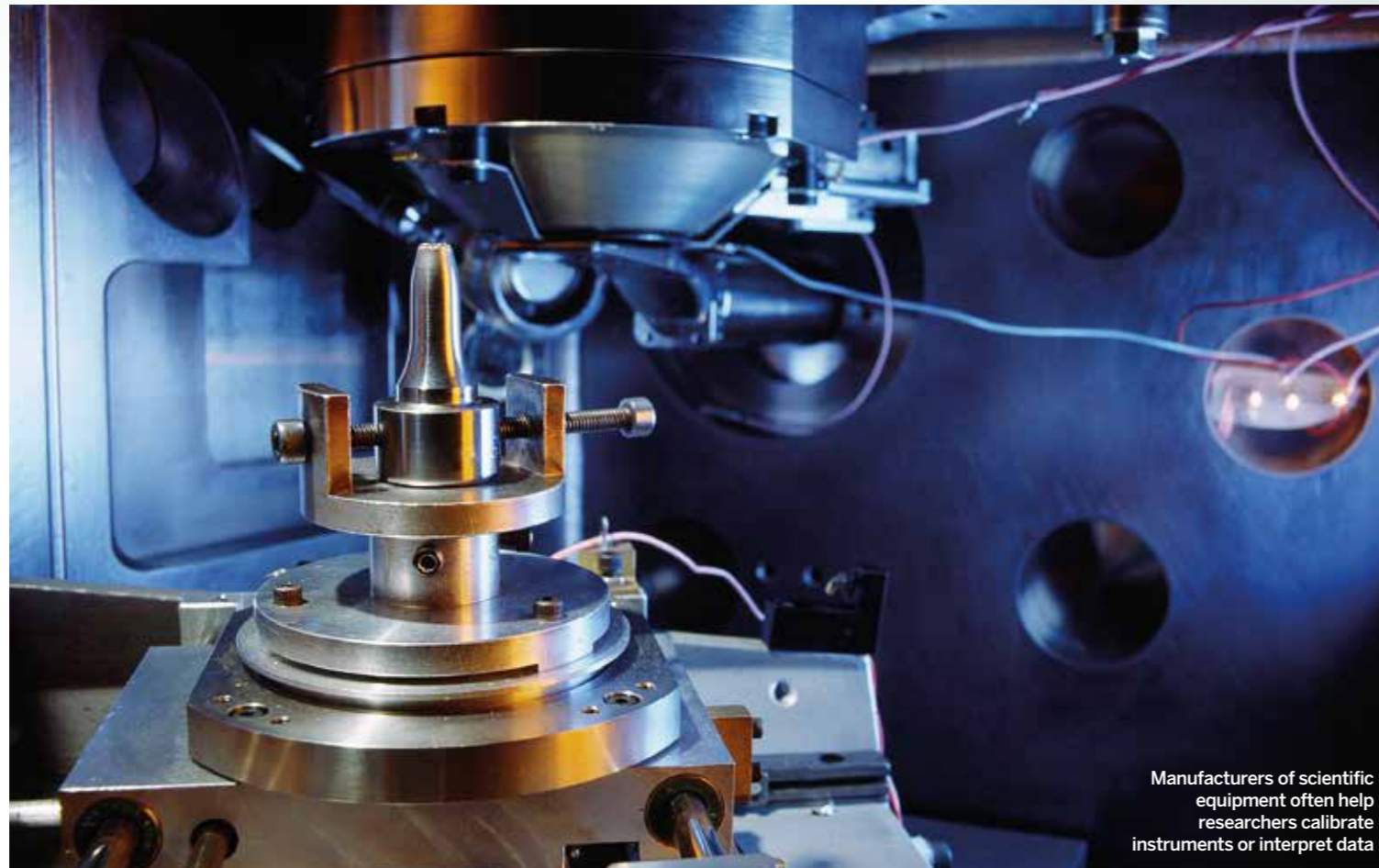
There must be more transparency and openness in research aided by scientific instrument makers, write Carsten Bergenholtz, Inge Seim and Sam MacAulay

Within academia and industry, scientific instruments are at the core of daily research activities. In recent years, various policies have been implemented to try to improve the reliability, reproducibility and transparency of scientific research, and to counter biases and the non-disclosure of important information in the pharmaceutical industry. But do we pay similar attention to the instruments upon which life science research is so often based?

The name of scientific instruments, and where they can be obtained, is traditionally mentioned in the 'materials and methods' sections of scientific articles. Having a product mentioned in a manuscript is not only useful information for researchers, but valuable marketing for the firms that manufacture the instruments.¹ To explore the relationship between academic researchers and the scientific instruments industry, we surveyed academic researchers in diverse fields in the US and EU to gain insights into how scientific instruments are perceived in published materials.

We found that academics discount the importance and reliability of information on instruments in papers co-authored by employees of scientific instrument firms, even when the firm's instrument was not mentioned in a manuscript.² The differences were substantial and significant: academics do not merely distrust biomedical companies, as previous research has established, but also seem to be sceptical of research involving commercial instrument firms.

This result helps explain the reported behaviour of instrument



Manufacturers of scientific equipment often help researchers calibrate instruments or interpret data

firms, some of which circumvent this perceived reduced credibility by not allowing employees to be listed as co-authors, even when they contributed significantly to published work.¹ What we see emerging is a pattern of incentives likely to encourage the non-disclosure of contributions being made by instrument firms.

We have seen at least one commercial producer of transgenic mice offering researchers monetary rewards for citations in scientific articles,³ and scientific instrument firms promising significant discounts on instrument reagents in exchange for 'excessive usage' of an instrument name in scientific articles (CB and IS, personal observation). Imagine a scenario where a researcher receives a 40% discount on an instrument, as well as substantial help with instrument calibration and data interpretation. The researcher intends to publish

We urge journals to adjust their guidelines

Reference
 1) Bergenholtz, C. *Eur. Manag. Rev.* 11, 159–171 (2014).
 2) Bergenholtz, C. *et al.* *EMBO Reports* 19 (6) (2018).
 3) Goldacre, B. 'So this company Cyagen is paying authors for citations in academic papers'. *Badscience.net* (2015, accessed 21 May 2018).
 4) Bergenholtz, C. *et al.* A survey on information sources used by academic researchers to evaluate scientific instruments. <https://bit.ly/2lWlQ1T>

the study in a journal with high esteem in your field, and the manufacturer will cite the paper on its website for marketing purposes. Are these scenarios acceptable? Should the financial benefit or the firm's involvement in generating and interpreting the data be disclosed? Should the firm's employees be acknowledged as co-authors on the publication?

An informal analysis of the guidelines of 20 top journals in the natural sciences shows that such information is not required to be disclosed.⁴ Since being affiliated with an instrument firm seems to influence how fellow academic researchers value the manuscript, the academic and the instrument maker have a shared incentive against disclosing such pertinent facts.

Editorial guidelines in peer-reviewed journals have helped tackle the non-disclosure challenge in other industries (in particular in medical

and biopharmaceutical devices), and we argue it is time for similar public debate on how and when researchers should disclose the involvement of instrument firms in science.

References to instruments in papers are clearly valuable marketing materials for firms, and journal guidelines should take this into account. If one receives a discount, this needs to be disclosed. If an industry-based scientist or technician has contributed to the use of the instrument, this should also be communicated.

Not only is non-disclosure against the ethos of reliability, reproducibility and transparency in science, it also constitutes a hidden barrier to market entry for smaller scientific instruments firms. Thus, we urge journals to adjust their guidelines, academics and their societies to proactively disclose information about assistance, and readers to demand transparency.

UPFRONT



Kelly Thomas, Primary Science Teacher of the Year



Dr Richard Spencer, Secondary School Biology Teacher of the Year

► CBE in recognition of her service to biology and education.

Professor Susan Hill FRSB, chief scientific officer of NHS England, was made a Dame in recognition of her broad work, which includes the ground-breaking 100,000 Genome Project, and Professor Louise Heathwaite FRSB from Lancaster University received a CBE for services to scientific research and scientific advice to government.

Professor Stuart Reid FRSB, principal at the Royal Veterinary College, received a CBE for services to the veterinary profession and higher education, while affiliate member Fiona Hightet was awarded an MBE in recognition of her work on bee health.

staff and volunteers from the RSB attended the Isle of Wight's Hullabaloo Festival (pictured) in May and the North London street party CallyFest in June. The RSB's 'Biology Big Top' brings life science organisations together at festivals to ensure the biosciences are well represented at public events.

AWARDS

Teachers and students awarded for excellence

Outstanding school pupils and teachers were recognised for their success at this year's RSB Education Awards Ceremony in London. The ceremony saw school students from the UK and abroad receive certificates and medals for their achievements in the Society's various biology competitions.

The Secondary School Biology Teacher of the Year 2018 award was presented to Dr Richard Spencer CBiol FRSB from Middlesbrough College, while Kelly Thomas, of Penllergaer Primary School, Wales, was awarded the Primary Science Teacher of the Year Award.

EVENTS

RSB brings bioscience to new festivals this summer



Hands-on biology-based outreach activities have appeared at a new range of UK festivals over the summer thanks to the RSB's outreach team. In addition to appearances at Glastonbury Festival, Green Man Festival and the Lambeth Country Show in recent years,

OUTREACH

Ready for Biology Week?

The Society is once again gearing up for a range of events and activities as part of Biology Week 2018, which runs from 6 to 14 October.

The annual celebration of the biosciences is now in its seventh year, and the number of events organised around the world has grown greater and more diverse each year.

Those hoping to take part can visit rsb.org.uk/biologyweek to find a range of resources for schools, parents, universities and other groups, plus information about local events.

Members are also encouraged to join in the #iambiologist social media campaign on Friday 12th October.

SCIENCE AND GOVERNMENT

Life Sciences Council focus must be broader

The Society has welcomed the first meeting of the Government's Life Sciences Council, but stressed the need for representation for more sectors, such as plant science.

The Council is chaired by business secretary Greg Clark and health and social care secretary Jeremy Hunt, and features a range of research and industry leaders, including Professor Jackie Hunter, CEO of BenevolentAI and RSB trustee.

RSB chief executive Mark Downs said the health-focused sector of the life sciences was a "huge area of scientific and industrial strength" in the UK but that "we



Labour's Chi Onwurah at Parliamentary Links Day

must not lose sight of the breadth of talent, capability and economic impact for the UK across the life sciences sector as a whole".

EU could legislate to boost gender equality in STEM

The EU's research commissioner has said the EU might need to introduce more rules and new funding strategies to ensure women get equal opportunities, according to reports. Carlos Moedas told a Politico event in June that "we have to push harder" on gender equality in R&D, and that he would support additional legislation.

At the RSB's Parliamentary Links Day in June, Labour's shadow minister for industrial strategy, Chi Onwurah, said her party would introduce legislation on gender equality as attempts to increase the number of women in senior STEM roles over the past decade "are not working".

'Evidence Week' launched

June saw the launch of the first Evidence Week, an initiative by the campaign group Sense about Science.

The week of events and briefings explored how parliamentarians seek and scrutinise evidence, and the role of services such as the House of Commons Library.

Writing in *The Guardian*, Sense about Science's Tracey Brown highlighted instances of exemplary evidence-based decision-making and said a greater use of evidence in policy would be a "national victory".

ENVIRONMENT

Workshop leads to paper on ecology policy

A policy paper on a new direction for conservation in England has been published in the *Journal of Applied Ecology* following work by the Natural Capital

Initiative, a partnership between the RSB, the Centre for Ecology and Hydrology, the British Ecological Society and the James Hutton Institute.

The paper describes a conceptual basis for defining and assessing a network of wildlife areas, following the announcement of the Government's ambition to create 500,000 hectares of wildlife habitat. The paper can be found at bit.ly/NCI_resilient

PUBLISHING

African scientists launch PrePrint

A group of open science campaigners have launched the first preprint service aimed exclusively at African scientists. *AfricArxiv* is designed to help academics share their work quickly and improve the visibility and accessibility of African science.

FUNDING

£11.6m announced for innovation partnerships

The Scottish Government is increasing its grant funding for university research and innovation by £11.6m in 2018/19, bringing the total to £296.2m. The extra support is intended to strengthen the competitiveness of universities and their industry partners when bidding for UK-wide funding pots.

QUALIFICATIONS

Briefing published ahead of T-level roll-out

The RSB has published a policy briefing paper explaining the Government's new T-levels, with roll out expected to begin in 2020.

The new two-year technical programmes have been designed with employers to help students get a skilled job. Two are science based: Health & Science, and Agriculture, Environment & Animal Care.



Helen Currie MRSB Policy intern at the RSB

Rethinking investment in research

Understanding those impacts of R&D that are hardest to quantify is key to generating investment in science that benefits all

Relative to other OECD countries, the UK is underinvesting in research and development (R&D). The Government plans to raise spending to around 2.4% of GDP by 2027, but world-leading research nations such as Japan, Germany and the US are already at or approaching 3%.

A recent research paper produced by the Department for Business, Energy & Industrial Strategy ('Non-market impacts of investment in R&D') provides a refreshing take on how spending might be best allocated to see the greatest returns from innovation in science and technology.

The paper suggests that a focus on the assessment of 'non-market impacts' produced by R&D could assist scientists, businesses, policymakers and the public in identifying where investment would be best placed to drive maximum societal benefit. 'Non-market impacts' may be a dry, vague term, but it describes the important outcomes, goods or services which may have a value to society in some way but cannot be directly bought or sold.

Non-market impacts resulting from R&D can be broadly categorised into several key areas including: clean and flexible energy; agriculture; social sciences; and healthcare and medicines. These categories are well aligned with the foundations and 'Grand Challenges' identified within the UK's Industrial Strategy, and encompass fields of interest across a range of the biosciences not currently given weight within the Government's life science sector deal.

Such impacts can come in the form of ecosystem services and/or public goods, including clean air (which holds health benefits); clean rivers with biodiverse wildlife populations (including fish stocks); or conservation of national parks (which



create cultural and health benefits). For example, primarily commercially motivated agricultural technology – designed to assist in efficient and profitable farming – may potentially drive wider environmental benefits; or sustainable management practices might lead to more efficiently targeted or reduced use of chemicals, profiting soil and pollinator health, and reducing both water pollution and energy consumption. Research itself is a public good, although the potential range of subsequent outcomes from research or data sets can be large, and sometimes unintended or unquantifiable.

The problem here of course is that public goods, such as clean air, cannot necessarily be supplied to society for a direct financial profit – making them hard to categorise and measure within a market system based on financial exchanges. Despite this, factoring non-market impacts into policymaking processes provides a useful method to capture the value and benefit society derives from science and technology – failure to do so poses the risk of underinvestment in endeavours that hold real benefits for society.

Conserving national parks such as the Brecon Beacons has cultural and health benefits

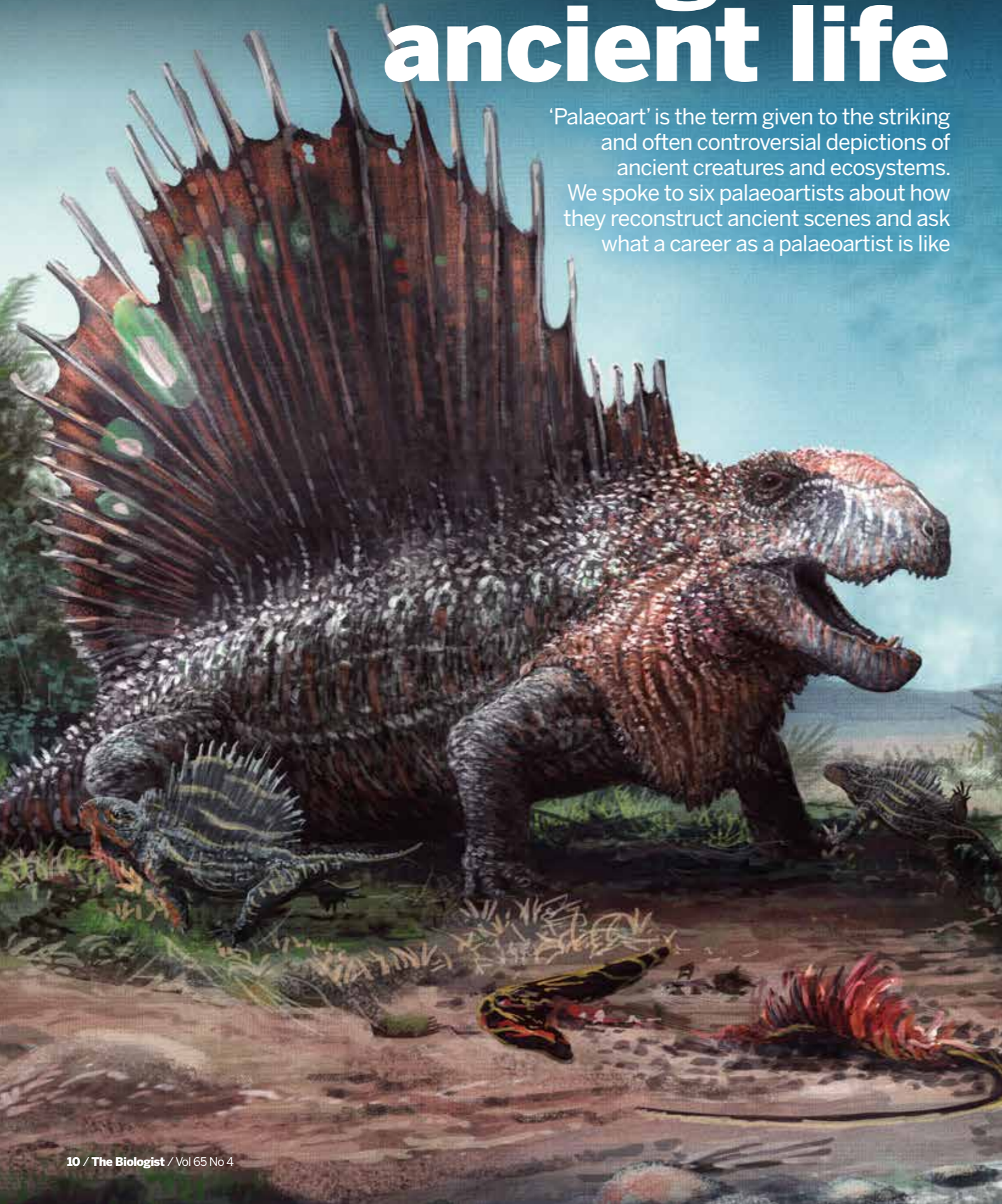
To capture these societal benefits of R&D appropriately, frameworks should be implemented to enable synthesis of views and expertise from a wide community. People from a range of sectors, disciplines, groups and communities must have routes to feed advice and expertise into policy development, implementation and analysis of the market and non-market impacts of R&D.

Given the impending EU exit and associated unprecedented legal challenges, it is imperative that policymakers understand the full extent of market and non-market impacts. Balanced strategies are key in policymaking, to ensure those non-market impacts that are hard to value financially (improved biodiversity, for example) are given proportionate weighting to those which are not. Deal or no deal, the UK must remain at the forefront of R&D, acting as world leaders in tackling global challenges including sustainable development and climate change. A rethink in investment strategy could ultimately help boost the UK's growth in research and innovation by making the most of what our resources have to offer.

Research itself is a public good

Art imitating ancient life

'Palaeoart' is the term given to the striking and often controversial depictions of ancient creatures and ecosystems. We spoke to six palaeoartists about how they reconstruct ancient scenes and ask what a career as a palaeoartist is like



◀ **Mark Witton is a freelance artist and author specialising in pterosaurs, and holds an honorary position at the University of Portsmouth. His book outlining the science behind palaeoart will be published later this year.**

I'm a palaeontologist by training and sort of fell into professional palaeoart. I've always drawn prehistoric animals as a hobby and when studying for my PhD, I started producing palaeoart for my colleague's research PR. I still do peer-reviewed research and am probably one of the more vocal individuals in the current palaeoart crop, regularly writing about palaeoart theory, methods and culture for my blog, online magazines and journals.

I'm self-trained and work entirely digitally. It's an ideal medium for palaeoart, as it's much easier to update images with new data and you can easily correct mistakes.

Few sciences have a related artform as PR-friendly as palaeontology. It's a great way to get the general public interested in prehistoric life, and from there, into science generally. It's also a terrific way to convert information in technical papers to a format that everyone can understand, and translates across barriers of language and age.

Another important function of palaeoart is as an illustrated history of palaeontological science. It's easy to look at the history of palaeoart with a cynical, dismissive edge because the science it's based on is now consigned to history. However, what we're looking at is a visualisation of evolving palaeontological understanding. Few other sciences can boast such a visually splendid record of their history.

Palaeoart is increasingly science-led, and there are vanishingly few parts of reconstructions that are entirely imagined or speculated. Even colour – that bastion of uncertainty that artists and scientists have traditionally conceded is beyond our knowledge – is now knowable, to some degree, with ever more sophisticated techniques of interpreting fossilised pigment cells and their relationships to animal colouration.

We do not always have answers to the questions about appearance, however.

There are a couple of responses to these data gaps: take them as licence for speculation or go conservative, taking the closest hint of an answer, to keep the work grounded. I think there's room for both approaches, as well as admitting that we don't know enough about some animals to restore them properly.

Some of my favourite images

"Few other sciences can boast such a visually splendid record of their history"

Mark Witton

Left: *Dimetrodon* by Mark Witton. The distinctive sail on its back is formed by spines extending from its vertebrae

Below: *Femme de Cap Blanc* – Elisabeth Daynès' reconstruction of the Magdalenian Girl discovered in Dordogne, France

are old-school palaeoart by artists such as Charles Knight and Zdeněk Burian. They excelled at evoking scale, atmosphere and mood, and I think this is sometimes lost in modern palaeoart. They weren't afraid of hiding their animals in shadow, of surrendering an intricate animal colour scheme to the hues of a dramatic lighting setup.

Palaeoartists must invest time in the research side of their work. As a science-led discipline, palaeoart is judged by the credibility of artwork as well as artistic execution. Research is also the best way to bring originality to your work – find your own inspiration in the books, papers and specimens that haven't been pored over by the rest of us.

Palaeoart is not a career you can do half-heartedly. The palaeoart community is very friendly and welcoming, but it's also crowded, so there's a lot of competition for work. Paying gigs are scarce and often underpaid, especially at early career stages. There are probably just a handful of people working as full-time palaeoartists around the world – the rest support their work through other means, be that other freelance artistry or part-time careers in other professions.

▼ **Elisabeth Daynès is a palaeoartist and sculptor who creates minutely detailed reconstructions of hominids, early man and historical figures. Her work is exhibited in museums around the world.**

The reconstruction methodology is always the same. There is a meeting between the artist and the scientists. From the fossil evidence and according to the same principles of a forensic investigation, I set up an identity card for the subject: fossil group, dating, age at death, probable sex, diseases, deficiencies, dietary pattern, associated fauna, climate, living conditions, environment, culture and so on. All this data is collected during long discussions with experts, anthropologists, anatomists, palaeopathologists and palaeogeneticists, and will guide decisions at every step of the reconstruction process.

When reconstructing sapiens, I work with a forensic expert at the Paris Institute of Criminology who uses computer-assisted technology of facial reconstruction. The reconstitution begins with the bones, the preserved parts of the skull, the teeth, the pelvis, the limbs. The skull is the most important piece – then the layers of soft tissues, muscles and deep dermis, where thickness values are provided by the forensic expert.

My goal is to show real people and real individuals who lived in prehistoric times and who are not mere prejudiced schemas





and discriminatory stereotypes. This work of individualisation is above all a work on faces, expressions and looks, where the starting point is the skull.

Precision and detail are essential to restore the dignity of the individuals, to arouse fragility and empathy, but also to be sensitive to the lost variety of the human family.

I want to create emotion through an extraordinary face to face. It is emotion that can overcome prejudices, whatever they are, and only an extreme attention to detail allows this. Neanderthal, my favourite, is no longer a discriminated brutal stereotype.

My work is at the border of art and science, and nothing would have been possible without privileged exchanges, meetings and collaboration with the international scientific community.

I also work on a contemporary art project called 'the truth of faces'. In my works, I reflect and explore a world of hyper-technology and virtual reality, and a time marked by man's obsessive quest for physical perfection and eternal youth. Boundaries between the real and the virtual, and between the artificial and the natural, are blurred. What will it mean to be human in 20 centuries?

"Through art, the public can come to know these dinosaurs as they were"

Emily Willoughby

Above: A *Caudipteryx* with chicks by Emily Willoughby. The genus is central to the debate around the relationship between birds and dinosaurs

▲ Emily Willoughby is a freelance illustrator who specialises primarily in feathered dinosaurs. She is also completing a PhD in behavioural genetics.

Before the invention of photography, artwork was the only visual method available to bring the natural world to the public. Today, palaeontology is unique among the natural sciences in that there is no other method to capture the reality of its subjects. Like the subjects we study, the methods of palaeontological reconstruction are old: we must paint, sculpt and draw to bring these animals to life.

My favourite type of work is illustrating newly described genera or behaviours for researchers, especially if it's a new taxon with some unique feature. I also do jobs for museums, and contribute to books about dinosaurs, birds and illustration. I have also done projects for magazines and television segments, and occasionally more unusual work such as tattoo design, band art and even a children's game.

I'm generally happy to illustrate anything with feathers, including modern birds, but my heart lives in Dromaeosauridae – *Deinonychus*, *Velociraptor* and their relatives.

I got into professional palaeoart almost by accident while completing my undergraduate degree in biology. I was contacted by Scholastic and

asked for one of my dinosaur drawings for a book. That experience motivated me to seek more paying work and to hone my skills to exhaustion while completing my degree.

Science writers and natural illustrators have a unique responsibility because these renditions are often what shape the public's perceptions of what these animals were actually like. We are, in a sense, bringing the bones back to life, but we must do so with care and respect. Through art, the public can come to know these dinosaurs as they were – not as movie monsters or mysterious creatures, but as real animals, full of beauty and life.

***Deinonychus*, the North American wolf-sized dromaeosaur,** was first described by John Ostrom in the 1960s and is largely responsible for the deepening understanding that dinosaurs were active, complex animals rather than tail-dragging behemoths. As far as I'm concerned, *Deinonychus* might well be the most beautiful animal that ever lived. Its proportions were built not for speed but for power, and it may have occupied a similar niche to today's big cats. I never get tired of drawing dromaeosaurs and *Deinonychus* has always been my favourite.

If you are considering a career in palaeoart, concentrate on achieving either great breadth or

"The Triassic is fun and intriguing to me because so many truly bizarre-looking taxa appeared during that period"

Gabriel Ugueto

Below: *Deinocheirus* by Gabriel Ugueto. The large omnivore lived around 70 millions years ago in the Late Cretaceous period

great depth in your work. I would gently caution against pursuing a career in palaeoart exclusively, since the demand for such work is relatively low and difficult to sustain. However, it can easily be a lucrative and enjoyable part of a broader illustration or wildlife artwork career.

▼ Gabriel Ugueto is a freelance scientific illustrator and palaeoartist specialising in illustrations of tetrapods.

I studied graphic design and illustration, but I grew up loving reptiles and amphibians, and for a long time I worked as a herpetologist researcher and authored numerous papers, including the descriptions of several new species of neotropical lizards.

My work reflects the latest scientific hypotheses about both the external appearance and the behaviour an animal could have had. In the absence of known details, I use what is known about the environment the animal lived in along with what we know about modern-day analogues to add details that most likely represent what the animal appeared and how it behaved.

Palaeoart helps people understand each new fossil discovery, while making connections to Earth's past life forms and environments. It is vital for an



illustrator to accurately depict an extinct animal. Otherwise, the public is misled.

Bones can tell us more than people think about the external appearance of an animal. Ideally, I prefer to examine the fossils in person. If this is not possible, I accumulate as much information as I can by examining photos, reading descriptions and talking to palaeontologists who specialise in that taxon. Unfortunately, most of the time fossils are incomplete or severely damaged, which is one of the biggest challenges of my work. To get around the myriad problems related to these challenges, I can model missing or damaged bones by comparing them to related species from which samples are available.

For me, it's all about the Mesozoic Era, which includes the Triassic, Jurassic and Cretaceous. Particularly, the Triassic is fun and intriguing to me because so many truly bizarre-looking taxa appeared during that period.

To be a palaeoartist, first and foremost you have to be a well-rounded illustrator both in traditional and digital media; you have to be a good animal illustrator. It is important to be very familiar with the anatomy of extant animals and be able to read a lot of scientific papers and keep up with current research. Be prepared to read a lot – you must be a lifetime learner.

► **Gary Staab has been a freelance sculptor since 1996, having worked at the Denver Museum of Nature and Science for seven years. He has been doing palaeoart since he was 19.**

I often say I specialise in being a generalist. I get to work on an extraordinary diversity of subjects, from the first invertebrates through early reptiles, primitive mammals, dinosaurs and hominids. All these forms complement

“I want my work to disappear. It is the animal that should be front and centre”

Gary Staab

Below: Prehistoric cephalopods by Gary Staab



each other: even though they might seem unrelated, there are still shapes and patterns that are repeated from organism to organism.

I formulated a dual degree in biology and art at Hastings College, which also included internships at the Smithsonian Institution and the British Museum of Natural History. My clients are primarily natural history museums, but I also create some work for zoos, nature centres and documentaries.

Since we primates have such a poor ability to conceptualise large spans of time, art is one of the only ways we can see past worlds with any clarity.

Blending realism, accuracy and drama is one of the greatest challenges. If the composition or design of the sculpture or image does not elicit a reaction, that may be a sign that it should be changed or executed in a different way. It needs to work on both levels of science and art.

If I have done my job correctly, you will only see the animal for what it is and not the mark of the artist who created it. With my sculpture, I want my work to disappear. It is the animal that should be front and centre.

When there are gaps of knowledge, we look to the next best anatomical proxy, living or extinct, to fill in the missing bits. I have done a lot of dissection work to back up the soft tissue reconstructions that I have done.

For me, the most interesting palaeo subjects are the animals that have not been fleshed out before. If you are lucky enough to work on a new species, you will be creating the first look of that animal for people to see.



▲ **Jenn Hall works at the Carter County Museum in Ekalaka, Montana, and runs her own freelance visual didactics business, Hell Creek Studio.**

I majored in printmaking and ended up getting a minor in geology, which is how I got into palaeoart.

Working closely with scientists and curators is essential to creating an accurate and believable image, and requires an iterative approach in which the image changes and has to remain versatile during draft stages. Especially when there are multiple co-authors or collaborators on a project, the back-and-forth can be quite extensive.

When encountering knowledge gaps, the collaboration has to continue to ensure that artistic decisions are believable. It's important not to run away with an idea because it looks cool or fierce, but to really consider why and how an animal would have appeared, which can be determined by considering ecological factors or bracket species.

That isn't to say that purely artistic decisions can't or shouldn't be made – on the contrary, the most compelling and striking images are those by artists who have a very distinct style with dynamic compositions and beautiful considerations of light and atmosphere.

“It's important not to run away with an idea because it looks cool or fierce”

Jenn Hall

Above: Pterosaurs by Jenn Hall. The flying reptiles are the earliest vertebrates known to have evolved powered flight

My projects include anything from scientific illustration to graphic design to taxidermy, typically for palaeontologists/geologists and museums. I don't specialise in any particular species or organism, but due to my background and work at the Carter County Museum (Montana's first dinosaur museum), I end up doing a lot of dinosaur-themed work.

I'm a sucker for Cambrian fauna. I find those wild, alien creatures captivating and enjoy visually imagining interactions between organisms and the individual events that changed DNA and pushed evolution forward. That said, I love doing fieldwork in Hell Creek and coming across Cretaceous fossils. We have the KT boundary here in Montana [the band of sediment dated to 65 million years ago, when dinosaurs died out], and when picturing individual events that's a biggie.

Palaeoart is full of artists with different styles and specialisations, so there are a lot of inroads for those who are passionate. Being versatile and picking up skills that complement your art can help develop your career, as well as distinguish you from others in the field. Most palaeoartists have a related career that supports their work, and makes them more marketable, whether in research, education or museum work. Also, get good at collaborating: working with and for others to communicate their message is what the job is about.

‘There is no time to waste’

TV science presenter **Liz Bonnin** talks to Tom Ireland about her love of biochemistry and big cats, and how she hopes her new documentary will help tackle plastic pollution

Liz Bonnin was born in Paris before moving to Ireland as a child. After studying biochemistry at Trinity College Dublin, a whirlwind showbiz career led to her presenting UK breakfast television and *Top of the Pops* in the early 2000s. However, she decided to return to her true passion, life sciences, completing a master's in wildlife biology at the Zoological Society of London and the Royal Veterinary College. Returning to TV on the award-winning show *Bang Goes the Theory*, Bonnin has gone on to become a much-loved wildlife and science broadcaster, fronting programmes including *Horizon*, *Stargazing Live* and *Springwatch*, and presenting live from nature reserves in California and Alaska. Her latest project is a film for the BBC on plastic pollution, due to be shown in the autumn.

Your new film is about plastic pollution, a huge and terrifying issue right now. Presumably you've seen first hand the impact of discarded plastic when filming at various locations around the world?

That's right. I've filmed from many places and been privy to some pretty depressing realities about the state of local ecosystems, but this plastic project has been so much more difficult to film because it's just a different ball game in terms of how bad it is and how visible it is. Everything we are filming is completely surpassing my expectations, and not in a good way.

As well as highlighting the awful scale of the problem, it sounds like the programme will be looking at some of the research and innovation that may help us find solutions.

Always one of my main remits is to celebrate the scientists working tirelessly to find a solution. They are the heroes and it's very humbling to watch what they are doing. As programme makers, we are aware that television storytelling of this ilk has to evolve,

As part of the BBC series *Galapagos*, Liz Bonnin joined various research teams to help protect the islands and their inhabitants

Atlantic Productions

“Our mission is to make viewers feel the way I'm feeling as I'm doing this, which is really motivated to step up and take responsibility for my planet”



because there is no time to waste any more. It's never wagging the finger, but we want to empower the viewer about what they can do, which is new and exciting. So there is a lot of fire in bellies at the moment. Our mission is to make them feel the way I'm feeling as I'm doing this, which is really motivated to step up and take responsibility for my planet. It goes far beyond giving up straws and using your reusable coffee cup.

Even for people who are aware of the problem, it's so hard not to end up with a trolley full of plastic every time you go shopping. Do you think governments and industry should do more, rather than asking individuals to try to avoid this ubiquitous material?

Undeniably. I'm halfway through filming and absolutely that is where the things need to change. I think we all know that, ultimately, with conservation issues across the board, that's where the buck stops. That's the bit that is difficult to negotiate and communicate in a way that is not too political.

Where did your love of science and nature develop?

I was lucky enough to grow up spending lots of time outdoors. We had a little wood next to our house in the south of France, and I spent a lot of time in the sea as a toddler on trips to the Caribbean. My sister and I used to have adventures with our two dogs, and hedgehogs, snakes and spiders.

What led you to study biochemistry? Presumably you did not have your sights set on a career in television then?

I was fascinated to know how living things worked down to the chemical equations. How do things see? How do I see? I loved biology and chemistry at school.

I'm always at pains to tell children at school not to put too much pressure on themselves to decide exactly what they want to do. I loved my degree, but towards the end I knew it wasn't quite what I wanted to continue doing. It wasn't that I wished I'd done a different degree, but I thought that the next bit of my journey would be in conservation and wildlife.

The next stage of your career got quite crazy quite quickly. You ended up presenting the IRMAs (Irish music awards) 'by chance'. What happened?

Well, I was singing in a sort of girl band at the time... Dublin's very small and the person producing the IRMA awards didn't want a presenter to present them – they wanted to do something a bit different. I tried out for it and got the job, and that led to other jobs and then [Channel 4 breakfast TV show] *RI:SE* in the UK and then *Top of the Pops*. It was just this crazy adventure and I never expected it to last too long. I just rolled with it.

You then did a MSc in wildlife biology with the Zoological Society of London and the Royal Veterinary College. What made you turn your back on showbiz to return to university?

There was a point where I wasn't really enjoying myself any more and missed academia. I took a break and had



Above: Bonnin with elephants in Botswana

"I came away feeling very strongly that big animals such as elephants, carnivores with big ranges and apes shouldn't be kept in captivity"

a 'eureka' moment on a mountain in South America – I'm sorry, that sounds like a cliché, but it's true. I thought "I'm going to go back and study wildlife conservation." I was accepted on the master's course, and when it started I began to wonder if I could work in conservation but somehow use the creative storytelling skills from television, which I'd grown to love.

I looked up the agent of my favourite wildlife presenters and told them I was in the middle of my master's and that my showreel was all entertainment shows. I guess timing is everything, because just as I finished my master's, *Bang Goes the Theory* was auditioning and I haven't looked back since.

What did you learn during your master's?

It was a seminal moment for me. I dug my heels in and insisted on going to Nepal to do a study on tigers' diets. It wasn't working out, to the point where my supervisor and best friends even said: "Liz, you've got to let it go" I ended up in tears in a hotel in Kathmandu – none of the equipment I needed had got out there, I was struggling to contact the local scientists and I really thought I would fail the course. Eventually, I made it to the Bardia National Park, carried out my research project and in the end came first in my class. It was a really important life lesson about working hard.

Toby Strong

Tell me about your fascination with cats and your most memorable big-cat experience.

There's something about domestic cats I was obsessed with as a kid. I think it's because they have retained a lot of their wild traits and they aren't as domesticated as dogs – you can never quite figure them out.

When I was still working in entertainment television, I did a programme for RTE where I went to Pench National Park in India. To this day, I think that is the most special big-cat experience I've had. We met a tigress who was fairly tolerant of people and allowed us to follow her through her territory for about four hours, which is so rare, and she stole my heart. So I knew I would go back to work in conservation and I would do whatever it took to work with tigers again.

What is the current situation in terms of efforts to conserve wild tigers?

Unfortunately, the challenges are the same as ever: our burgeoning human population means tiger habitat and key wildlife corridors are being lost. I did get news from the researchers who helped us with Operation Snow Tiger that numbers are slightly up in that subspecies in the far east of Russia. But we mustn't be complacent about a few individuals doing well. Tigers are critically endangered and it's a really sad state of affairs. Sometimes I do speak to conservationists who say it's too late: that's the reality. I don't know what the answer is. The idea of trying to set aside wild spaces for animals with ranges as large as tigers need doesn't seem realistic any more. We need to find ways to live alongside them, which is very difficult when they don't have enough prey and start to encroach on people's land and animals.

You reported on zoos for a Horizon documentary in 2016. How did you feel, coming

"The idea of trying to set aside wild spaces for animals with ranges as large as tigers need doesn't seem realistic any more"

Below: Bonnin joins experts in a submersible to search for the elusive mola, or sunfish, in the seas around the Galapagos



QUICK QUESTIONS...

Favourite location you've filmed in?

If I have to pick, one is Botswana. One evening after filming, we watched this herd of elephants with two baby calves just splashing round as the sky went from pink to deep red to blue. We watched them until the sun set and they just walked off into the darkness. We had tears in our eyes.

The second has to be the Galapagos. When you're on the beach with all of these animals – fur seals, hawks, marine iguanas, giant tortoises – and they look at you as if to say "Hi, are you just here to find your food too?" They are not fazed at all. I went down 1,000m in a submersible and dived beneath hammerhead sharks doing this swirling courtship ritual in their hundreds. It's unbelievable that these places still exist.

Atlantic Productions

Which science broadcasters do you admire?

Saba Douglas-Hamilton – I used to love watching her on *Big Cat Diaries*. Alice Roberts is a consummate communicator; Brian Cox has revolutionised how the general public view physics. And I think Chris Packham is extraordinary.

But, of course, above and beyond everyone is Sir David Attenborough. He is the gold standard.

Are there any scientists or researchers who you particularly admire?

I'm a huge fan of Jane Goodall and the marine biologist Sylvia Earle. Together with David Attenborough, they are the people I

away from the programme, about the idea of keeping animals in captivity to help conserve critically endangered species?

I consider myself a member of the zoo community and I wanted to take a long, hard look at the science of how animals are faring [in zoo settings]. We know so much more about how sentient and intelligent some animals are, and what those with large ranges need and what captivity does to them. Then you have to weigh up the argument that zoos could be some kind of repository for a species should they go extinct in the wild. For me, it's as simple as that – do we have the right to keep an animal in captivity even if it is a safety net, when we know how harmful it is for these species?

The science is telling us it is our responsibility in the zoo community to evolve and make tough decisions. I came away feeling strongly that big animals such as elephants, carnivores with big ranges and apes shouldn't be kept in captivity. I do not think that if all tigers go extinct in the wild, it is worth keeping them in captivity. They are not suitable for release in the wild after just a few generations and if we can't secure their habitat now, why would we in the future?

However I came away hopeful about how zoos could evolve. Twycross Zoo in the UK, Detroit Zoo and others are trying to do the right thing – taking a long hard look at what animals need and have even let go of some of their larger animals. I think part of the solution is for zoos to create small ecosystems that showcase insects, plants and maybe even small mammals that do well in captivity. Showing how everything is interconnected in this way has more educational value for visitors than a large animal pacing back and forth in an enclosure. Detroit let go of its elephants and visitorship is on the increase.

really look up to. I'm inspired by them to work and never retire until I drop dead. But, really, there are extraordinary people in every corner of the planet working 24/7 to save a species or better understand an ecosystem while we go about our daily lives.

Hopefully, the more programmes we make the more we can celebrate them.

What other scientific areas interest you?

Over the last seven or eight years doing *Stargazing Live*, I have been blown away by the research being done to discover what's out there – and even what is being done to prepare should we find other life and get it in a petri dish.

Double vision

Melvyn Goodale and David Milner describe the extraordinary case of patient DF, a woman whose bizarre perceptual deficits led to a new understanding of how the brain processes visual information

Thirty years ago in a small village in northern Italy, a young Scottish woman known as Dee* was taking a shower in the cottage she and her partner were renovating. She was unaware that their water heater was improperly vented, and carbon monoxide began to slowly and insidiously accumulate in the bathroom. This colourless, odourless and deadly gas displaces oxygen from the haemoglobin in red blood cells, starving the body and the brain. Dee's brain quickly became hypoxic and she passed out. Miraculously, her partner, Carlo, found her before she stopped breathing and rushed her to hospital.

When Dee regained consciousness some 24 hours later, it was clear that something was badly wrong. She seemed totally blind, unable to see Carlo standing beside her or anything else in the room except light and dark. Over the next few days, her vision gradually improved, but although Dee could tell the colour of objects, and even the material they were made from, she could not identify anything on the basis of its shape or form. She couldn't even recognise her partner or mother, except when Carlo was wearing a pullover with a familiar and distinctive colour. On one puzzling occasion, she remarked that she could clearly see the small hairs on the back of her mother's hand, yet could not recognise the hand as a hand.

Some months later, when Dee came back to Scotland for a visit, we had an opportunity to assess her visual abilities in our laboratory at the University of St Andrews. It became clear she could not discriminate between shapes as simple as a square and a triangle.

Her failure to recognise objects was not because she had some sort of disconnection between the visual appearance of an object and its name or meaning. When asked to copy simple line drawings of objects (drawings that she could not identify), her copies bore very little resemblance to the originals, yet when asked to draw the same objects from memory, her drawings were quite recognisable. She also could not recognise her own drawings when shown them later. Dee's object recognition did benefit from the addition of colour and shading.

She could clearly see the small hairs on the back of her mother's hand, yet could not recognise the hand as a hand



We found that Dee was also quite unable to identify letters of the alphabet or digits. In short, Dee appeared to have a fundamental deficit in the visual processing of form, rather than a higher-level deficit in understanding what an object is. The damage in Dee's hypoxic brain had left her with a rare neurological disorder called visual form agnosia, an inability to perceive the form or shape of objects. Moreover, her deficit was purely visual: she had no problem identifying objects from touch.

One day, however, we were given a hint that would lead us to change our assessment of Dee's visual abilities – and to change our thinking about how the human visual system might be organised. To demonstrate to a colleague just how profound Dee's visual deficit was, we held up a pencil at different orientations in front of her, and asked her to tell us whether the pencil was oriented vertically, horizontally or diagonally. Even though she could report (correctly) that the pencil was yellow, she had absolutely no idea what its orientation was. Her guesses were completely at chance.

Then something extraordinary happened. She suddenly said "Wait a minute, let me see that" and reached out and grasped the pencil. The orientation of her grasping hand as it approached the pencil

corresponded exactly to its orientation, even though a moment before she had been unable to tell which way it was oriented (see Fig. 1). We tested her again with a different orientation and once more she rotated her hand 'in flight' so that her fingers closed around the pencil perfectly. This dramatic observation led us to test her on a range of different visually guided motor tasks, from posting a card through a slot to picking up rectangular objects with different widths.

In all these tests, her behaviour was essentially normal: she rotated her wrist appropriately to insert a card into a slot presented at different orientations (see Fig. 2) and she scaled the opening of her fingers in flight to objects of different widths in order to pick them up adeptly. Yet at the same time she was completely unable to use vision to indicate either verbally or manually the orientation of the slot or the width of the object.

The fact that Dee could use vision to control limb and hand movements toward objects whose features she could not perceive presented us with a real puzzle. How could she act on visual information she apparently could not perceive? One clue came from the brain scans that she had undergone in Italy after her accident. Although the scans showed the typical

pattern of diffuse brain damage associated with carbon monoxide poisoning, it was evident that Dee had particularly dense damage on both sides of her brain in the so-called ventral stream of visual projections, one of two major visual pathways in the primate brain that arise in early visual areas (Fig. 3). The other pathway, the dorsal stream, appeared to be relatively unscathed. Could it be that it was the damage to her ventral stream that was disrupting her ability to 'see' the shape of objects, while her spared dorsal stream allowed her to grasp those same objects quite normally?

There was certainly tantalising evidence from anatomical and electrophysiological work in monkeys to support this idea. It had been known for a long time, for example, that monkeys with large lesions of the occipital and temporal lobes, largely destroying the ventral stream, could no longer recognise objects, even though they had no trouble in picking them up quite deftly. And while we were testing Dee in Scotland, a group in Japan had shown that neurons in the monkey's dorsal stream were 'tuned' to the size, shape and orientation of goal objects that the monkey had been trained to grasp.

There was also supporting evidence from other human studies. A group working in France had

The fact that Dee could use vision to control her movements toward objects she could not perceive presented us with a real puzzle

*Not her real name. She is known in the literature as patient DF

HOW DOES DEE SEE THE WORLD?

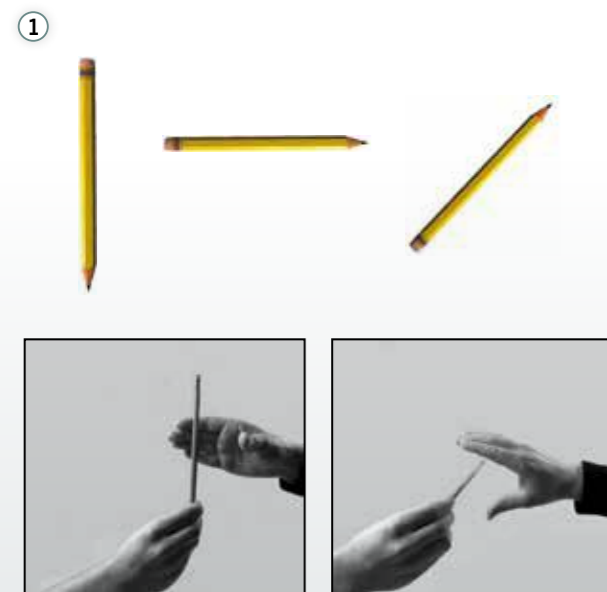
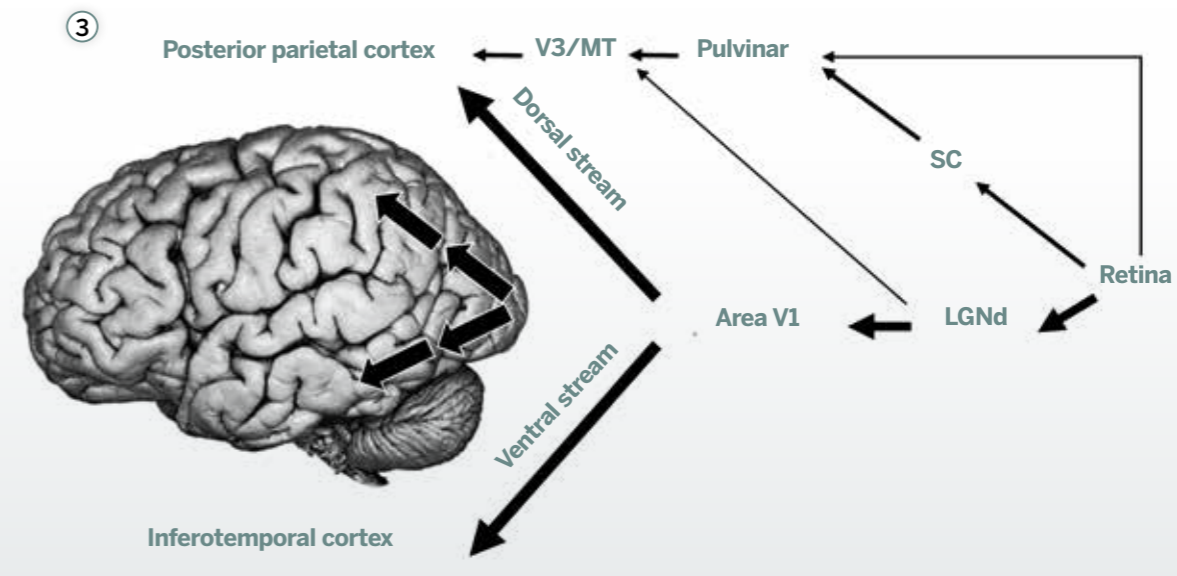
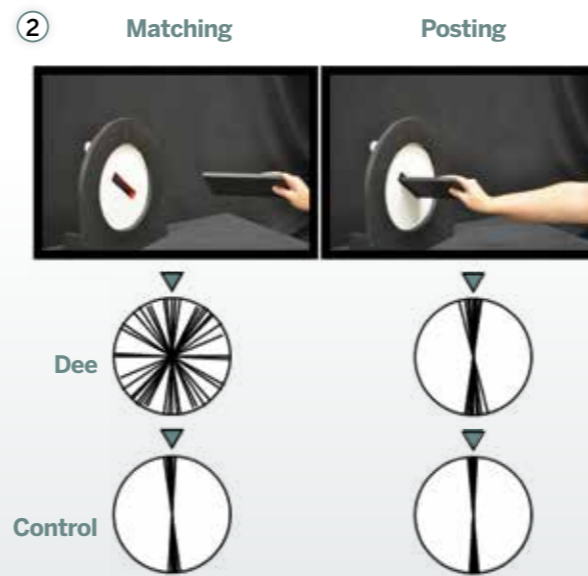


Fig. 1 The examiner held a pencil vertically, slanted or horizontally. Even though Dee could only guess the orientation of the pencil, she always grasped it perfectly.

Fig. 2 Dee was asked to turn a hand-held card so that it matched the orientation of the slot, without reaching out toward the display ('matching'). She was later asked to 'post' the card into the slot ('posting'). Dee performed almost randomly when matching the card to the slot, but had no problem posting it at the right angle. (Although the slot was presented in several orientations, the diagrams show 'correct' as vertical. Healthy control subjects had no problem with either task.)

Fig. 3 A schematic diagram of the two streams of visual processing in a primate cerebral cortex. The ventral stream receives nearly all of its visual input from the primary visual cortex (V1), which in turn receives its input from the lateral geniculate nucleus (LGNd) of the thalamus. The dorsal stream also receives input from V1, but also gets substantial inputs from the superior colliculus (SC) via the pulvinar, another nucleus in the thalamus that projects to areas (V3 and MT) in the cerebral cortex that eventually carry visual information to the posterior parietal cortex. The arrows on the inset photograph of the brain show the approximate route of the two streams within the cerebral hemispheres.



shown that patients with lesions of the parietal lobe, damaging areas within the dorsal stream, exhibited a pattern of behaviour that appeared to be the exact opposite of that shown by Dee. These patients could recognise the orientation of a slot, for example, but had great difficulty rotating their wrist so that they could insert their hand into the slot – until they made contact with it.

We too had an opportunity to test individuals with dorsal-stream damage and found that, in stark contrast to Dee, many of them could easily identify the shape and size of objects, while unable to shape their fingers into the correct posture as they reached out to pick up those same objects.

At the time, all of this evidence was pointing to one inevitable conclusion: the ventral and dorsal visual streams seemed to be doing very different jobs. But why should that be the case? To answer this question, we realised, one had to step back and ask another fundamental question: why do we need vision in the first place? A compelling argument could be made that we need vision for two quite different but complementary reasons.

On the one hand, we need vision to understand the world beyond our bodies, to identify and remember objects and places, and to plan different courses of action. On the other hand, we also need vision to guide our actions in that world at the very moment we make them. These are quite different job descriptions, requiring very different computations – and, as a consequence, two different visual systems have evolved to carry them out.

In 1992, in a brief essay published in *Trends in Neurosciences*, we proposed that it is the ventral visual stream, a network that is intimately interconnected with the cognitive areas of the brain, that enables us to recognise objects and build up a 'database' of the world. Thus, when we talk about 'seeing' something, it is the ventral stream that allows us to have that perceptual experience.

By contrast, we argued, it is the dorsal stream that

provides the visual control of our actions, enabling us to move about and interact with objects, often with exquisite timing and control, even though we might have no conscious experience of the visual information that is providing that control. Although we can see that we are playing a game of tennis, for example, the visual information that allows us to hit the approaching tennis ball with the sweet spot of the racquet is quite inaccessible to consciousness.

The idea of two visual systems in a single brain might seem initially counter-intuitive or even absurd. Our visual experience of the world is so compelling and apparently unitary that it is hard to believe that some other quite independent visual system – one that operates completely outside of consciousness – is guiding our movements. Indeed, at the time we began testing Dee's visual abilities, it was the near-unanimous belief of neuroscientists, including researchers specialising in vision, that vision was served by a single system.

Although the inputs to the system were known as being extremely complex and to some degree handled through separate neural channels, the consensus was that they were somehow combined in the brain to provide us with a unified visual representation of the world that then served as a perceptual foundation for all our thoughts and actions. The striking dissociation we had observed in Dee challenged this monolithic conception of how vision works, and we now know that there is a fundamental difference in the way in which vision for perception and vision for the control of action are organised in the human brain.

Since we put forward these ideas 25 years ago, a lot has happened. The advent of functional magnetic resonance imaging (MRI), in particular, has revealed in exquisite detail the functional organisation of the human visual system. The story that is emerging from imaging studies largely confirms the conclusions of the earlier neuropsychological studies in patients and the

neurophysiological work in monkeys. Thus, when the brains of healthy volunteers are scanned while they are simply looking at objects, there is robust activation in the ventral stream, and when the same volunteers are asked to reach out and grasp the object, there is activation in the dorsal stream.

Functional MRI has also shown that within the ventral system there are separate channels for analysing object geometry and surface properties. Dee's brain damage spares the areas serving colour and texture perception, whereas other patients lose their perception of such surface properties while retaining good shape perception.

The division of labour between the ventral and dorsal stream is one ultimately geared towards the requirements of the output systems that the two streams serve. Natural selection slowly moulded the neural circuitry in these pathways to reflect the different demands the environment presented to our distant mammalian ancestors. We have talked about dissociations between perception and action but, of course, perception is shorthand for the more elaborate visual processing that higher mammals can exploit in order to improve on their choice and planning of behavioural acts.

In other words, the ventral stream contributes to action every bit as much as the dorsal stream – it just does it in a more circuitous way, by engaging other cognitive modules with which it is connected. If it did not promote more adaptively successful behaviour, the ventral stream would simply never have evolved.

It should be emphasised that this new conception of unconscious vision playing a critical role in the online control of movements in no way denies that we often have a full visual awareness of the objects upon which we are acting. What it does claim is that the visual processing that controls our movements is segregated from the processing that furnishes our awareness. The two kinds of visual processing are, at least to a great extent, going on quietly in parallel. Our common-sense

belief that our conscious vision controls our actions is an illusion.

Yet even a cursory glance at the anatomical connections between different visual areas in the brain shows that the two streams are not hermetically sealed from one another. Indeed, they need to work together constantly in everyday life. To illustrate one important kind of interaction, we may draw an analogy with tele-assistance, whereby a human operator acts to guide semi-autonomous robots on the surface of a distant planet. The robot can efficiently gather rock samples, but is guided by the operator as to which samples would be most worthy of attention. This has proven to be a highly successful mode of operation, and is reflected in the way the ventral and dorsal streams interact.

In the case of the human brain, inter-stream interactions take several forms. For example, the ventral stream through its close links with memory systems can provide the dorsal stream with information not only about recently encountered visual objects, but also with functional or 'semantic' knowledge about objects. These long-term memories include, for example, the material properties that characterise particular objects and the uses to which manufactured objects such as tools can be put.

None of this, of course, sheds much light on the age-old concern of philosophers to 'explain' consciousness. Although modern cognitive neuroscience is constantly offering clues as to what kinds of brain processing are and are not associated with visual awareness, we are still far away from an understanding of the neural basis of consciousness.

The ventral stream through its close links with memory systems can provide the dorsal stream with information

Professor Melvyn Goodale FRSC FRS FRSB is distinguished university professor in visual neuroscience and director of the Brain and Mind Institute at Western University, Canada.

Professor David Milner FRSE FRS is emeritus professor at Durham University and an honorary professor at the University of Edinburgh.

We need vision to understand the world beyond our bodies, but we also need vision to guide our actions in that world. These are quite different job descriptions



Setting the standard

The RSB has been accrediting bioscience degrees since 2012. **David Coates**, who chairs the Society's Accreditation Committee, explains what the programme does and why it was badly needed in the biosciences

The Society's Accreditation Programme is an independent and rigorous assessment of bioscience degree programmes in the UK. It recognises degrees that contain a "solid academic foundation in biological knowledge and key skills" and that "prepare graduates to address the needs of employers".

The programme also assesses degrees that focus on academic excellence and educate the "future leaders of research and development" (Advanced Accreditation), and overseas degrees (International Accreditation).

Accreditation of training has a long history, especially in fields such as medicine where the effectiveness of the teaching can have a dramatic impact on future practice. The concept of a collective of experts defining curricula goes back to the early days of the trade guilds and the training of apprentices. In the UK, this is usually a responsibility of professional associations.

While compulsory accreditation of medical and other healthcare courses has long been the norm, and even the voluntary accreditation of engineering disciplines is seen as the best way to ensure the

The process has changed the way people think about putting together, reviewing or modifying curricula

standard of engineering training, this has not been the case for biology, where subject-specific accreditation has been largely ignored.

Our sister sciences – chemistry and physics – have a much longer history of degree accreditation. There may be many reasons for this, to do with the breadth of the subject, the lack of a professional employment route for most graduates and the very wide range of approaches that need to be taken. Chemistry and physics naturally have a relatively easily defined core component that is common to all degrees, but this has not been the case for biology. The nature of the subject has also changed. Forty years ago, biology was still largely a collection of bits of knowledge in many different areas that did not link together coherently. Now, there is a strong linking framework and set of technologies across the subject, and it has become much easier to define 'core' skills and knowledge for the different general areas.

Several additional factors have emerged to convince the bioscience community of accreditation's value and the government of the importance of skills. For the community, it was about having an external reference point that could be used to protect and enhance the skills base of biology degrees. It started

By Royal Charter

The first of the listed powers in the royal charter of the RSB, originally granted to the Institute of Biology in 1979, is "to establish and maintain appropriate standards of education and experience for persons engaged in biology or its application".

with a report written by the Association of the British Pharmaceutical Industry (ABPI) and submitted to government in 2005 highlighting the lack of practical skills in graduates in a wide range of STEM areas, including biology. The formation of the Society of Biology in 2009 as a single voice for biology was seen as the most important collective action the community could take, creating a focus for policy and education initiatives that had not existed before.

Finally, government was pushed to address the ABPI's concerns, and told the Society quite clearly that it was its responsibility, under its royal charter, to deal with the issue of skills and quality. The government also supported a funding bid to the UK Commission for Employment and Skills to assist the development of an accreditation system.

This prompted a period of consultation and discussion with the community, which initially communicated that if we don't do it, someone else will force it on us. Our focus at first was on degrees that would provide excellent research training, coupled with the other skills that are needed in the biotech and pharmaceutical industries, rather than on general degrees in biology.

The agreement was that if this was a success, we would develop a much broader-based accreditation for which anyone could apply.

So what would this new accreditation system measure? Many other systems – in particular that for chemistry – were developed at a time when knowledge was the important measure of success for graduates. The more current concept of 'intended learning outcomes', expressed not just as knowledge but as skills and competencies, is still a relatively new idea and poses many challenges for assessment: how do we know that students have achieved these outcomes? It is still much easier to assess their knowledge than what they can do with it.

And yet that is the problem for the employer. In our modern world, information is everywhere, but understanding and use of knowledge and skills is much rarer. Indeed, one of the most common criticisms of biology graduates in the past was that they knew a lot, but didn't know what to do with it. Engineering and the physical sciences had successfully argued for funding for an extra undergraduate year, taught at master's level, to be able to implement a period of practice, and produce much more mature graduates in those disciplines.

We wanted to do the same, but there was a concern that the huge increases in fees that were just about to come in would stop students from wanting to take that extra taught year. The solution was what is commonly called the Year in Industry, where a student takes a year out to work in an employment

One of the most common criticisms of biology graduates in the past was that they knew a lot, but didn't know what to do with it

setting, and so Advanced Accreditation (our first step into the accreditation world) included that option. Interestingly, that option turns out to be quite difficult to deliver, because of the quality assurance and assessment needs, and students seem not to have been put off by an extra year of loans to get the integrated master's.

Since the launch of Advanced Accreditation, we have also developed a standard model that is suitable for any bachelor's degree in the biosciences. It uses the same approach of a small number of learning outcomes, which allow for flexibility while focusing on the areas where curriculum development was vital to deliver competencies – laboratory skills, creative approaches, critical thinking and problem-solving.

A real advantage of the outcomes-based approach is that there is no preconception about what is right and what is wrong. This celebrates the variety of learning environments and the breadth of the subject, always a challenge when trying to accredit a subject such as biology and one of the reasons that accreditation has come later to this area.

We have chosen to ask the developers of programmes to say what they think is appropriate, and then use a peer review system to review and comment on that knowledge base. At the same time, there is a heavy emphasis on laboratory skills and projects using critical thinking and information analysis because that is what our graduates need to succeed afterwards.

Has the approach worked? It is too soon to have evidence about the impact on employment other than subjective comments. What is clear is that a significant number of courses and universities have sought accreditation, and that the impact of the process itself has changed the way people think about putting together, reviewing or modifying curricula.

The focus on laboratory skills in particular, and ways of showing that every student has had the opportunity to develop those skills, has changed the way many bioscience departments approach the teaching of practical skills.

As we go forward, we will be looking to see whether employers of our graduates see a positive difference – change in educational approaches, especially in higher education, can be slow and somewhat uncoordinated. Accreditation has the opportunity to help colleagues develop their approaches and raise the standards of our graduates to even greater heights.

Accreditation in numbers

536 programmes accredited by the RSB since 2012

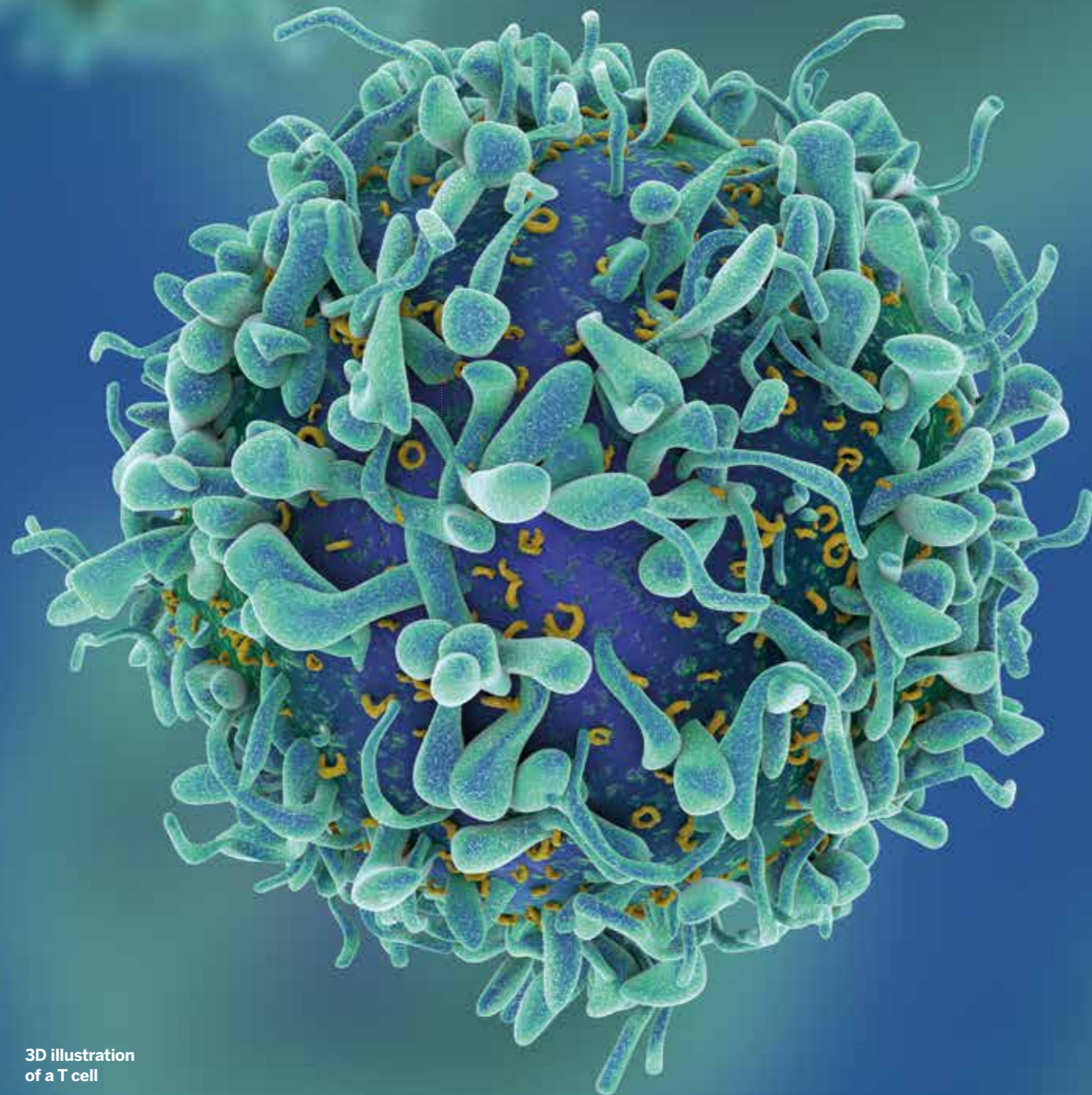
6 countries with institutions being accredited

6 months – average accreditation process period

10,000 students graduating from accredited programmes each year, approximately

Focus on: Cancer vaccines

After decades of research, therapeutic cancer vaccines are finally beginning to show promise in clinical trials. We look at why earlier efforts failed and how the latest approaches work



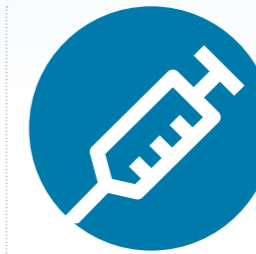
3D illustration of a T cell

Therapeutic cancer vaccines aim to ‘teach’ the immune system to attack and break down cancerous cells and tumours. First, an antigen must be found that is expressed exclusively by the cancer cells, then the body’s T cells must be encouraged to attack any cell found to have that target molecule.

The antigen might be a complete surface protein found on cells in the tumour, or the peptide fragments of any protein expressed by the cancer cells. To be effective, the vaccine must stimulate cytotoxic T cells (such as CD8+ T cells) to attack any cell expressing the target antigen. Helper T cells (such as CD4+ T cells), which modulate the immune response to pathogens and tumours, are known to be recruited in successful vaccines, although the exact response of the two types of T cell is complex and depends on the antigen.

In early efforts to develop cancer vaccines, many of the target antigens failed to trigger a strong enough immune response to halt the cancer’s progress. After all, for cancer cells to have progressed into a tumour, they must already be successfully evading or suppressing the body’s immune response. Many early trials were also often conducted on patients with advanced cancer whose immune systems were severely compromised.

The latest approaches use algorithms to identify antigens that the immune system may not have seen yet (neoantigens), and combine the antigen-based



1,922

clinical trials featuring the term ‘cancer vaccine’ currently listed on clinicaltrials.gov

approach with adjuvants that boost the immune system’s response to the antigen of interest. The way the vaccine is packaged and delivered (see ‘Special Delivery,’ p28) also has a profound effect on whether the immune system reacts and therefore whether the vaccine is effective.

“It’s all about the tricks you use to make your antigen interesting to T cells,” says Christian Ottensmeier, professor of experimental cancer medicine at the University of Southampton. “It is an open question in the field – what is the best way to make that happen?”

Potential delivery methods include DNA and RNA-based vaccines, viral or bacterial vectors, or patients’ own immune cells or tumour cells. The exact approach depends on the type of target antigen, type of cancer and its location in the body.

Haval Shirwan, a cancer immunotherapy expert and professor of immunology at the University of Louisville, says cancer vaccines almost certainly need to be delivered with other immunomodulatory substances in order to have an effect. Checkpoint inhibitors, for example, are drugs that help block signals that suppress the body’s immune response, boosting the number of immune cells available to fight the cancer cells.

“Our ideas about the design of cancer vaccines have changed. Using the right antigen alone is not enough: you have to have an adjuvant that

Categories of cancer vaccine*

Antigen- or peptide-based cancer vaccines

These vaccines use peptides that are found exclusively or in large amounts in cancer cells. They might be injected directly in peptide form alongside an adjuvant that boosts the immune response.

DNA- or RNA-based cancer vaccines

The target antigen is encoded in DNA and RNA, which is translated into a peptide once within the body.

Cellular or dendritic cell vaccines

Certain immune cells known as antigen-presenting cells (APCs) help ‘present’ antigens to T cells in order to provoke an

immune response. The most potent type of APCs are dendritic cells (known as ‘professional’ cells, as they specialise in this antigen-presenting function). Many new vaccines involve culturing dendritic cells in the

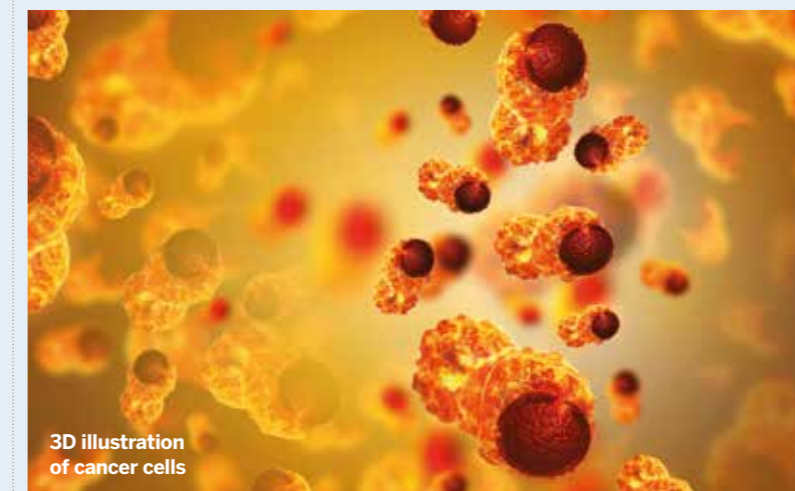
laboratory alongside tumour antigens before injecting them into the patient.

Tumour cell vaccines

These vaccines are made from actual cancer cells that have been removed from the

patient during surgery, killed then modified to stimulate an immune system response

*This article focuses on therapeutic cancer vaccines – that is, those that are developed to treat cancer, not preventative cancer vaccines, which immunise against cancer-associated infections such as HPV (cervical cancer) or Hepatitis B (liver cancer).



3D illustration of cancer cells

“The important thing is to find a vaccine that is effective, then we will find ways to make it cost-effective”

Professor Haval Shirwan

helps the immune system overcome the evasive mechanisms that are stopping it from fighting the cancer itself.”

GETTING PERSONAL

Some of the most high-profile advances in cancer vaccines have been personalised therapies, which involve sampling a patient’s tumour and analysing the antigens specifically found in those cells. Computer algorithms help clinicians decide which antigens will most likely elicit an immune response.

This approach, despite showing promise for cancers that change rapidly, inevitably comes with cost implications, given that each treatment is bespoke.

Other cancer vaccines target a more general antigen that is common to a particular type of cancer. However, many of these techniques still require the culturing of immune cells from each patient. A new technique involving dendritic cells from a human stem cell line, announced earlier this year, has raised hopes that ‘off-the-shelf’ cell-based cancer vaccines could be possible too (see ‘Success Stories’, right).

“There are issues with the personalised approach in terms of cost and whether it is practical,” says Shirwan. “But I don’t want to downplay the importance of personalised medicine. The important thing is to find a vaccine that is effective, then we will find ways to make it cost-effective. Both approaches

should be entertained in order to push forward on different fronts.”

In light of recent successes, and armed with a more sophisticated understanding of how the immune system tackles and is suppressed by cancer, oncologists are hopeful that cancer vaccines will play a key role in fighting the disease – perhaps not as a silver bullet, but in combination with other treatments or possibly to prevent reoccurrence or metastasis.

“After a period of great doubt, we are now back in a period where there is a great deal of excitement,” says Ottensmeier.

SIDE-EFFECTS AND SAFETY

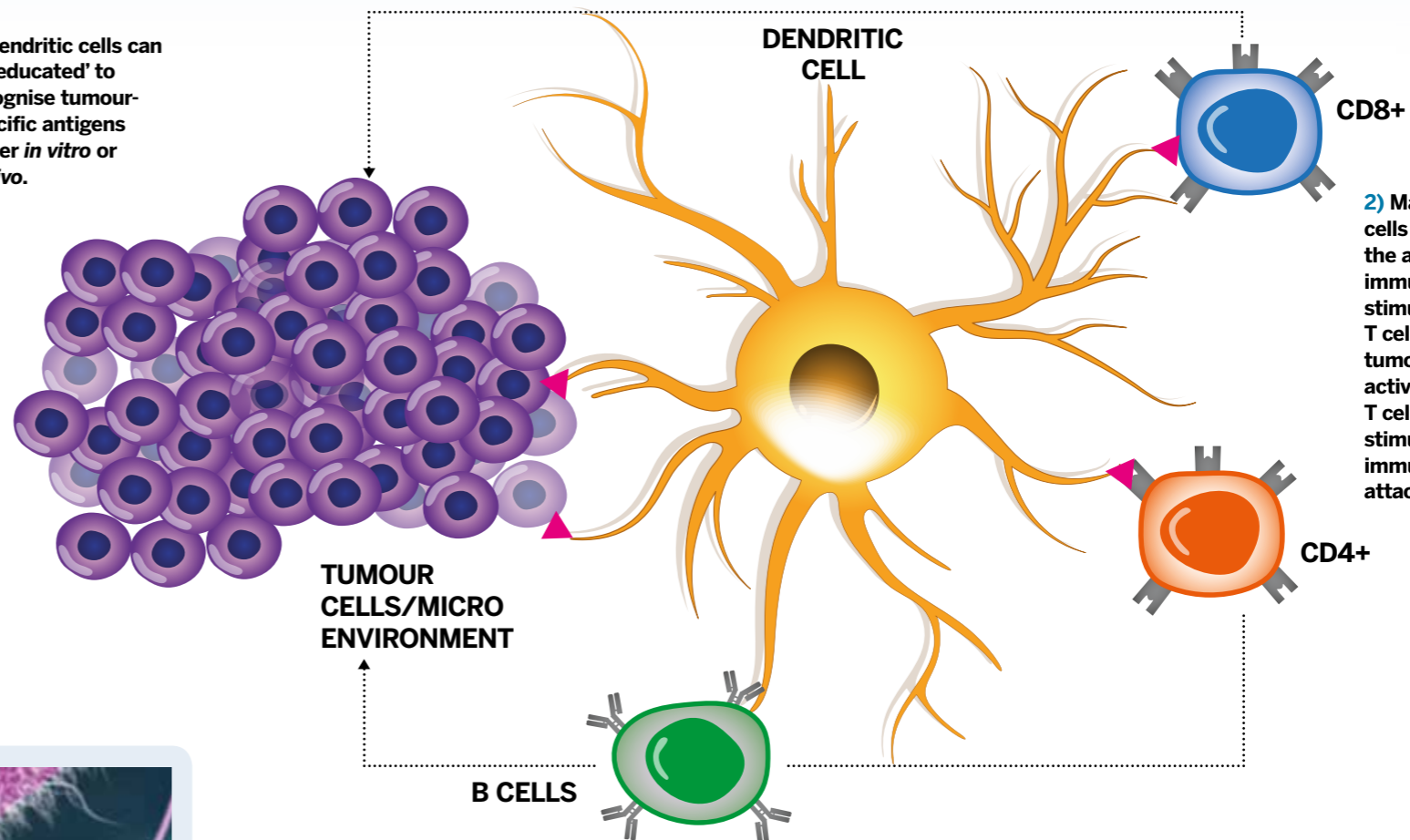
Unlike other immunotherapies, which can cause dangerous ‘storms’ of immune system activity, cancer vaccines have not raised any significant safety concerns – the main problem so far being a disappointingly weak response from the immune system. However, there can be side-effects, including infections or allergic reactions at the site of injection where whole cells or viral vectors are used.

A limited number of trials reported that vaccinated cancer patients did less well than unvaccinated patients, leading some to conclude that certain methods of presenting antigens can lead to ‘sleepy’ or deactivated T cells. The effect of cancer vaccines on long-term health has not yet been evaluated, either.

CELL MATES: CANCER ANTIGENS AND THE IMMUNE SYSTEM

Dendritic cells play a key role in presenting cancer vaccines to the immune system

1) Dendritic cells can be ‘educated’ to recognise tumour-specific antigens either *in vitro* or *in vivo*.



2) Mature dendritic cells then ‘present’ the antigen to the immune system, stimulating CD8+ T cells to attack the tumour directly or activating CD4+ T cells, which stimulate other immune cells to attack the target.



95–98%

of tumour-associated antigens are expressed at times by other, healthy cells, meaning the immune system is likely to ignore them

Special delivery

Vaccine antigens may be injected directly, but there are several approaches to delivering the vaccine ‘payload’ into patients that can be more effective.

Cellular vaccines These involve the injection of live cells primed to display the target antigen to other immune cells. These are often dendritic cells, which carry out this role in the body anyway. Cellular vaccines may also be made from whole or parts of tumour cells that have been killed and modified to stimulate an immune response.

Viruses These are useful vectors for transporting material into cells. The viral material also helps stimulate an immune response.

Bacteria Strains such as *Salmonella* can also be used as vectors for cancer vaccines, although results have been less successful.



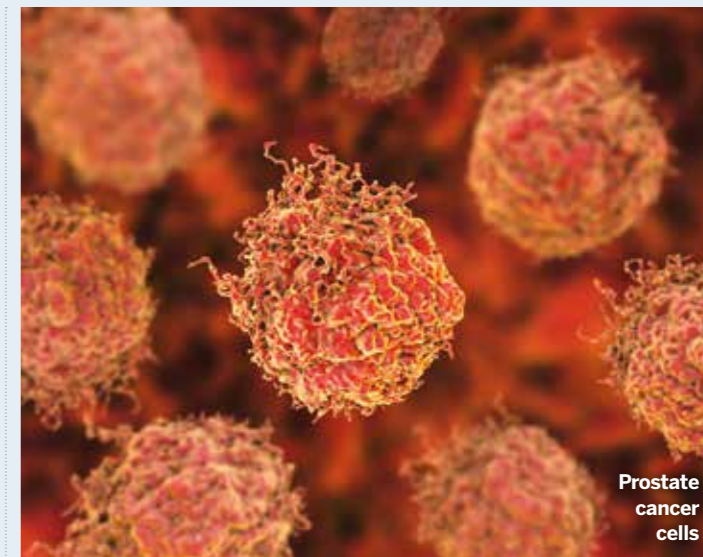
“After a period of great doubt, we are now back in a period where there is a great deal of excitement”

Professor Christian Ottensmeier

Success stories

While no cancer vaccines have been approved for use in Europe yet, one vaccine, Sipuleucel-T (known as Provenge) has been approved in the US to treat prostate cancer. Immune system cells are taken from the patient’s blood and differentiated into dendritic cells. They are then exposed to the target antigen, a protein called prostatic acid phosphatase, found in cancer of the prostate. The dendritic cells are then infused back into the patient several times over the space of two weeks.

A new cancer vaccine that is being developed in the UK for lung cancer, known as AST-VAC2, is based on the same principle, but for the first time uses dendritic cells from a single



human embryonic stem cell line, rather than requiring cells to be cultured from the patient. Currently at Phase 1 in clinical

trials, this new technique has raised hopes of an ‘off-the-shelf’ – and therefore less expensive – cell-based cancer vaccine.

MEMBERS

A snapshot of our members at work and leisure



Evelyn Keaveney is assessing how the management of lakes affects their ability to store carbon

A day in the life...

Evelyn Keaveney MRSB, carbon cycling researcher and teacher

Evelyn Keaveney MRSB studies carbon cycling in lakes at Queen's University Belfast. She hopes to better understand what determines whether lake ecosystems add to atmospheric carbon or act as carbon sinks. She can be found on Twitter @ceibheannaigh

FIRST THING IN THE MORNING...

I have breakfast at work and check my emails, and if I'm not doing laboratory or fieldwork, I begin a 'do not disturb' writing session for two hours. During this time, the aim is just to write – no reading or checking emails. It really works, although it does require discipline!

MY RESEARCH INVOLVES...

Looking at carbon storage in lakes. I'm interested in how lake management can affect whether lakes store carbon or are net sources of carbon to the atmosphere. I use radiocarbon to tell the source of carbon from its age. So, for example, I can tell the difference between carbon from 'within lake material' such as algae versus terrestrial carbon such as peat, based on the age.

I'M CURRENTLY...

Working on Rostherne Mere, Cheshire, a very eutrophic lake due to its limestone

bedrock. A sewage plant ran into the lake from the 1930s until 1991, which led to artificial eutrophication. The resulting algal changes altered carbon accumulation – as cyanobacteria became more dominant during that time, more carbon was buried. When the sewage was diverted in 1991, carbon accumulation actually went down.

So you could allow eutrophication and carbon storage at the expense of fish in the lake, or encourage the natural biology of the lake – depending on whether climate change mitigation or biodiversity is your goal. What my work does is feed into lake management strategies so we can try to achieve a balance and find the optimum community structure to promote carbon burial.

MY FIELDWORK INVOLVES...

Taking samples at the lake a few times a year. My grant is very small, so I have to maximise what I can do – I often piggy-back on the sampling schedule of teams already working out on the lakes. I do all the radiocarbon dating myself. My friends joke about me sitting and watching my water samples evaporate, which is actually like watching paint dry. Then there are lots of other pre-treatments: we have to purify and convert all the different types of sample

we've taken into graphite to go in the accelerator mass spectrometer. So even a sample of lake water ends up as graphite. It probably takes around a week.

I ALSO...

Do a bit of teaching and a lot of interacting with the public about my research. It's really nice when people come to find out about carbon-dating mummies and end up being interested in my research. I've also done events such as Soap Box Science and New Scientist Live, and even the National Waxworks Museum – it was really weird to be sitting in a corner talking about fossils with people who'd come in to see David Beckham.

AFTER WORK...

I tend to leave work at about four or five o'clock and I head home and try to switch off for the evening. If I'm in the middle of intensive field or laboratory work, I will work late, but I try to keep evenings and weekends free to enjoy my other interests.

I live with my fiancé in Lisburn and we go to a lot of sports matches – I love Gaelic football and rugby, but I follow Manchester United so I don't watch so much of those any more...

The career ladder

Dr Tina Joshi MRSB on her movie inspiration and her love of lecturing

Inspired by the disaster film *Outbreak*, Dr Tina Joshi MRSB is now a lecturer in molecular microbiology specialising in microbial diagnostics and infection control. She works at the University of Plymouth.

I FIRST DISCOVERED BIOLOGY...

When I was encouraged to garden and grow plants at a young age. As time progressed, I realised I really enjoyed biology. When I first watched *Outbreak*, I realised I wanted to be a microbiologist and study infectious diseases.

I STUDIED...

Microbiology – I was keen to specialise in that area early on. At the time, it wasn't routine to do a year in industry and I went on to do a PhD in pharmaceutical microbiology straight afterwards. That led to a postdoctoral scientist position, and in 2017 I secured a lectureship at the University of Plymouth.

CURRENTLY I AM...

A full-time academic lecturer at the University of Plymouth. My areas of research include the development of molecular diagnostic innovations to tackle infectious diseases, including antimicrobial resistant bacteria, at point of care and infection control. I teach clinical microbiology to biomedical science, healthcare

science, dental and medical students, and enjoy every minute of it.

A PIVOTAL POINT IN MY CAREER WAS...

When the funding ran out! It was clear it would be difficult to remain in the same postdoctoral role, so I realised I had to push myself and my career forward by applying for other jobs. I took a leap of faith and applied for several

lectureships. The day I got my lectureship changed my life for the better and I'm so much happier.

THE BEST THING ABOUT MY JOB IS...

Teaching students about the latest developments in biology.

THE WORST THING ABOUT MY JOB IS...

Nothing at the moment! I love it.

THIS IS AN INTERESTING AREA TO WORK IN BECAUSE...

Antimicrobial resistance is a hot topic right now on the global stage. Plus there are new DNA-based innovations such as the nanopore, which can tell us so much about the microbiome and microbial world around us. Who wouldn't want to be a microbiologist right now?

A KEY PIECE OF ADVICE WOULD BE...

Take that leap of faith and believe that you can take the next step in your career. As they say – if you don't try you won't ever know. I pushed myself out of my comfort zone and now I'm more comfortable than ever.

IN THE FUTURE I HOPE TO...

Progress within my institution to become the lead for a degree programme, and I hope to be a professor one day.

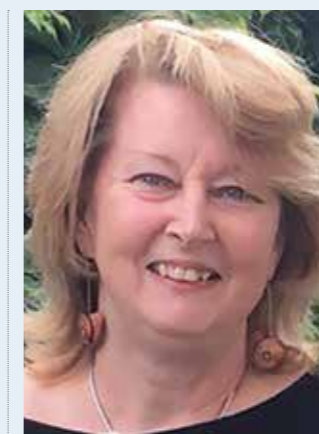


My Society and me

Maggie Linford FRSB is heavily involved with RSB's school biology competitions

I retired from my last teaching job in 2014 after 40 years at the chalk face, but felt that I still had more to give. I first heard about the British Biology Olympiad in 1996 when it was a small pen-and-paper competition and entries were posted to Norma Broadbridge (now deputy chair of UK Biology Competitions, or the UKBC, a special interest group of the RSB).

Over the years, many of my students entered this



competition. Before I retired, I became involved with the competitions as an RSB Committee member and I am now secretary of the UKBC.

The competitions have evolved to be wholly online and there are now three for different age groups. Last year, the International Biology Olympiad was held in the UK at Warwick, with around 70 countries taking part. It was a mammoth two years bringing the event to fruition.

The questions for the national competitions are written by a small group of volunteers, including retired and current teachers and past IBO medallists. I enjoy working with this amazing group of people both with the UKBC and the RSB. I love the week-long trips abroad to meet the International Biology Olympiad community and I really wish more teachers would become involved. It keeps the brain ticking over.

Opportunities, awards and events

A round-up of upcoming RSB activity to look out for

VOLUNTEER

The Society is gearing up to celebrate biosciences as part of **Biology Week 2018**, which starts on 6th October. For information about volunteering, organising an event or resources to help your school or university get involved, contact Ellie Oakley via events@rsb.org.uk

CAREERS

The Society's third **Bioscience Careers Day** will take place in October. The event is aimed at undergraduate and master's students, but PhD students, postdocs, careers advisers and school/college students are also welcome. The event will run from 10:30 to 16:30 on 27th October at Manchester Metropolitan University and costs £10. Contact Ellie Oakley via events@rsb.org.uk

LUNCHEAS AND RECEPTIONS

The Society will hold an **informal Fellows' lunch** in Cardiff to discuss current issues and the Society's overall direction. The free, invite-only event will be hosted by Professor Nigel Brown OBE CBiol FRSB, and will be on 13th September, 12:30–14:30.

As part of Biology Week 2018, RSB chief executive Mark Downs will be hosting a free and informal **canapés and drinks reception** for members in Northern Ireland on 8th October from 18:00 to 20:00.

INFORM STRATEGY

RSB Member Organisations are invited to attend a **workshop on the Society's**



Learning about microscopes at Biology Week 2017

strategic plan for 2018-21. The free event runs from 12:00 to 15:00 on 15th August. One representative from each full Member Organisation is invited. Email rachel.lambertforsyth@rsb.org.uk.

The Heads of University Biosciences (HUBS) will be holding its **first annual meeting** at the Wellcome Sanger Institute in Cambridgeshire next year. The conference, which takes place on 30th April and 1st May, will include sessions on research, higher education policy, and teaching and learning in the biosciences. There will also be networking opportunities, poster sessions and tours of

the institute on the Wellcome Genome Campus. Email hubs@rsb.org.uk

POLICY EVENTS

Scientists in Scotland should save the date for the **18th Science and the Parliament** event at Holyrood on 14th October from 12:00 to 20:00. Organised by the Royal Society of Chemistry, the event will draw people from across the science and engineering community who are active in the education, public, private and third sectors, as well as policymakers and politicians. Full details will be posted on www.rsc.org closer to the event.

MEMBER NEWS

Congratulations to all our Members and Fellows named in this year's Queen's birthday honours list (see p4). Well done also to Duncan Vaughan CBiol MRSB, senior environmental specialist at Natural England, who has been awarded the Churchill Medallion by the Winston Churchill Memorial Trust.

The honour marks the successful completion of his overseas research as a Churchill Fellow. Vaughan travelled to Norway, the Netherlands, Belgium, France and the United States to investigate how marine planning could deliver environmental benefits.

Education and training

The Society's programme of courses and workshops

LABORATORY HEALTH AND SAFETY TRAINING, INCLUDING COSHH

14 September, 10:30–16:30, Newcastle University

A one-day course for members working in biological containment laboratories and those keen to acquire relevant skills for progression to supervisory and laboratory management roles.

**15 CPD points
£60 + VAT**

MINUTE-TAKING MASTERCLASS

13 November, 09:30–16:00, Charles Darwin House, London

A course in which participants learn how to filter conversations so they can capture the main

points, motions, decisions and actions in fast-moving meetings. They will also practise producing clear and informative minutes.

**18 CPD points
£120 + VAT**

SECURING FUNDING FROM GRANT-MAKING TRUSTS

14 November, 09:30–16:30, Charles Darwin House, London

This one-day course provides hints and tips as well as helping participants read between the lines to understand what funders are asking for.

**18 CPD points
£110 + VAT**

learn.rsb.org.uk



The RSB now has more than 18,000 members

ASSOCIATE (AMRSB)

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BIOINSPIRED DEVICES: EMULATING NATURE'S ASSEMBLY AND REPAIR PROCESS

Eugene C Goldfield
Harvard University Press, £32.95



Bioinspired designs have come a long way since Ovid's story of Daedalus and his legendary attempt to make wings. George De Mestral's invention of Velcro in 1948, inspired by burdock burrs, has certainly been far more successful. Nature-inspired research has influenced innovation in fields as diverse as medicine, engineering and renewable energy technology, to name a few. There are now a number of academic journals devoted to biomimetics, bioinspired design and bioderived materials. Goldfield describes much of the research at the Wyss Institute for Biologically Inspired Engineering at Harvard.

Throughout the text, he provides up-to-date illustrations of how bioinspired research principles have been applied, bringing the work to life. With good humour, he uses examples of familiar science fiction to illustrate how far things have come. For example, Wallace and Gromit's visit to the moon made of cheese, which features a comic vision of a self-assembling, autonomous robot skiing over the lunar landscape, is compared to real-life 'self-healing' materials inspired by pitcher plants.

The founding principles of design based on nature are based on physical laws and the dynamics of complex systems.

Exploring these underlying principles and how they have been applied makes up the



Downy woodpecker

first section in the book. There are descriptions of robo-bees and soft-bodied octobots that function using microfluidic circuits rather than electrical ones.

This is followed by specific work relating to the structure, function and repairs to the nervous system that emulate responses by nature. This gives hope for possible future therapies and regenerative treatments of cerebral palsy, stroke and schizophrenia.

The readable style, interesting illustrations and humorous anecdotal accounts make this book a good read. It provides a rich tapestry of examples that will hopefully inspire further developments in the design of materials, drug action and robotic devices.

Alexander Waller

ANIMAL VOCAL COMMUNICATION: ASSESSMENT AND MANAGEMENT ROLES (2nd EDITION)

Eugene S Morton
Cambridge University Press, £75.00



Animal Vocal Communication covers the history of animal communication theory, its ethology, form and function, and in this second edition the replacement of the long-standing dogma in vocal communication. This is the 'new approach' in which assessment by the receiver of communication is the central driver in evolution, replacing simple information transmission. If communication is looked at in this way, how animal communication really functions can be explained.

The long-standing view is that animal communication functions primarily to transmit information, either 'honest' or otherwise. Chapter two, the focus of the text, looks at the changing view of how communication is understood and analysed by the receiver. In some cases, the assessment of the communications by the receiver does not always match its supposed function. An example is the downy woodpecker, where a general contact

communication between individuals can be associated with an 'all-clear of predators' signal. Thus the bird can assess the signal and manage it according to their situation.

The section on the origin of vocal communication, in chapter three, has an in-depth look at individual size as a component of selection. Size expression is included in vocalisation, with low, harsh sounds indicating a challenge would end in an



Burdock burrs were the inspiration for the invention of Velcro

aggressive contest. The growl quality of the sound is important to the strength of the individual in terms of aggressiveness.

Animal Vocal Communication is an academic text that challenges the way researchers approach animal vocal communication. The wealth of examples in each chapter aim to show that the sender is the manager of communication, while the receiver is the assessor of it. Perhaps the most dramatic example of the assessor role is that of the ground squirrel and rattlesnake. Morton describes the situation of a rattlesnake entering the squirrel's burrow as a narrative of the event by placing the reader in the burrow. What the squirrel does is fascinating and can be read in the introduction section.

The standard of this text is exemplary, detailed and exhaustive in its behaviour research, explanations and examples. It is a work of considerable effort and expertise.

Pat Sang MRSB

HUMAN ERRORS

Nathan H Lents
Weidenfeld and Nicholson, £16.99



As Alexander Pope said: "Trust not yourself, but your defects to know" – after all, "perfection is a trifle dull". *Human Errors* is a description of some of our 'defects', many of which are peculiar to humans, but a number of which, such as the presence and replication of 'junk' DNA, are common to all multicellular

organisms, and a number of which are common to all vertebrates (such as the 'unnecessary' path of the recurrent laryngeal nerve passing underneath the aorta before returning up the neck to the larynx).

The author admits that his survey covers only a fraction of the design faults in the human body, but it is still surprising that he does not describe one that most people are familiar with, our useless appendix. The book also describes some of our mental insufficiencies. An anecdote is used to explain why we tend to believe anecdotes rather than more objective information. The book is written for a US audience and in a politically correct manner uses 'she' and 'her' whenever referring to human behaviour.

Despite our errors, life expectancy – especially in the developed world – has increased substantially, but has come with an increasing impact on the planet. The author places great faith in science and medicine as saviours of humankind. In particular, he says that the "real prize is the search for immortality" (and, indeed, he admits that given recent advances in aging research, he has taken up exercise and stopped smoking in order to be alive when such advances may be of use to him).

Surely, however, goodness should be one's ultimate goal, rather than the prevention of death. As Schopenhauer said: "To desire immortality for the individual is really the same as wanting to perpetuate an error forever." But then I now wear a T-shirt

that says that I am a founder member of the 'Grumpy Old Men's Club' so my own opinions need to be taken with a pinch of salt.

Jacques Derek Charlwood

INVASIVE SPECIES: RISK ASSESSMENT AND MANAGEMENT

Andrew P Robinson, Terry Walshe,
Mark A Burgman and Mike Nunn (Eds)
Cambridge University Press, £39.99



Most plant and animal species can be described as invasive in a geological context, spreading from their centres of evolutionary origin to the world beyond.

However, since the age of exploration began in the 14th century, a different kind of invasion, associated with human activity, has become established on an accelerated time frame.

The introduction and spread of individual species has been both deliberate and accidental, and has had varying forms and degrees of impact. Today, the issues are becoming increasingly complex, given the backdrop of a warming world and all the unknowns that entails, plus the globalisation and intricacy of trade and travel, as well as increasing human populations.

It is also important to recognise the potential adverse effects that invasive organisms might wreak on the biogeography, ecology, agriculture and economy of a region. *Invasive Species* focuses on methods to quantify such risks, determine the scale and threat of pest and pathogen invasion, and formulate solutions to generate quarantine and biosecurity policies.

The emphasis is on multidisciplinary approaches, with reference to the research of Australia and New Zealand's Centre of Excellence for Biosecurity Risk Analysis. There are 18 chapters that present methodologies to tackle these issues. Topics range from identifying the problem to difficulties associated with declaring the eradication of an invasive species and an examination of the resources needed to establish biosecurity programmes. This is a book for the specialist, but its message is strong: safeguarding environments and economies in a rapidly changing world is complex but essential.

Dr A M Mannion

LAGOMORPHS: PIKAS, RABBITS, AND HARES OF THE WORLD

Andrew T Smith, Charlotte H Johnston,
Paulo C Alves and Klaus Hackländer (Eds)
Johns Hopkins University Press, £66.50



Andrew Smith and his colleagues have produced an outstanding book that summarises the current knowledge of the world's 92 species of lagomorphs in one reference volume. Drawing on the expertise of 82 specialists on lagomorphs, this is a truly comprehensive reference work that provides detailed, species-specific information as well as a review of the ecological role of lagomorphs.

Following introductory chapters on the evolution, systematics, introductions, diseases and conservation of pikas, rabbits and hares, detailed information is provided for each species. This includes scientific and common names, a contemporary range map and description, a detailed description



A pika gathers food for its 'haystack', which will help it survive the winter

REVIEWS

of appearance together with morphological measurements, accompanied by high-quality colour photographs of most of the species.

Discussions of relevant palaeontological data, taxonomy and geographic variation follow, and are iterated for each species. Information on ecology, habitat, diet, behaviour, genetics and physiology, reproduction and development, as well as parasites and disease, are also included.

The book is written in a very accessible style, heavy with factual material, but presented in straightforward language and conveniently grouped under relevant headings. Information related to any one species is easy to find and presented succinctly. The discussions bring knowledge and understanding right up to date and are very much to the point without being over burdensome. As such, *Lagomorphs* is accessible to the general public as well as the scientific community.

This is, without doubt, a definitive reference work that will be useful to anyone with a serious interest in these animals, but particularly professional biologists, students at all levels and naturalists in general. There is such breadth of coverage that anyone working in fields that involve lagomorphs, such as conservation or biodiversity, will find use for this book.

Dr Alan Woolhead

MAKING SENSE OF GENES

Kostas Kampourakis
Cambridge University Press, £32.99



What is a gene? This sounds like a simple question, but dig a little deeper and it isn't quite as clear as it first seems. This question is just one of the themes covered in Kostas Kampourakis's cleverly written book.

To answer such questions, the reader is first given an introduction to the world of 21st century genetics. Starting with



Students need to hone their report-writing skills if they are to progress to writing academic papers

Mendel's famous pea experiments, the past 150 years of genetics, right up to the 'postgenomic' era, is described in a logical and timely manner. The book also clarifies time, myths and common misconceptions that have evolved alongside the facts.

Each topic throughout the book is accompanied by clear, informative figures and examples to help explain concepts, many of which may not be familiar to the average reader. Further explanations are also aided by comparisons of DNA in development and disease to *The Phantom of the Opera*, a link that works better than it ought to!

After explaining the intricacies of genetics, Kampourakis cleverly concludes the book by highlighting the numerous limitations facing those working with genes, as well as those whose lives are affected by their genetics every day.

The book covers numerous topics in detail, from DNA replication, independent assortment and splicing, to the role of

genetic variation in determining traits such as eye colour and gender, and in diseases such as cancer.

While the topics may not all be suitable for an absolute beginner, *Making Sense of Genes* would be an attractive read for anyone studying, or with an interest in, genetics.

James Poulter MRSB

WRITING UNDERGRADUATE LAB REPORTS: A GUIDE FOR STUDENTS

Christopher S Lobban and Maria Shefter
Cambridge University Press, £12.99



Writing reports is an important skill that students have to build on during their degrees in order to explain their results in a clear and concise way. This book is a very useful guide for students looking to better understand the composition of a laboratory report and it actually covers more than the title would suggest.

It not only looks at how to produce undergraduate laboratory reports, but also discusses how to progress onwards to the production of academic papers – a very useful insight in itself.

The reader is guided through the structure and content of report sections such as Introduction, Methods and Materials, Results and Discussion, and provides tips for the title, abstract and references. The layout makes it easy to flick between the sections so the book does not have to be read in its entirety if the reader has a specific difficulty.

Sketches and diagrams have been added to prevent the book from being too text heavy, and it is a relatively easy and quick read.

Overall, it is a helpful guide for those wishing to know more about how to produce laboratory reports. Although students are clearly the focus of this book, it would also be appropriate for anyone expected to produce these types of reports for the first time.

Natalie Lamb MRSB

ASTROBIOLOGY, DISCOVERY, AND SOCIETAL IMPACT

Steven J Dick
Cambridge University Press, £54.99



An evocative front cover indicates the nature of *Astrobiology, Discovery, and Societal Impact*: the cosmos, and what would happen should humans discover life other than that on Earth.

The author asks if humans can move on from thinking 'life' must be as it is known now on this planet, because maybe life is out there but very different. The chapter looks at fundamental life types on Earth, where carbon is the scaffold upon which all life is built. But what about life beyond our preconceptions of what life must be? The author says humans need to move their mindset beyond what is known.

The book is divided into three parts, with chapters covering ideas such as the impact on society when non-Earth life is confirmed and how we might embrace the knowledge of such life. One factor in accepting other life is to stop thinking of the universe as a purely physical thing and move towards the concept of a 'biological universe'.

The author introduces the inevitable factor of religion in chapter seven and all the ramifications of knowing that neither humans nor planet Earth are special

How will humankind react if we discover extraterrestrial life in the course of space exploration?

creations. Naturally, the impact of finding life elsewhere in the universe could be greater for the religious person than those who have no beliefs.

When other life is confirmed, which laws would be valid? Would there be 'metalaw', which is universal in meaning and breadth. These issues are discussed under the wonderful heading 'Astropolicy'.

Much of the book is reflective, putting forward what has been known and expressed before, and analysing that in light of new knowledge and acceptance of the possibility of extraterrestrial life. If you are prepared to open your mind and get away from anthropocentric views, take this book and explore the actions already taken by governments for when the big day comes and we find out we have extraterrestrial neighbours.

Pat Sang CBiol MRSB

LIFE ON EARTH: OCEAN

Heather Alexander
Wide Eyed Books, £9.99



This is a colourful and inviting hardback children's book, with simple, clear text and beautiful illustrations. Each double-page spread of information has a particular focus, be it 'sharks', 'shells' or 'how the creatures move'.

The pages are littered with questions and key facts about ocean life: is a shell fish a fish? How do oysters make pearls? Why do fish feel slippery? Great questions such as these are answered in simple terms for younger readers as well as anyone with an interest in oceans, marine life and science.

More than 70 flaps lift up to reveal answers to questions and to supplement the already quite detailed information on the pages.

Lift-the-flap books can be fiddly and prone to ripping, but this book's flaps are small and well placed, so the book should last well.

How often do we stop to think about the lives of feral pigeons?



Another bugbear about such books is that the first reader ruins the surprise for the next, but these flaps can be resealed so it feels like you are the first reader each time.

Kulvinder Kaur Johal

THE GREATER WORLD OF LITTLE THINGS

Ross Gardner
Brambley Books, £8.99



I didn't know what to expect when I offered to review this book. Was it a book on microscopic life, a tour of invertebrates or something different? It was the last of these and the author has portrayed the world through a different type of lens. Ross Gardner, who has worked in environmental and conservation roles, has taken the common and overlooked aspects of the living world and asked us to look at them from a different viewpoint.

I was particularly fascinated by the chapters on pigeons and bumblebees, and how, although we see these often through the year and find them commonplace, we don't really look and observe them or think about their place in the ecosystem. From sitting in a car park observing feral pigeons to collecting data on bumblebee flower preferences, each chapter takes a different aspect of the living world around us and asks us to think about it again.

Chapters are grouped into sections with an introduction to each – I found these a little rambling and difficult to follow, but the chapters themselves were enlightening. You do have to open yourself up to different viewpoints when reading this text, but it definitely makes you think about the world around you, your part in it and how the myriad creatures play out their lives without a thought from ourselves. A thought-provoking book – I will definitely look again at the little things around me.

Janet Preece CBiol MRSB

ME AND THE BIOSPHERES: A MEMOIR BY THE INVENTOR OF BIOSPHERE 2

John Allen
Synergetic Press, £40.00



This is the autobiography of the visionary behind the Biosphere 2 project, a huge closed-system research facility built in Arizona and sealed in 1991 with eight 'biospherians' living inside it. To dream up such a vast and forward-looking project it took an unusual and enterprising person. John Allen – poet, author, mystic, existentialist, engineer and scientist – used all his skills and those of many others to fulfil his dream.

The many activities and projects of Allen's Institute of Ecotechnics prepared the way for the ambitious Biosphere 2, and include the Synergia Ranch in Santa Fe, a hotel in Nepal, a ranch in Australia and the Heraclitus, a Chinese junk ship with a concrete hull. Training in all these varied circumstances prepared the eight people who would spend two years inside Biosphere 2.

The projects of the institute also contributed much to finding ways of sustainable living. Allen was obviously a leader, a team builder and a motivator in spite of his unusual qualifications for the task he set himself. Biosphere 2 had its problems but it paved the way for further research on closed ecosystems, was a useful experiment in community living and has had more significance for the study of climate change than the originators ever imagined.

Built with a 100-year lifespan, Biosphere 2 has continued to be an important facility for further research long after the original founding group left the site. This book is fascinating reading on how to achieve the almost impossible through vision, teamwork and persistence against all opposition.

Ghillean Prance CBIol FRSB

WILSON AND WALKER'S PRINCIPLES AND TECHNIQUES OF BIOCHEMISTRY AND MOLECULAR BIOLOGY (8th EDITION)

Andreas Hofmann and Samuel Clokie (Eds)
Cambridge University Press, £115.00 (hardback), £39.99 (paperback)



Now in its eighth edition, and with new editors, *Wilson and Walker's Principles and Techniques of Biochemistry and Molecular Biology* is a compact textbook, barely half the size of fundamental texts, but still containing a wealth of details. Several chapters have been added for this edition, including genomics, bioinformatics and data analysis, and this book focuses on the theory behind techniques.

Each chapter starts with explanations of the fundamental principles of biology, chemistry or physics that underpin the analysis. The types of question the techniques are designed to answer are then discussed and the details of the techniques explored. Examples and case studies help guide the reader through how a real-world situation might develop. A combination of diagrams, idealised graphics and real-world data is used to illustrate the concepts.

While some of the techniques discussed are more for historical context, the new informatics sections are particularly easy to follow and relevant, since modern molecular biology requires a comfortable familiarity with these tools. There are excellent walk-throughs for these techniques to help the reader, without the text becoming overly complicated.

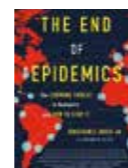
This book should not be treated as a fundamental biochemistry and molecular biology text, but each chapter is a highly informative and detailed description of how to undertake different types of experiments and analyse the results.

Dr Ellis O'Neill



THE END OF EPIDEMICS: THE LOOMING THREAT TO HUMANITY AND HOW TO STOP IT

Jonathan D Quick and Bronwyn Fryer
Scribe Publications, £14.99



As another Ebola outbreak hits the Democratic Republic of the Congo, the world is reminded that we are never far from the next epidemic. The battle against infectious disease is far from – and probably never will be – won. The 2014 Ebola epidemic in Sierra Leone, Guinea and Liberia was terrifying but, it might be said, was fairly small and contained compared with the 1918 influenza pandemic that killed 50 million people.

The End of Epidemics is a substantial, well-structured and comprehensively referenced text, although it may have only limited value as an undergraduate or reference text. However, it will be hugely valuable to anyone with an interest in any aspect of healthcare and infectious diseases, from public health and epidemiology to prevention, containment and treatment, as well as to ecologists and environmentalists.

The authors list seven sets of key actions needed to prevent and to cope with epidemics: bold leadership; developing and maintaining resilient health systems for all; strengthening key lines of defence against disease to prevent, detect and respond; timely and accurate communication; investment in innovation; investment in prevention before the next epidemic strikes; and citizen activism.

There are salutary reminders of the critically far-ranging impact of global epidemic infectious diseases – described

as the 'epidemic cascade' – including the wider healthcare consequences and the social, business and economic impacts of epidemics. If still unconvinced, the authors remind us of the economic cost of recent epidemics and pandemics – £3.77bn for BSE and £7.5–£11bn for foot-and-mouth disease in the UK; £22–£38bn in east Asia for SARS; and globally even more for the H5N1 and H1N1 influenza epidemics – to say nothing of the personal loss and distress, pain and suffering they wrought.

The book contains more than its cover might suggest, with technical information and examples that provide a sound foundation and the building blocks for further study. It offers well-informed analyses of existing and projected medical dangers and presents a well-thought-out programme for averting catastrophic loss of life across the planet.

The book's subtitle, 'The Looming Threat to Humanity and How to Stop It', is an optimistic but in all probability unrealistic expectation, though we must hope that enough lessons can be learned to reduce the impact of epidemics in the future.

Ian Blenkarn FRSB

BEYOND BIOETHICS: TOWARD A NEW BIOPOLITICS

Osagie K Obasogie and Marcy Darnovsky (Eds)
University of California Press, £27.00



The dramatic pace of scientific discoveries in recent decades has not only led to remarkable improvements in domains such as healthcare or forensics, but has also posed new questions and challenges to society. How do we deal with privacy in an

age of commercialised genome sequencing? How do we decide to incorporate concepts of race, gender and class into our restructured healthcare system? These thorny issues and many more are tackled in *Beyond Bioethics*.

The book itself is a collection of dozens of essays by bioethicists, activists and thinkers from a range of disciplines, collected and curated by Osagie Obasogie and Marcy Darnovsky. Grouping these essays into thematic categories, the imposing bioethical problems of our age are investigated one by one. While the negative outlook provided by many essayists may sometimes seem overwhelming, the diversity of opinions and approaches does justice to the importance of topics such as surrogate pregnancies, negligence of underserved segments of the population, or the finicky subject of who is testing the drugs of the future in clinical trials.

In fact, as the editors of the book argue,



Carlton K Erickson's book explores a range of issues around addiction, from its molecular and neurobiology to stigma and semantics

Though the idea of us 'ending' large outbreaks of disease is unlikely, *The End of Epidemics* provides a comprehensive study of how best to deal with them in future

as the age of bioethics which focused on the individual draws to a close it should be superseded by biopolitics focusing on whole societies (and ideally the world). As this includes every potential reader, the issues presented in this book and their eventual solution concern every one of us, which is why I urge everyone to inform themselves about these topics.

Daniel Bojar

THE SCIENCE OF ADDICTION: FROM NEUROBIOLOGY TO TREATMENT

Carlton K Erickson
WW Norton & Company, £22.99



The second edition of *The Science of Addiction* provides a solid foundation for anyone wanting to learn more about this area plus in-depth information for professionals.

An expert in his field, author Carlton K Erickson introduces various fundamental concepts, from the stigmas associated with addiction, the molecular biology and pathways associated with addiction, and current treatments. He also states that we shouldn't be using the word 'addiction' as much as we are: 'addiction' to computer games or fatty foods is demonstrably not the same as disastrous physical and mental dependence on addictive substances, and only serves to promote misunderstanding about the condition.

This insightful and illustrative text has particularly engaging chapters on alcohol, the world's most common addiction. Erickson not only discusses the scientific background, he also incorporates much socio-political thoughts in to the text that other authors might not. The abundance of information is well written and formatted in an easy-to-read manner, and benefits from a pedagogical approach to learning. If only I had had this book for my degree.

Callum Tebbatt

Biosphere 2 contributed more to science than its founder John Allen could have imagined



REGIONAL GRANTS

RSB-funded events and activities in the past year

The RSB's regional grants programme funds members to run an event in their region. We hope this run-down of our recent grant-funded activities will inspire you to start planning for our next round of grants in 2019



Visitors enjoy a birds of prey demonstration at ECO-FEST



Female role models in science at the University of Wolverhampton

WOMEN IN SCIENCE

PROMOTING DIVERSITY

Three grant-funded events over the last 12 months have aimed to celebrate female scientists and encourage girls to study science. In October 2017, academics from the University of Wolverhampton hosted more than two hundred children from local schools in Birmingham and the Black Country to showcase female role models in science. The event coincided with Biology Week, the International Day of the Girl Child and Black History month. As well as Q&As with leading female researchers from the university, there was a screening of *Hidden Figures*, a drama about African-American women hired by NASA during the US space programme in the 1960s.

At the same time at Aarhus University, Denmark, six laboratories opened to girls aged nine to 15, including the institution's Interdisciplinary Centre for Nanoscience. A second event, the Saturday of Science, was for boys and girls of all ages and their parents to learn more about topics as diverse as climate change, plant communication, ageing, bradycardia, ecoinformatics, DNA and atoms. The organisers report that two groups of researchers from two research institutions who had not met before have as a result now formed a network with possibilities to collaborate.

In March this year, 240 Rainbows, Brownies and Girl Guides gathered for an

afternoon of 'science in the sunshine' in Waterbeach, Cambridgeshire. The event, organised by RSB member and girl-guiding volunteer Holli Bielby (MRSB), involved 70 adult volunteers helping to deliver 50 science activities. Rainbows (aged five to seven) particularly loved exploring the nature garden, where they hunted for hidden butterflies and identified trees by their leaves or fruits. Brownies (aged seven to 10) were equally fascinated and gossiped out by the contents of an owl pellet, and learned micropipetting. Guides (aged 10 to 14) tackled some of the more advanced activities on offer: extracting DNA from bananas, preparing onion-cell microscope slides and dissecting daffodils.

FUN AND GAMES

PLAYING WITH BIOLOGY

Organopoly is a board game developed by the University of Cambridge's Ralitsa Radostinova Madsen AMRSB and her colleagues Patsy Tomlinson, Adele Pinnock and Rachel Knox. The game borrows concepts from the well-known property-

based game, but instead of money, players use energy (ATP) to build systems made of organs and cells. As the game evolves, players learn useful facts about the human body and about the importance of a healthy lifestyle. A whole day event to launch the game was funded by the RSB as part of Biology Week 2017 and was attended by children and parents from around Cambridge. Resources from the game have since been requested by local schools.

In Malaysia during last year's Biology Week, staff and students at the Sekolah Kebangsaan Sri Pulau Perdana (SKSPP) Faculty of Biosciences and Medical Engineering hosted primary school children and their parents for a day of biology-based activities, including colouring and painting competitions, games, quizzes and talks aimed at encouraging interest in studying science.

As part of the Brighton Science Festival in February, Professor Alison Sinclair led a group of staff, researchers and undergraduate students from the University of Sussex to help visiting families learn about DNA and viruses. As well as extracting DNA from fruit, the more nimble-fingered visitors made inflatable viruses with one balloon inside the other to represent the capsid and envelope, decorated with pom-pom glycoproteins.

In March, more than 500 guests enjoyed DNA-based activities at a Science Discovery Day hosted by the University of St Andrews. Children learned about the concept and structure of DNA with the aid of folded

origami papers. Afterwards, children could personalise a short sequence and keep their own DNA bracelet. Organisers also created an illustration introducing the four main biomolecules and debunking common science myths such as 'the five second rule' for dropping food and the short memory of goldfish.

THE GREAT OUTDOORS

ECO-FEST ACTIVITIES IN CHESHIRE

On a glorious autumn day in Cheshire last year, the surrounds of Lower Peover primary school were the setting for ECO-FEST, a day of activities to investigate and appreciate the biology in the local area.

There were displays of birds of prey, pond dipping, identification and dissection, 'composting chaos', dragonfly craft activities and an earthworm survey, with Cheshire Wildlife Trust providing expertise. The day helped to restore the school's pond and create a community outdoor learning space.

THE GREAT INDOORS

PUB SHOWCASES SUPERPOWERS

Meanwhile in a Glasgow pub, 'Agent Laura', Lisa Di Meo and Kevin O'Dell FRSB from the University of Glasgow delivered an action-packed show about the science of superpowers. Featuring videos, demonstrations, audience interaction and a



Science outreach activities

gripping storyline, the event won The Herald Higher Education Award for Outstanding Contribution to the Local Community 2016.

Thank you to all our grant-funded event organisers:

Helen Carney (BioArt); Nicola Kelting (Ignite Curiosity); Diane Lees-Murdock (Dazzling Digestion); Melissa Lennartz-Walker (Bugs for Life: The Future of Food); Ralitsa Madsen (Organopoly); Wanda McCormick (Moulton's Big Biology Day 2017); Petula Nurse (The world of biology and female role models); Kevin O'Dell (Superhero Science); Julie Peacock (Ecology at Kirk Fenton); Catherine Williams (Girls in Biology); and Nor Zain (Biology Outreach Programme for Malaysia Primary School Children).

Events planned for Biology Week 2018

The Living City: How Biology is Woven into the Fabric of Dundee	Dundee
Photosynthesis in Virtual Reality	Midlothian Science Festival
BioBlitz Showcase: Inspiring Involvement in Citizen Science	South Devon
Become a Plant Health Detector	North Yorkshire
Find the Cure	Staffordshire University
Let it Flow: The Journey of a Red Blood Cell	STEM Outreach Centre, Kingston University
Me, You and the Superbugs	Festac Town, Lagos, Nigeria
A Blend of Biology and Beverage	Chapmanslade, Westbury

For details see rsb.org.uk/events



Children investigate the results of a pond dip at ECO-FEST

Event calendar August 2018 onwards



BEDS, ESSEX AND HERTS

AGM & BIRDS OF PREY LECTURE
Sunday 30 September 2018
 12:30–15:00

A two-hour talk on birds of prey by CJ's Birds of Prey team with a selection of birds and photographic opportunities, preceded by the AGM.
 Westmill Farm, Ware,
 Hertfordshire SG12 0ES

DEVON AND CORNWALL

BEHIND THE SCENES AT DARTMOOR ZOO
Tuesday 18 September 2018
 10:30–17:00

Keeper-guided tour of Dartmoor Zoo with talk by owner Benjamin Mee.
 Dartmoor Zoological Park, Sparkwell,
 Devon PL7 5DG

EAST ANGLIA

AGM, LUNCH AND A GUIDED TOUR OF TRUMPINGTON MEADOWS
Saturday 18 August 2018
 10:00–13:00

AGM at the Clay Farm Centre and a tour of Trumpington Meadows, which will depart from the nature reserve's Wildlife Trust office (CB2 9LH).
 Clay Farm Centre, Cambridge CB2 9FN

KENT, SURREY AND SUSSEX

CONSERVATION OF THE LOCAL MARINE ENVIRONMENT
Wednesday 15 August 2018
 11:00–12:30

Hear about the marine fauna of the south east coast, its health and conservation from chief fishery officer Tim Dapling.
 Sussex Inshore Fisheries and Conservation Authority, Shoreham-by-Sea, West Sussex BN43 6RE

TOUR OF WAKEHURST PLACE AND THE MILLENNIUM SEED BANK
Sunday 11 November 2018
 11:00–13:00

Discover the trees and shrubs in their autumn colours followed by a tour of the Millennium Seed Bank, led by RSB member Keith Manger.
 Wakehurst, Ardingly, Haywards Heath,
 West Sussex RH17 6TN

SCOTLAND

RSB SYMPOSIUM ON GENOME EDITING/CRISPR AND AGM
Saturday 13 October 2018
 11:00–13:30

Researchers will look at genome editing/CRISPR, its applications in agriculture and ethical considerations associated with the technology. The symposium is part of Easter Bush Campus Open Day.
 The Roslin Institute, Easter Bush Campus,
 Midlothian EH25 9RG

WEST MIDLANDS

APPLE ORCHARD VISIT
Saturday 6 October 2018
 14:30–16:00

Guided tour around orchards with apple picking, juicing and tasting.
 Orchards – off Bittell Farm Road,
 Alvechurch, Worcestershire B45 8BL

Event reports

DEVON AND CORNWALL

OBESITY RESEARCH – ARE WE BARKING UP THE WRONG TREE?
 19 April 2018

Our AGM was followed by a lecture by Dr Phil Langton, senior teaching fellow at the University of Bristol. His talk gave an overview of the causes of obesity and the resulting problems. He pointed out that too much food, lack of exercise, too much fat, excess sugar, the 'wrong type' of gut bacteria, possibly lack of sleep and, more recently, certain combinations of alleles have all been blamed for an increase in obesity in the Western world.

In the 1960s, only 10% of the UK population was thought to be obese, whereas now it is closer to 35%. We eat because we enjoy food and not necessarily because we are hungry. The spread of a Western diet to other parts of the world has been linked to a rise in obesity and an increase in the diseases associated with it.

Our hunter-gatherer ancestors probably ate more complex carbohydrates with a slower release of sugars. Cereals and fruits were only seasonal and very little sugary food, like honey, was available.

The evidence suggests that a high-sugar diet leads to rapid glucose intake, followed by a rapid rise in insulin production and fast removal of glucose from the blood, leaving us feeling hungry. The failure of many diets is due to an unacceptable feeling of hunger. This can lead to snacking and further episodes of insulin release.

Despite health warnings from government, the NHS and the media, we still consume too much prepared food. Its sugar, salt and fat content is not always clear and frequently ignored. Dr Langton's talk left us with much food for thought.

Mary Jenking CBiol MRSB

EAST ANGLIA

ADULT POND DIPPING
 12 May 2018

Vicky Chambers' enthusiasm and passion for wetland habitats really came through during our hour-long pond dipping session at Ferry Meadows. We really appreciated the work of the Nene Park Trust and learnt a lot about freshwater life in our local area. Not only did we find it a really enjoyable way to spend a Saturday morning, but the identification we did will fit into a larger ecological study.

Afterwards, we had time to network with cake and coffee in the café, before doing a



Pond dipping with Vicky Chambers

bit more independent exploration of Ferry Meadows. One member specified that the event could have been improved with "More time! We could use another hour". Overall, we all had a hugely enjoyable visit and would love to repeat the experience. Thank you to Vicky.

Natalie Lamb MRSB

KENT, SURREY AND SUSSEX

GOD SAVE THE QUEENS
 24 April 2018

Bumblebees are in trouble, with many having undergone dramatic declines in range in the UK. Without the whole gamut of pollinating insects, we could lose many of our food products, as well as many flowering plants.

As Professor Brown explained during a lecture to the branch and guests, this loss of bumblebee numbers and species appears to be multifactorial, being a consequence of the decline in the number and range of wild flower species, the prevalence of emerging parasites and the widespread use of pesticides.

A key factor in the decline of pollinating insects is thought to be the increased use of neonicotinoids: when applied as seed dressings or as sprays, these insecticides have been shown to appear in pollen and in nectar, and to leach into wild flowers and thus adversely affect pollinating insects. For example, they have been reported to reduce foraging behaviour, increase worker mortality, affect egg laying by the queens, alter hibernation duration and impair brood development.

In addition to these anthropogenically driven stressors, bumblebees also face natural stress, including endemic parasites. Of these, perhaps the common and abundant trypanosome *Cnithidia bombi* is the most significant, infecting several common bumblebee species, affecting ovarian development in the queens and so negatively impacting their reproductive fitness. These parasites also affect early

colony establishment after the queens have emerged from hibernation.

Using laboratory experiments to simulate the anthropogenic stressor of the neonicotinoid thiamethoxam and the natural stressors of hibernation and parasitism, it was possible to determine the impacts on queens and populations. While the parasites alone had little or no effect, the addition of low doses of thiamethoxam to queens reduced egg laying. Mathematical modelling showed that these impacts could seriously reduce population persistence.

David Ware FRSB

GLIMPING THE LESS COMMON SPECIES OF BRITISH WILDLIFE
 9 May 2018

It has been reported that eagle-owls, the largest of the owls, with a wingspan of over 1.5 metres, normally found in the mountain valleys and coniferous forests of northern and Eastern Europe, may be becoming established in Britain – a possible threat to indigenous species and even to young lambs. This formidable predator is still, however, a rare sight.

We were introduced to a mature specimen during our guided tour of the British Wildlife Centre in Lingfield, Surrey.

The centre, formed in 1994 primarily as an educational resource, contains some 40 species of British wildlife, including all six of our native mustelids plus an American mink, now an established species. There are also four of the six species of deer found in the

The eagle-owl is becoming established in some parts of Britain

country and four of our native owls, plus the eagle-owl and a snowy owl, although not, at present, a short-eared owl.

Most of the animals in the centre were either born there or in other wildlife parks, or were orphans that could not be released back into the wild.

For this private visit, our guide not only told us about the animals and lured them from their hideouts with titbits of food, but also explained about the breeding programmes that the centre runs – for example, producing two wildcat kittens that can be exchanged with other centres to form a breeding stock uncontaminated by feral cats, which have insinuated their DNA into the native Scottish population.

The centre is also the biggest breeder of red squirrels in the country, rearing 50 or 60 kits per year then passing them on to join new colonies – for example, on Tresco Island in the Scillies and Caldey Island off the Pembrokeshire coast.

The trip was an excellent opportunity for us to brush up on our identification skills.

David Ware FRSB

NORTHERN IRELAND

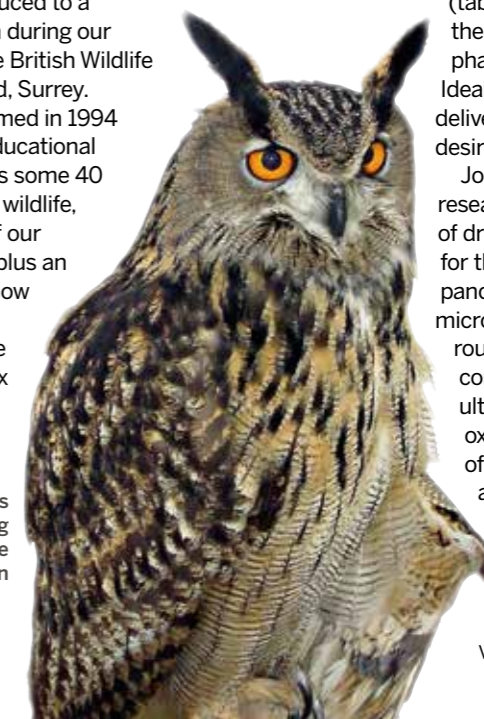
DRUG DELIVERY STRATEGIES FOR THE 21ST CENTURY
 26 March 2018

Professor John Callan, the Norbrook Chair in Pharmaceutical Science at Ulster University, gave this year's Annual Joint Norbrook Laboratories and RSB Lecture, attended by approximately 50 people.

Most medical conditions are localised (headaches, infections and so on) and while some common drug delivery vehicles such as inhalers do manage a degree of targeted drug delivery, other common vehicles

(tablets, injections) saturate the whole body with pharmaceutical agents. Ideally, drugs should be delivered directly to the desired site.

John's collaborative research is exploring the use of drug-loaded microbubbles for the treatment of pancreatic cancer. Gas-filled microbubbles have been used routinely for decades as a contrast agent in ultrasound scanning. Iron oxide nanoparticles and off-patent chemotherapy agents are attached to these physiologically benign, oxygen-filled microbubbles. After





Rathlin Island is home to Northern Ireland's largest seabird colony

Brian O'Neill, Wikimedia

the microbubbles have been injected, a focused magnetic field, acting on the iron oxide, is used to concentrate the microbubbles proximal to the cancerous tumour. The microbubbles are subsequently burst using low-intensity ultrasound to release the chemotherapy agents and oxygen. This localised delivery of the drugs reduces the amount required by two-orders of magnitude, while the presence of oxygen enhances the effectiveness of the drugs.

Since the physiological effects of microbubbles, oxygen and off-patent drugs are well characterised, the regulatory hurdles to trial this treatment in humans are reduced, and John's team are hopeful that such a trial could commence early next year.

Pancreatic cancer has the worst survival rates among the 21 most common cancers. Currently, surgery is the only treatment that can cure pancreatic cancer, but less than 20% of patients diagnosed are eligible for curative surgery. This novel treatment is not a silver bullet, but it is hoped it will downstage tumours to make surgery possible in more patients.

Dr Paul Matthews CSci CBiol MRSB

TRIP TO RATHLIN ISLAND 27 June 2018

The 2018 summer outing was to Rathlin Island, off the coast of north Antrim, Northern Ireland. The trip comprised of a 25-minute boat ride aboard MV Rathlin Express followed by a short bus journey to the newly renovated RSPB West Light Seabird Centre.

Rathlin has Northern Ireland's largest seabird colony along with quite spectacular

panoramic coastal scenes. At the Seabird Centre, the group enjoyed close-up views of the colony, with razorbills, puffins, fulmars, guillemots and kittiwakes congregating in their thousands to breed, which they do from late April to July.

A wide range of other fauna and flora were seen during the trip, including grey seal (*Halichoerus grypus*) and harbour seal (*Phoca vitulina*). One member even spotted the rare Irish hare (*Lepus timidus*).

Rathlin is Northern Ireland's only inhabited offshore island, with a population of about 150 people. The reverse L-shaped island is one of 43 Special Areas of Conservation in Northern Ireland. There is much history associated with the island, including Bruce's Cave, named after Robert the Bruce. It was there that he was said to have seen the legendary spider, which is described as inspiring Bruce to continue his fight for Scottish independence.

The world's first commercial wireless telegraphy link was established by East Lighthouse on Rathlin to Kenmara House in Ballycastle on 6 July 1898.

Dr Richard Briggs CBiol FRSB FLS

SCOTLAND

23RD RSB SCOTLAND ANNUAL TEACHERS' MEETING 31 May 2018

This year's meeting was particularly relevant in that the Scottish Qualifications Authority is changing specifications for qualifications, so speakers and exhibitors were able to offer a range of information and resources to delegates. Not only did speakers provide updates on knowledge, they gave resources that

could be used for planning coursework in biology at all levels.

The morning session, chaired by Professor Jack Jackson, began with an exciting proposal from Professor Kevin O'Dell that genetics degrees might begin with the sequencing of students' genomes and they could then spend the rest of their degree analysing the information.

Dr Liz Patton talked about the use of zebrafish in her research on melanoma. She explained how even quite humble animals can produce startling insights into gene regulation. Some delegates were heard to announce prospective purchases of zebrafish for their schools.

Dr Anna McGregor spoke passionately on the hot topic of plastics in our seas. She gave an interesting twist on this by describing how students could use the types of plastic found on beaches to model various species' richness instead of using organisms, and in the process help to clean up beaches!

After lunch, Dr Paul Beaumont and Kate Andrews of SSERC, our fantastic sponsors, outlined helpful, cheap and effective ways of using some materials they have developed for student projects, and generously gave out samples of the materials to delegates.

Last but not least was a fascinating talk from Geoff Morgan, who related how his team have used IT to analyse their pupils' performance in homework and feed back to them. Geoff showed data on how this can make a difference to performance. The fact that his statistical evidence backed up long-held anecdotal beliefs was very satisfying.

It was a great day with very positive feedback for what is the only national CPD event for biology teachers in Scotland this

year. The grateful thanks of RSB Scotland go to all speakers and exhibitors.

Alastair MacPherson CBiol MRSB

LOCH LEVEN NATURE RESERVE 12 May 2018

Tayside reserves warden Vicky Turnbull and principal conservation scientist David Douglas gave a warm welcome and an introductory overview of RSPB Loch Leven and the work of the RSPB at the nature reserve. On the approach to the wetland area, we glimpsed the wildlife around the loch and on settling into the hides along the south shore of Loch Leven we were delighted by close-up sightings of lapwings with their chicks, geese with their goslings, grebes and nesting black-headed gulls.

We returned to the visitor centre via the wildflower meadow and the Loch Leven Heritage Trail, which provides a 21km car-free route around the shores of the loch. Quotes from attendees often appear in branch event reports, but for this event, the calls from the range of birds in the wetland area, along the trails and in the woodland at RSPB Loch Leven provided the most memorable soundbites.

YORKSHIRE

FOUR SOCIETIES JOINT MEETING: FRONTIERS OF SCIENCES II 10 March 2018

Repeating the resounding success of this event in 2017, our third joint society meeting in Leeds was a well-attended and popular

affair. Thanks to the generosity of accountancy firm KPMG, which donated its state-of-the-art lecture theatre, as well as many other services, the venue turned out to be an impressive location for the event.

The original sponsors – the RSB, and the Royal Society of Chemistry – were joined this time by the Astrobiology Society of Britain and the Royal Astronomical Society, ensuring that a wide spectrum of science was covered. Thanks also go to the organisers, who ensured 70 keen and enthusiastic attendees on the day, despite the appalling weather.

Once again, we were able to recruit some excellent speakers to the cause: Dr Dominic Papineau of UCL, whose subject was 'Bio-signatures in the Eoarchean rock record'; Peter Stazewski of Université Claude Bernard Lyon 1, who talked about 'The chemist's challenges of the future: how to animate dead matter'; and Sergio Ioppolo of Queen Mary University of London, who discussed the star formation process, with emphasis on the several physical and chemical steps.

Unfortunately, our fourth speaker, Frances Westall of CNRS Orleans Campus, had to cancel at the very last minute due to severe illness, but Dr Sohan Jheeta stepped into the breach and delivered a presentation on recent advances in the origin of life.

Feedback data was collected after the session, together with interesting and positive comments, encouraging us to maintain this annual event.

Dr Sohan Jheeta



Loch Leven is home to a variety of wetland bird species

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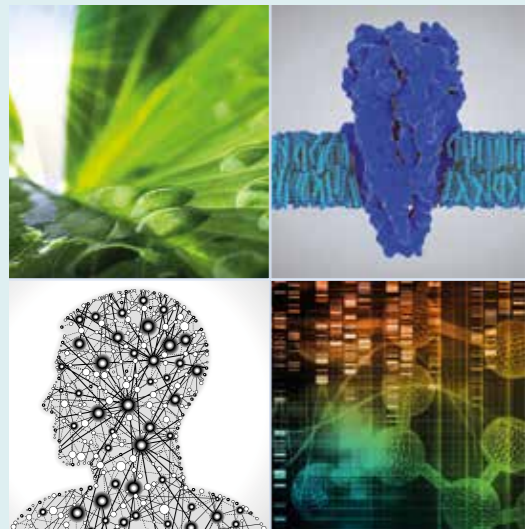
AUSTRALASIA

Professor Lloyd Reeve-Johnson
• australasia@rsb.org.uk

Get involved

Visit your local branch's page on the Society's website to find out who is on your branch committee and how to get involved in local events and activities.
www.rsb.org.uk/regional-activity

Emerging Topics in Life Sciences



A new journal of commissioned reviews, written for a broad audience. Each issue focusses on a new, or growing, topic and is guest edited by an expert in the field.

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Guest Editor: Dr Anton Enright (EMBL European Bioinformatics Institute)

GENE EDITING IN AGRICULTURE: BIOTECHNOLOGY AND BIOSAFETY

Guest Editor: Professor Wendy Harwood (John Innes Centre)

MICROBIOME IN HEALTH AND DISEASE

Guest Editor: Professor Julian Marchesi (Cardiff University)

CANCER IMMUNOTHERAPY

Guest Editor: Professor Franco Marincola (Sidra Research Center)

INTEGRATED STRUCTURAL BIOLOGY: NEW DEVELOPMENTS

Guest Editor: Marcellus Ubbink (Leiden University)

LIFE IN EXTREME ENVIRONMENTS

Guest Editor: Timothy Lyons (University of California, Riverside)

CELLULAR MECHANOBIOLOGY

Guest Editor: Armando del Río Hernández (Imperial College London)

Native Pollinators

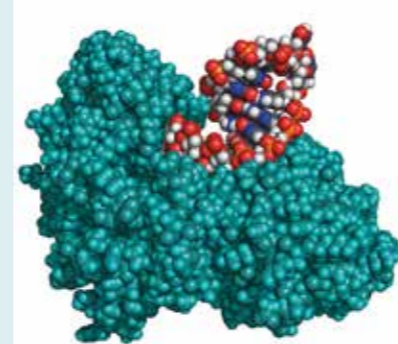
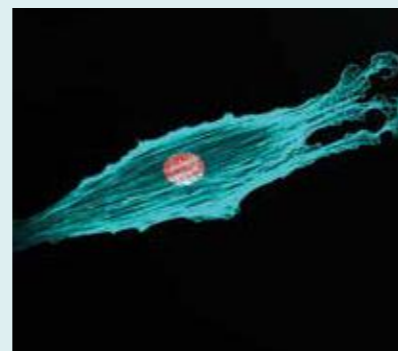
Marine Microbes

Climate Change

Organoids

www.emergtoplifesci.org/alerts

Jointly owned by the Royal Society of Biology and Biochemical Society



CROSSWORD

The biology brainteaser

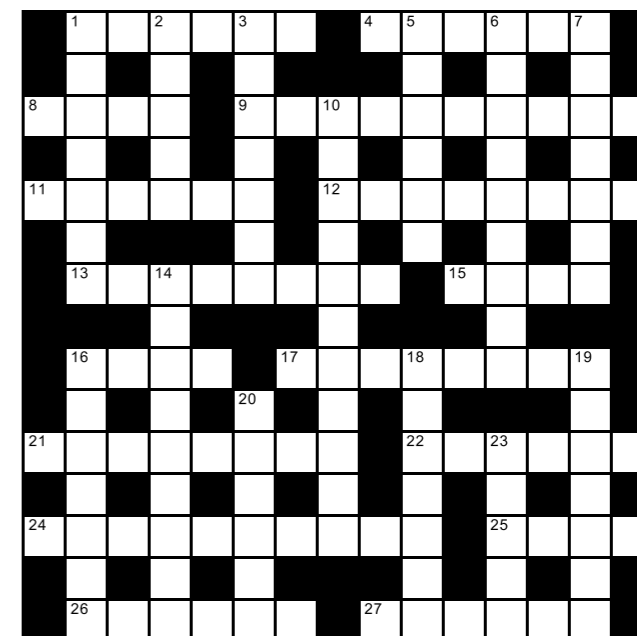
Pit your wits against our autumn puzzle and you could win a £25 book token

Across

- 1 Terrible smell in empty space (6)
- 4 First of stereo recordings (6)
- 8 To start with bachelor single (4)
- 9 All so green – that's changed (10)
- 11 Outside of parka torn (6)
- 12 Hard metal? No, can be bent (8)
- 13 With this place, about time for do-it-yourself (8)
- 15 Resistance offered outside (4)
- 16 An enclosure for returning beast of burden (4)
- 17 I'm pieced together somehow (8)
- 21 Too many swarming around an indication of multiplication (8)
- 22 Pedal bin only has this in it (6)
- 24 Piece of bread, first class one (10)
- 25 Last dance? (4)
- 26 Soldiers led back (6)
- 27 Where you find baby requires knotted suture (6)

Down

- 1 Opening church, that can handle intake (7)
- 2 To be sexy peel off some outer bits, showing too much flesh (5)
- 3 Tango to occupy active old age – felt quite smug about it (7)
- 5 Number of commandments set out; they're believed to be true (6)
- 6 Personal assistant in short is as good as gold (9)



Volume 65 No 4
compiled by Doug Stanford

7 Design right diet so you get vitamin D (7)

10 Plucky to fight by the sound of it; doesn't occur in every generation (11)

14 Getting drunk? Right, do so in Public House – that'll make your eyes red (9)

16 A horse sheep mixture? (7)

18 On back road deploy agent, that's one way to catch a criminal (7)

19 Kind of light attachments for holding things when cold not hot (7)

20 Go to get fare possibly (6)

23 Misusing energy bars is not so ethical (5)

This issue

A return to the regular format puzzle this issue. All across answers are from the world of biology and their clues only provide a subsidiary indication of those answers. Down clues consist of the normal combination of a definition and a subsidiary indication.

How to enter

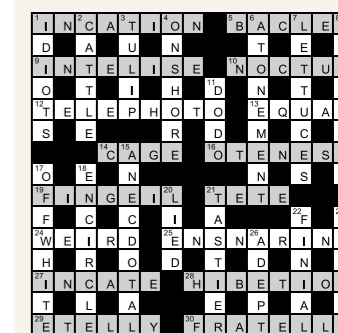
To be in with a chance of winning a £25 book token, send us your completed puzzles by Friday 24th August. Please include your name, address and membership number with your entry – an email address would be handy, too. Post your entries to: **Crossword, The Biologist, Royal Society of Biology, Charles Darwin House, 12 Roger Street, London WC1N 2JU**

Last issue's winners

Well done to last issue's winners, Colin Gilbert FRSB and Dr KWG Shillam CBiol FRSB. Book tokens are on their way to you.

Last issue's solution

Vol 65 No 3



Could you recommend a member?

The Royal Society of Biology represents, supports and engages with anyone who has an interest in the life sciences, and offers membership grades to suit all levels of expertise.



Existing members are uniquely placed to help grow our membership – and to increase the influence we are able to exert. A significant number of new members join as a direct result of a recommendation from someone they know and trust.

If you have a colleague, friend or family member who would benefit from Society membership, please email their details to us – and let us know if you'd like us to mention your nomination.

Email: membership@rsb.org.uk www.rsb.org.uk



A wasp nest built inside empty armadillo armour



#33 Beavers to Weavers Exhibition

Leeds City Museum

The diversity of organisms living on Earth is breathtaking. However, counting and describing their appearance merely scratches the surface of what makes a species unique. To dig deeper, we must observe how a particular species lives and behaves, including the objects that it creates in order to survive. This theme is the main focus of the Beavers to Weavers exhibition at Leeds City Museum, which explores how animals build their own tools, homes, armour and even camouflage.

One familiar animal featured is the wasp, whose atypical nests can be built around whatever is available to them. One

particularly unusual nest on display here is built within an armadillo shell. Close inspection suggests the empty armadillo shell was hung up, which then attracted a fertilised queen looking for a suitable home. From there, the queen has constructed a 'petiole' and laid her eggs within hexagonal-shaped cells.

The nest subsequently grew, becoming a colony, turning this once empty shell into a home, furnished with wood recycled from the local area (untreated fences, wooden beams and so on).

This piece is a fascinating example of how one natural object commonly found in South America became a home for thousands of wasps elsewhere.

Further pieces of interest in the

exhibition include oyster shells containing Buddha-shaped pearls and the amazingly constructed nests of the tailorbird, which intricately sews leaves together with its beak using plant material as thread. As the exhibition's title suggests, there are also beautiful objects made by beavers and weaver birds, as well as spiders' nests and the tiny leaf cases of leafcutter bees.

By James Poulter

Leeds City Museum is open Tuesday to Sunday and admission is free. The Beavers to Weavers: The Wonderful World of Animal Makers exhibition runs from the 6th July 2018 to the 6th January 2019. www.leeds.gov.uk/museumsandgalleries/leedscitymuseum



Photographs courtesy of David Lindsay

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Bioscience



Careers Day

- Mock interviews
- CV workshop
- Speed networking with professionals
- Ask experts for career advice
- Meet learned societies and organisations
- Network with students, speakers and exhibitors from across the UK



Saturday 27 October 2018 | 10:30 – 16:30
Manchester Metropolitan University
Tickets £10

For further information and to register, visit bcd.rsb.org.uk or contact us at events@rsb.org.uk