BIOMIMETICS
DESIGN INSPIRED BY BIOLOGICAL STRUCTURES

FOCUS ON...
GENE EDITING AND CRISPR-CAS9 EXPLAINED

48 PAGES OF INSPIRING BIOSCIENCE

THE Biologist

THE MAGAZINE OF THE ROYAL SOCIETY OF BIOLOGY / www.rsb.org.uk

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FROM SMELLS TO SIGNALS

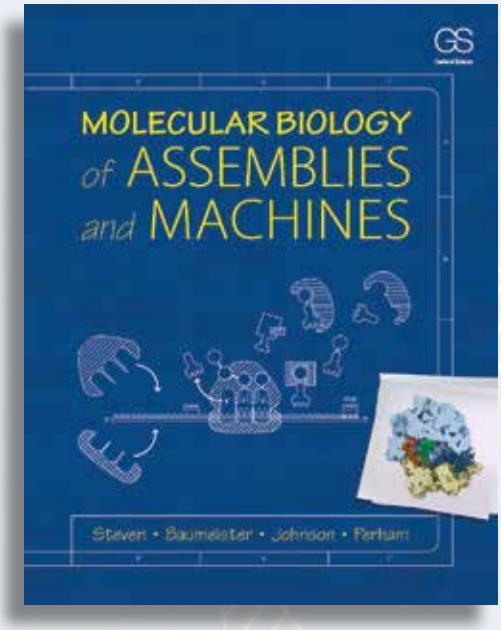
The evolution of animal pheromones

Royal Society of Biology

New from Garland Science

Molecular Biology of Assemblies and Machines

Alasdair C. Steven, Silver Spring, MD, USA, **Wolfgang Baumeister,** Max Planck Institute of Biochemistry, Germany, **Louise N. Johnson,** formerly Oxford University, UK and **Richard N. Perham,** formerly Cambridge University, UK



Molecular Biology of Assemblies and Machines presents a comprehensive narrative describing the structures of macromolecular complexes and how they assemble and interact. Richly illustrated, it is written for advanced undergraduates, graduate students, and researchers in biochemistry, structural biology, molecular biology, biophysics, cell biology, and microbiology, and will also appeal to those in chemistry, immunology, and medicine.

Essentially all major biological activities are performed by assemblies of macromolecules (proteins, RNA, and DNA) acting in concert. These assemblies are dynamic and many are endowed with machine-like properties. This unique book explores the molecular mechanisms employed at the critical level between individual macromolecules and cells and organelles.

Key Features:

- Written as the go-to reference for advanced students and researchers in biochemistry, molecular biology, biophysics, cell biology, chemistry, structural biology, immunology, microbiology, and medicine
- Covers eukaryotic, bacterial, and archaeal systems
- Relates certain diseases to mutations or malfunctions affecting macromolecular assemblies
- Uses vivid illustrations to convey the ways in which macromolecular structures assemble and how they interact with other complexes and organelles in the cell
- Chapters contain boxes exploring difficult concepts in more depth and end with curated lists of references for further reading.

March 2016 • Hardback • 892pp • 819 illus • 978-0-8153-4166-6 • £70.00

For more information please contact us at **garlanduk@tandf.co.uk**

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Royal Society of Biology

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Things are hotting up

As we peer into the natural world around us at this time of year, we should be seeing the first signs of a long-anticipated spring. Yet in December, during Christmas week, I was mowing the lawn and noticed quince blossom. Such marvels remind us how exquisitely sensitive nature is to a changing environment.

The warm December was put down to El Niño, a warming of the waters along the equator, influencing the jet streams. However, it's not all balmy winters: in eastern Ethiopia, El Niño related dryness has led to a severe drought in many areas and is expected to contribute to a large scale food security emergency in 2016.

Climate experts worry that dramatic alterations to the planet caused by anthropogenic climate change may interact in unpredictable ways with natural phenomena such as El Niño. This is uncharted territory. The reality of global warming is now beyond doubt, thanks to the perseverance of climatologists.

Indeed, it was their warnings that led to the recent Paris accord on climate change, which achieved universal agreement on plans to limit global warming to less than 2°C. Although the Paris Agreement as it stands does not include specific national, binding commitments for greenhouse gas reduction, it does mark a vital starting point. We now have a process – the binding commitments will come in time. They have to.

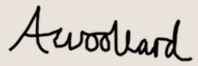
In this issue of *The Biologist*, we marvel with Tristram Wyatt (page 16) at the intricate chemistry between mates, whether they be goats or even sea slugs, and learn how such complex signalling of intent and desire may have evolved.

Another gift of evolution is CRISPR-Cas9, a gene editing facility found in bacteria that can be adapted for use in any kind of cell. Biologists have never before been able to make targeted changes to DNA sequences with utter precision. CRISPR-Cas9 is revolutionising research and has the power to revolutionise medicine. Read how it works and how it could be used in our new Focus On section on page 32.

"Nothing in biology makes sense," said geneticist and evolutionary biologist Theodosius Dobzhansky, "except in the light of evolution." What about applying this truism to architecture? Caroline Wood (page 12) explores how biological structures have inspired some of the world's most innovative buildings.

And, finally, how did you do at university? Francis Hooton's survey of Fellows of the Royal Society reveals some unexpected findings on page 7. What would happen to these great minds in today's ultra-competitive, CV-centric higher degree market?

What would happen to these great minds in today's competitive, CV-centric market?



ALISON WOOLLARD FRSB
Chair, Editorial Board of *The Biologist*

BioPic

CORAL SAND
By David Maitland
Many types of marine invertebrate can accumulate as 'coral sand' on the sea floor, which can form a major constituent of tropical beaches. Featured in the Royal Photographic Society's *International Images for Science 2015* exhibition.

DR DAVID MAITLAND/RPS SCIENCE.ORG

Up front
Society news

Minister for life sciences George Freeman, right, and Nigel Brown of the Microbiology Society unveil the plaque

Freeman and the Society's director of parliamentary affairs, Stephen Benn

Minister opens bioscience hub

Charles Darwin House 2 to showcase societies' work

The minister for life sciences, George Freeman, officially opened the new biosciences hub in central London at the end of last year.

Charles Darwin House 2 is owned by several bioscience societies, including RSB, and home to organisations including the Landscape Institute, the World Obesity Federation and the Association of Medical Research Charities.

It follows the success of Charles Darwin House, where the joint owners of the two buildings are based.

Freeman joined leading figures in the life sciences to unveil a plaque and declare Charles Darwin House 2 officially open, and said that the new building would be a hub for showcasing the best of bioscience to the world.

He said: "Most people in this public policy game talk loudly and deliver later.

"I think biology has delivered hugely and we're catching up now in telling the story."

FELLOWS NAMED IN NEW YEAR HONOURS LIST

A range of Fellows of the Society, including a vet, an ecologist and a neurologist, have been named in the 2016 New Year Honours list.

Professor William Donachie CBiol FRSB, of the Moredun Research Institute, Edinburgh, was awarded an OBE for services to animal and veterinary biosciences.

Professor Maggie Dallman FRSB, associate provost at Imperial College London, was awarded an OBE for services to bioscience.

Alastair Compston FRSB, professor of neurology at the University of Cambridge, received a CBE for services to multiple sclerosis treatment, while Cait MacPhee FRSB, professor of biological physics at the University of Edinburgh, was honoured with a CBE for services to women in physics.

Left: Cait MacPhee received a CBE for services to women in physics
Right: Maggie Dallman was awarded an OBE for services to bioscience

Society attends international bioscience group meeting

Representatives from the Society attended the 2015 biennial general meeting of the International Union of Biological Sciences (IUBS) to explore how the two organisations might work together.

The IUBS already coordinates 12 unions within the biological sciences cluster of the International Council of Science. The organisations offer the opportunity for international bodies to cooperate on multidisciplinary issues.

The Society's senior science policy adviser, Alessandro Allegra, attended the IUBS general assembly in Berlin in December. "The event outlined the main challenges and opportunities for a unified approach to biology and IUBS efforts and plans in this direction," he said.

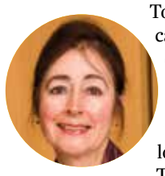
© WILLIAM RICHARDSON / COMEDY WILDLIFE PHOTOGRAPHY COMPETITION 2015

BioPic

YOU HAVEN'T SEEN ME
By William Richardson Shortlisted in last year's 'Comedy Wildlife Photography Competition', which celebrates unintentionally amusing pictures.

Obituary: Maureen Josephine Easton

1953–2015 "Her research and auditing skills made a difference"



Maureen was a professional scientist and very proud of her scientific background. Her research, analytical and auditing skills made a difference, both to people and the environment in which she worked.

She was a senior scientific officer for 30 years in a government laboratory analysing many things, including food and other consumer products, and environmental pollution.

As a lead auditor, she audited all of the practices and procedures followed by the various sections within the laboratory, which provided comprehensive scientific advice and services to six councils in the West Midlands.

She also worked for a time in the pharmaceutical sciences department of Aston University. Her work on the development of epilepsy drugs meant that she consulted both GPs and lecturers, and she especially enjoyed this element of her career. She assisted MSc students in their research projects on pharmaceutical products and would have provided excellent support in their investigations.

Towards the end of her career, Maureen became a quality and performance auditor, taking a lead role in developing quality management systems for local coroners.

This was an important task that Maureen approached with emotional resilience, sensitivity and rigorous assuredness. Her efforts helped them achieve compliance with new government legislation on deadline – for example, when the Human Tissue Act came into force in September 2006.

Maureen always looked forward to receiving news and updates in *The Biologist* and enjoyed participating in some of the Society's scheduled events.

Pauline Young and Jean Boyle (Maureen's sisters)

Apply for a 2016 travel grant by 1st March
www.rsb.org.uk/travelgrant

TRAVELLERS' TALES 2015

Each year, the Society awards thousands of pounds in travel grants to help members conduct research or study overseas. Here's a selection of some of our favourite journeys made by members last year using a Society grant.

2015 AFFILIATE/AMRSB RECIPIENT

Chi-Ching Tsang MRSB

▶ 19th Congress of the International Society of Human and Animal Mycology (ISHAM), Australia

The triennial ISHAM congress is one of the largest medical mycology meetings in the world, enabling clinical scientists and fundamental mycologists to discuss current trends and development of the subject.

At the Young ISHAM day, I gave my first overseas oral presentation in front of mycologists from all over the world. I delivered a talk on my research on a novel fungal species, which I proposed naming *Phialemoniopsis hongkongensis*.

During the six-day event, I also attended workshops on matrix assisted laser ionisation, a mass spectrometry technique for fungal identification in clinical laboratories, and testing for antifungal susceptibility. It was my first time in Australia, and the intense and diverse cultural atmosphere in Melbourne was impressive.

2015 EARLY CAREER MRSB RECIPIENT

Laetitia Gunton MRSB

▶ 14th Deep Sea Biology Symposium, Aveiro, Portugal

Around 400 delegates from 35 countries gathered in Aveiro to discuss the latest deep sea biology research.

This year, deep ocean stewardship and deep sea mining were hot topics. There were special sessions on both, including one on the potential impact of UK mining on the deep sea fauna in the North Pacific Ocean. Other interesting talks included advances in video footage of full colour bioluminescence during deep sea trench exploration.

This was the first time I had presented a poster at an international conference.

It was a great opportunity to meet scientists from around the world as I approach the end of my PhD and search for postdoctoral research opportunities.

2015 AFFILIATE/AMRSB RECIPIENT

Fergus Kennedy

▶ Danum Valley Field Centre in Sabah, Borneo

In my 10 days at the Danum Valley Field Centre, there were daily lectures on Southeast Asian forest ecology and conservation, as well as four tutorials covering the region's biogeography, ecology and experimental design of the studies conducted there.

The fieldwork provided practical skills in mist netting, taxonomy, predation dynamics and experimental design in the forest. Working in the forest was fantastic, with plenty of opportunities to watch the wildlife.

My final days involved a small group project focusing on the relationship between human disturbance of trails and mammal diversity.

2015 EARLY CAREER MRSB RECIPIENT

Dr Samuel Dean MRSB

▶ Kinetoplastid Molecular Cell Biology Meeting (KMCB), Massachusetts, USA

The KMCB is held every two years at the Woods Hole Marine Biology Institute and is, without doubt, the biggest event in my field. I gave a talk and presented one of the main outputs from my fellowship, looking at a specialised flagellum structure called the transition zone. In particular, I focused on finding new components and the roles they play, using these to obtain insights into human disease of the flagellum.

Despite my nervousness (and the final night party playing Abba until 04:00 outside my room), the talk itself went well and I was able to speak to colleagues afterwards about my work.

These discussions were very encouraging and together we thought of some good experiments that I am now in the process of performing.

Don't judge a scientist by their degree grade

A survey of Fellows of the Royal Society reveals many distinguished scientists might struggle to get a research post nowadays

Many people, for many reasons, have failed to get the grades they are capable of, or messed up their degrees completely.

Yet throughout history, people have pursued scientific investigation or engineering, often through the help of others, with poor grades or having never studied science formally at all. These people have gone on to develop world changing technologies or made great breakthroughs in our understanding of the natural world.

Eminent examples include three Copley Medal winners: Michael Faraday, who did an apprenticeship, and had no degree; Charles Darwin, who got an 'ordinary' degree in theology; and James Joule, who had no degree. John Walker, who won the Copley Medal and the Nobel Prize, got a third class honours degree due to illness; and Admiral Henry Jackson, who invented radio communication between ships, did not have a degree.

Is it possible that these pioneers in science would struggle to get a research placement today, where research councils demand no less than a 2:1 BSc honours degree? (Exceptions to this entry requirement do occur, but only where laboratory leaders are well funded and know the student.)

I decided to look more closely at the degree grades of Fellows of the Royal Society (FRS) who worked in the experimental sciences*. It is, of course, difficult to compare the grades of people studying centuries apart, because degree terminology has changed significantly. But of nearly 300 surveyed, 17% achieved third class honours or worse, and even more had 'ordinary' degrees (the definition of which has changed over time, but generally means a pass without honours). Contrary to the general belief that 70% to 80% of experimental scientists at FRS level have first class honours, I found the figure is closer to half (54%); 9% of these distinguished scientists never did degrees, and almost a third (30%) have a second, 2:2 or lower. Many of the most well known scientists on my list got the lowest grades.

Charles Darwin, above, got an 'ordinary' degree in theology

The findings have important implications for decision making when offering PhD places and research jobs: clearly degree grades are not a reliable indicator of research ability and potential. A similar study to mine by Liam Hudson in 1960[1] reached similar conclusions, and although his sample was a fairly small cohort of Oxbridge graduates, his message has clearly been ignored.

A more thoughtful approach needs to be adopted by academics, industry and the research councils when selecting and interviewing students for research jobs. The system should mean students who have potential and are motivated, but have lower grades, can still get jobs, while those with firsts who are not suited to research are prevented from entering the system.

Students being interviewed for PhDs or research jobs could be given some new data to analyse or problems to solve. Those who have research ability, creativity or can think laterally are more likely to come up with interesting analyses or solutions; those who memorised their way to a first might not. If the quality of undergraduate research projects and theses are considered too, degree grades could almost be ignored.

I am told certain institutions such as Imperial College do employ similar sounding methods, but in my experience of meeting PhD and research supervisors I have never been given a problem to solve or take away to work on.

And do employers or academics do enough to understand a student's motivation? Those with a first who just want to get their PhD may not be as valuable as those with worse grades but a dedication to a life in research.

The UK faces a skills shortage in science and other STEM subjects. Why would any academic institutions want to turn away people who could be very good at research? Looking at some of the great scientists of the last two centuries, it would be madness to shut the door to their potential modern day equivalents because of a couple of percentage points on their degree.

***For more details of Francis' survey of Royal Society Fellows, see thebiologist.rsb.org.uk/degreegrades**

Francis Hooton is doing an ecology research internship with the University of Glasgow. He has Asperger's syndrome, which affected his original degree grade. After being diagnosed and given the appropriate support, he completed a master's in biochemistry and molecular biophysics at Nottingham University.

References
1) Hudson, L. Degree Class and Attainment In Scientific Research. *The British Psychological Society* 51 **(1)** 67–73 (1960).

Society honours leading female African agricultural scientists

The Society has awarded five new Fellows of the African Women in Agricultural Research and Development programme (AWARD) free membership for five years in recognition of their work.

The programme equips female agricultural scientists across sub-Saharan Africa to strengthen their research and leadership skills. The organisation's work aims to contribute to the prosperity of African smallholder farmers, most of whom are women. To date, 460 African women scientists from 11 countries have benefited as AWARD Fellows.

To find out more, visit www.awardfellowships.org

▶ **Olivia Carolina Narciso Pedro** is a lecturer and researcher at the Eduardo Mondlane University in Mozambique. Her work helps to evaluate aquatic pollution in Mozambique, focusing on cyanobacteria and their toxins in fresh water used for drinking.

▶ **Adey Feleke Desta** is an assistant professor at Addis Ababa University. She teaches graduate and undergraduate students, and works on issues related to water pollution, specifically monitoring how polluted water goes into farms through irrigation.

▶ **Flower Ezekiel Msuya** is a researcher at the University of Dar es Salaam's Institute of Marine Sciences in Tanzania. She designs devices that help Tanzanian seaweed farmers protect their crop, cottonii seaweed, from rough seas. The farmers can no longer grow it in shallow waters because of warming seas.

▶ **Angela Obiageli Eni** is a senior lecturer at the Covenant University in Nigeria and is working on the West African Virus Epidemiology (WAVE) project, which aims to help farmers prevent diseases affecting root crops in six countries.

▶ **Nkiruka Celestina Odoh** from the University of Abuja, Nigeria, explores how mycorrhizal fungi can help yams survive and thrive despite environmental stress.

AGM 2016 and Council vacancies

This year's AGM will take place at 14:00 on Thursday 12th May at Charles Darwin House 2, London.

There are two vacancies on Council, one to be filled from the Society's College of Individual Members, and one from the College of Organisational Members.

Members at MRSB grade or above may nominate other members, and nominations must include the names and signatures of five members, or three Member Organisations if appropriate, supporting the application.

Nomination forms and role descriptions are available to download from our website. All nominations must be received by post or electronically by 10:00 on 14th March.

Responses to UK plant science report published

The four working groups set up in response to a large scale evaluation of plant science in the UK have published their reports.

In 2014 the UK Plant Sciences Federation (UKPSF), a special interest group of the Society, produced a report entitled 'Current Status and Future Challenges' on the state of UK plant science.

The UKPSF's report identified four key areas – regulation, training and skills, funding, and translation of research – that required detailed investigation by specific working groups.

The working groups' reports have now been published, each setting out key proposals and potential solutions to the issues affecting the sector.

Dr Sandy Knapp FRSB, head of the Plants Division of the Natural History Museum (pictured), said the working groups have "set the stage for a 10 to 25 year visionary roadmap for UK plant science," but added that "it is up to us, the plant science community, to work together to take many of these actions forward."

The reports can be found at *bit.ly/1JckzDo*

© RACHAEL INGLIS/RPS-SCIENCE.ORG

BioPic

SKELETON OF A SEA URCHIN LARVA
By Rachael Inglis

The skeleton of this *Lytechinus variegatus* larva appears in rainbow colours through its transparent body, due to the angle of the light shining on it. The image was selected to feature in the Royal Photographic Society's *International Images for Science 2015* exhibition.

Above: The 'glowing' hawksbill sea turtle filmed near the Solomon Islands
Below: A close encounter with a 12ft squid in Japanese waters

In case you missed it...

▶ **The editor's pick of biology stories being shared online**

RARE GIANT SQUID FILMED IN JAPANESE HARBOUR
Underwater cameraman Takayoshi Kojima swam alongside a giant squid after it was spotted near the surface of a harbour in Toyama Bay, Japan. Kojima filmed his encounter with the 3.7 metre (12 foot) squid, and then helped guide it out of the harbour.
BBC
bbc.in/1MEKA92

MY WHIRLWIND YEAR
One of the pioneers of the CRISPR-Cas9 genome editing technology describes her sleepless nights as the full ramifications of her work became apparent in 2015.
Nature Comment
bit.ly/1mxCeLu

THE HUMAN CHIMERA
After failing a paternity test, a US man discovered that DNA found in his saliva was different to that found in his sperm. Doctors believe the man absorbed cells from an unborn twin in the womb and that this DNA was passed on to his child. Or, as one newspaper put it: "His dead twin, whose DNA the man absorbed in the womb, is the genetic father of the child."
BuzzFeed
bzfd.it/1i9nfo4

HOW WOLVES CAN CHANGE RIVERS
This remarkable video tells the story of how, when wolves were reintroduced to Yellowstone National Park, a 'trophic cascade' completely transformed an entire landscape.
Vimeo
vimeo.com/86466357

VIDEO APPEARS TO SHOW 'GLOWING' TURTLE
Scientists diving near the Solomon Islands film a critically endangered hawksbill sea turtle (*Eretmochelys imbricata*) exhibiting biofluorescence – the first reptile known to do so.
National Geographic
bit.ly/1FD9ysK

Send your suggestions to @Tom_J_Ireland

The key to creating medicines is a multidisciplinary approach

The right formula

For effective drug discovery, academia and industry must mix

Science is increasingly an interdisciplinary endeavour, and early stage drug discovery is no exception. The times when a team of scientists from a single discipline working in an isolated laboratory found candidates for a therapy are behind us. The drug discovery process has gone from being largely the domain of big pharmaceutical companies to a more collaborative and multidisciplinary approach, in which academia, charities, small to medium enterprises (SMEs) and the National Health Service work together.

Learned societies have found that skills associated with creating medicines are vulnerable, therefore multidisciplinary teams and partnerships between the pharmaceutical industry and academia are essential for effective and sustainable early stage drug discovery. To enable these partnerships and knowledge sharing, it is important to assist the movement of researchers between disciplines and industries, and support their career development throughout the process.

Moving disciplines and sectors permanently might not be for everybody, but even short term fellowships, where academics get a chance to work in industry, can be an eye opener. Working in a different setting gives a better understanding of the challenges the pharmaceutical sector is facing and the skills needed to address them. This improves teaching back in academia, which can be tailored to prepare graduates for industry.

Although industry-academia partnerships are not new, making them work in practice can be challenging. Culture, goals and motives differ between the two sectors: in industry, we are talking about a research portfolio, while academia still values high impact publications.

Making these partnerships work in practice can be challenging

Another challenge is geographical: how should teams be arranged for maximum convenience? And when you do manage to set up a collaboration, issues can arise around the confidentiality of the data and findings, and the right to intellectual property.

Many researchers say it is difficult to find time to spot relevant opportunities to network and contact prospective collaborators or mentors. To tackle this problem the Society, together with the Biochemical Society, the British Pharmacological Society and the Royal Society of Chemistry, have formed the Drug Discovery Pathways Group (DDPG). The DDPG is working with academia, industry and funding bodies to help establish an environment that encourages researcher mobility between different sectors and disciplines.

The group's flagship event, the Researcher Mobility in Drug Discovery Workshop, brings together researchers from different disciplines within drug discovery – for example, biology, chemistry, pharmacology and clinical sciences – to encourage networking and highlight existing support and schemes.

The last one took place in December in Chicheley Hall, Buckinghamshire, and attracted more than 50 delegates and mentors. It was great to have senior drug discovery experts, drawn from major pharmaceutical companies, providing mentorship and outlining opportunities for workshop participants to build stronger links with industry.

Attendees were encouraged to raise their concerns about career progression and support in drug discovery, as well as discuss the role of learned societies. Researchers said that more networking and 'speed dating' events would help them build connections, and a comprehensive resource pack would be useful when looking for grants and fellowships.

Healthcare challenges are becoming more and more complex, with antimicrobial resistance just one of the major global threats at the moment. Finding ways to support the environment in which multidisciplinary research and partnerships between industry and academia can flourish is a good way to ensure the best talents can work together on creating new medicines.

Gabriele Butkute AMRSB is science policy assistant at the Royal Society of Biology.

POLICY UPDATE

Event tackles gender inequality

The Society recently organised the first of its Athena SWAN Biosciences Best Practice events, which aim to support universities and research institutes in addressing gender equality.

Attendees heard from departments that successfully obtained Athena SWAN awards and engaged in interactive workshops by the Equality Challenge Unit.

The event was organised in partnership with the Biochemical Society, the British Ecological Society, the Microbiology Society and the Society for Experimental Biology.

In all sciences, women remain underrepresented in senior positions

More data required for Natural Capital progress

A range of speakers and around 80 experts gave a broad update of the science, policy and business practice around natural capital monitoring at a meeting organised by the Natural Capital Initiative in January.

The idea of 'natural capital' is to assign real values to the natural environment and its services. It is hoped businesses and governments will put it on an equal footing to financial, manufactured, human and social capital.

Discussions at the meeting showed there are encouraging developments in all sectors. However, speakers at the meeting said the data required for accurate monitoring is often patchy and more research is needed. Presentations from the meeting can be found at www.naturalcapitalinitiative.org.uk

Society gives evidence ahead of EU referendum

The Society has submitted written evidence to the House of Lords consultation on the relationship between EU membership and the effectiveness of science, research and innovation in the UK.

The Society's response explores the many ways UK science would be affected should the UK vote to leave the EU in 2017, including funding, the free movement of European researchers, collaboration, regulation and scientific advice.

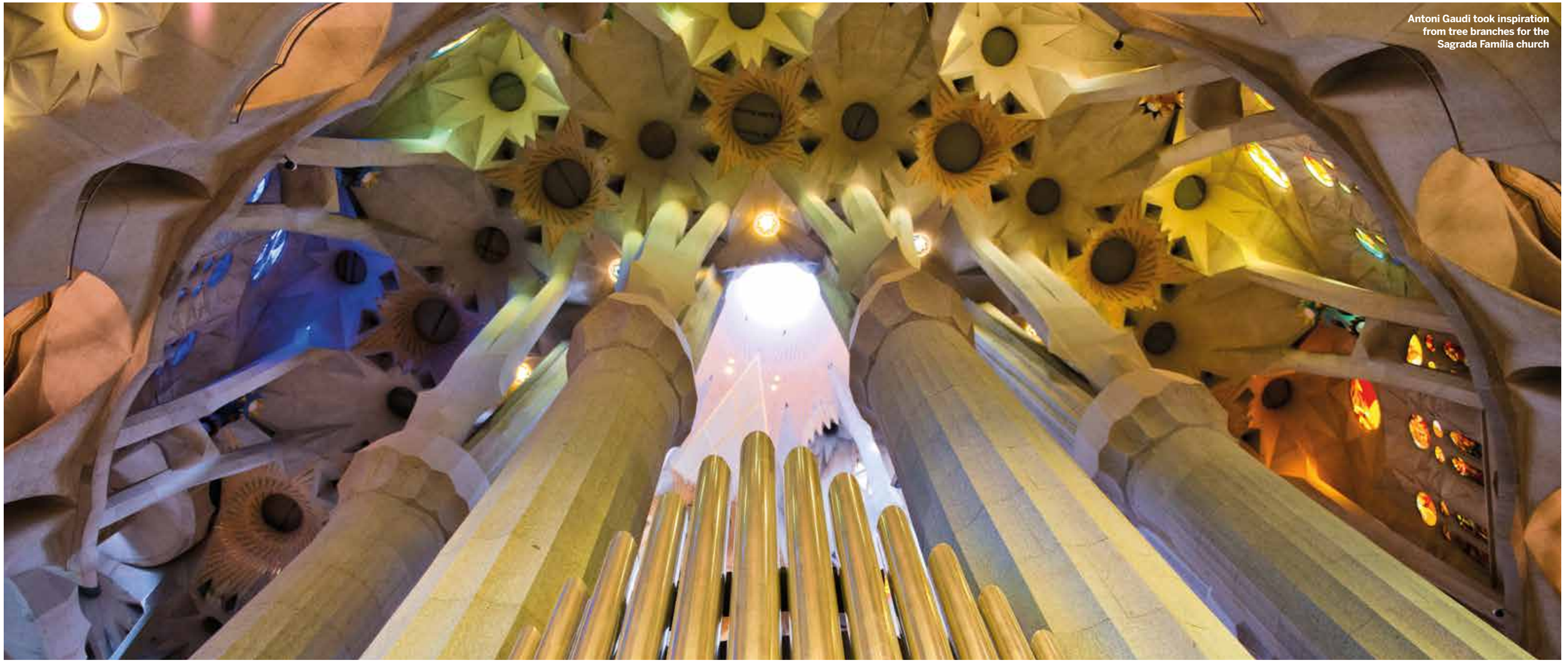
The Society's full written evidence can be found at bit.ly/1P8RsQb

Free movement of staff is a key benefit of EU membership

Animal science networking event

The 13th Animal Science Meeting was jointly hosted by the Society and the Home Office's Animals in Science Regulation Unit in December.

It brought together Home Office staff and stakeholders from around the country, offering an opportunity for discussions and networking. This annual event promotes enhanced working relationships between those engaged in animal science and the regulators in the Home Office.



Antoni Gaudi took inspiration from tree branches for the Sagrada Família church

IMITATING LIFE

Caroline Wood explains how biological structures have inspired some of the world's most innovative buildings

The challenges of the modern world are testing our architects to the limit. Not only do we desperately need more affordable housing for our growing population, but our buildings have to be as energy, water and space efficient as possible.

The latter are problems that also challenge living organisms and that evolution has been addressing since the dawn of time. Little wonder, then, that architects and designers are increasingly turning to nature for inspiration. This area of research – using efficient biological designs in man-made constructions – is known as biomimetic architecture.

It should be emphasised that this is completely distinct from using natural motifs simply for aesthetic decoration. As Jamie Dwyer, a biologist and design strategist for the Biomimicry 3.8 Institute, says, it is "the conscious emulation of nature's genius – consulting how other organisms succeed, and then bringing that understanding into design".

An early example is considered to be the columns of Antoni Gaudi's Sagrada Família church, begun in 1882. To support the weight of the vault, Gaudi modelled these on the branching pattern of an upright tree, noting how this efficiently bore forest canopies. However, other instances of biomimetic architecture can look far removed from their natural origins, as the examples here show.

SEA SPONGES AND SKYSCRAPERS

Although more often likened to a vegetable, the famous 180m high Gherkin tower in London (30 St Mary Axe) was actually inspired by a curious marine animal known as Venus's flower basket sea sponge (*Euplectella aspergillum*). This exquisite creature is named after its hollow tubular structure (or 'basket'), supported by a lattice-like skeleton. Although it may look delicate, *E. aspergillum* makes its own fibreglass by extracting silicic acid from seawater and converting it into silica.

This is then fashioned into small, six-pointed spikes (or 'spicules'), which are arranged vertically, horizontally and diagonally to form a cage-like structure. This organic scaffold provides immense mechanical strength, enabling these sponges to live at depths of up to 1km.

Meanwhile, silica-based cement, deposited on the points of intersection in the lattice, provides reinforcement, enabling the structure to flex without damaging the core arrangement. The mesh-like construction also effectively filters

water: flagella on the cells lining the inner tube provide a motile force that draws water (and hence nutrients) in through the openings in the lattice.

The external scaffold of the Gherkin mimics the lattice arrangement of *E. aspergillum*. The curved sides allow winds to pass easily around the building, rather than being deflected down to street level to blast pedestrians.

Because more air can flow around the side of a cylinder than the corner of a rectangle, its speed increases, causing a higher negative air potential at the back of the building. Architects Norman Foster & Sons used this to drive a natural ventilation system. Large vents at street level suck in air and funnel it upwards throughout the building, reducing the need for air conditioning by 50%.

The Gherkin is a steel interpretation of a natural lattice

The Gherkin is inspired by the Venus's flower basket sea sponge (*Euplectella aspergillum*)

TERMITE TECHNOLOGY

Inside their towering mounds, Zimbabwean termites farm *Termitomyces* fungi as their principal source of food. It is critical that the fungi remain at their optimum temperature, even while the outside temperature fluctuates between below 0°C and over 40°C. Consequently, termite mounds have an elaborate system of heating and cooling vents to allow for tight temperature regulation. Vents at the base of the mound catch breezes and funnel these along muddy passageways, lowering the temperature of the air. Convection currents then draw the cool air up into the warmer parts of the mound, before it exits out the flue at the top.

The concept was used to develop a 'passive cooling system' for Zimbabwe's largest shopping complex, the Eastgate Centre in Harare. During the day, heat energy generated is stored in the building's internal fabric: because this has a high heat capacity, it only causes a minimal temperature increase. At night, the warm air is vented through a central chimney, causing cooler air to be drawn in at the base of the building. These mechanisms cool the complex before the next day and reduce the energy requirements to less than a tenth of those of a conventionally cooled building of the same size.

INSPIRATION FROM PARADISE

Besides whole buildings, biomimetic principles can also be applied to smaller structural details, particularly those that endure a lot of wear and tear.

Mechanical devices such as joints and bearings are prone to failure and dysfunction. Professor Jan Knippers, of the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart, decided to investigate the moving parts of the bird-of-paradise flower (*Strelitzia reginae*), pictured left.

Renowned for its striking blooms, the plant has an ingenious, hingeless lever that can be elastically deformed time after time without compromising its structural integrity. *S. reginae*'s flowers are made up of three upright orange sepals and three violet petals, two of which are fused to form a 'perch', with a cavity at the base containing nectar. The plants are pollinated by sunbirds, which land on the perch to reach the nectar. As a bird lands, the weight of the bird causes the perch to bend downwards, triggering the wings of the petals to flap sideways in an elastic movement.

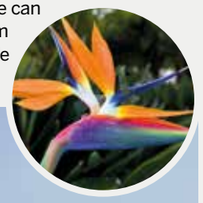
This exposes the stamens, allowing pollen to be transferred to the bird's feet. When the bird leaves, the perch closes again, enclosing the stamens once more. Remarkably, this deformation is completely reversible, with biomechanical tests suggesting that it can occur more than 3,000 times without structural damage.

A closer investigation of the flower's structure reveals how it works. The perch is bilaterally symmetrical, with three

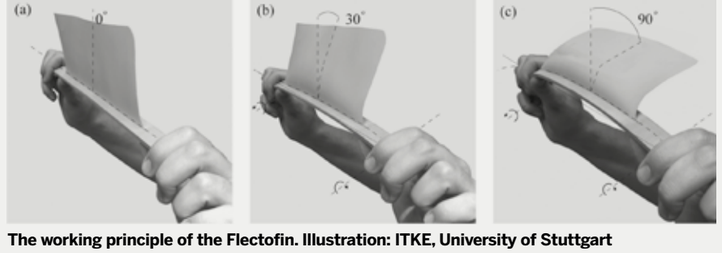
From flower to Flectofin

The hingeless lever of the bird of paradise flower (inset) was the inspiration for the Flectofin (bottom) and scaled up to the Thematic Pavilion in South Korea (below).

Bending the central rib of the Flectofin induces torsional buckling, causing the lateral shade to flip sideways by up to 90°. This simple structure can be formed into vertical blinds for a versatile shading mechanism with no hinges and joints. The Thematic Pavilion's gill-like facade is composed of 108 fins, each a modified form of the Flectofin.

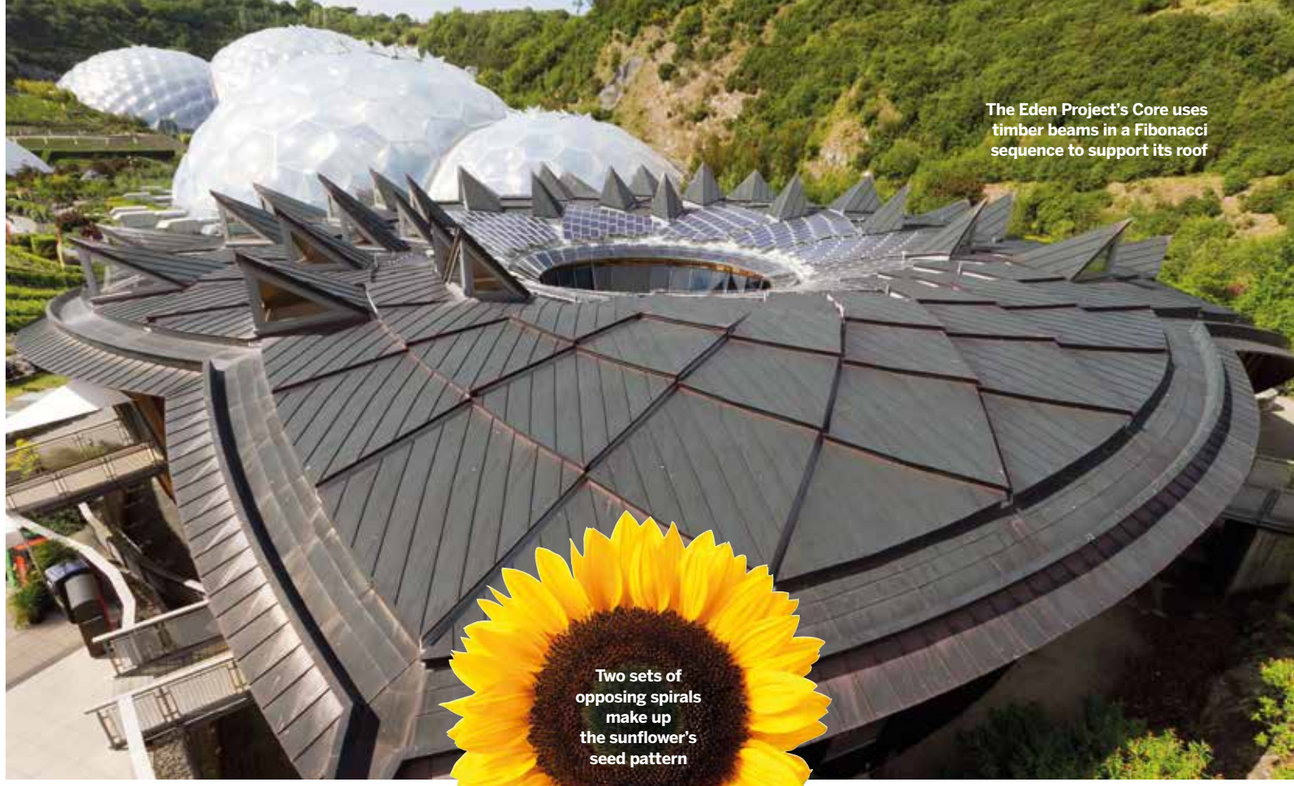


The Thematic Pavilion, South Korea



The working principle of the Flectofin. Illustration: ITKE, University of Stuttgart

ARCHITECTURE: SOMA ARCHITECTURE, VIENNA. ENGINEERING KINETIC FAÇADE: KNIPPERS HELBIG ADVANCED ENGINEERING, STUTTGART. PHOTO: SOMA



The Eden Project's Core uses timber beams in a Fibonacci sequence to support its roof

Two sets of opposing spirals make up the sunflower's seed pattern

© GARY WOODS / ALAMY STOCK PHOTO

reinforcing lateral ribs on each side; the two upper ribs carry the thick wings of the petal that cover the stamens. Tough, fibrous tissue makes the ribs strong enough to support a bird's weight, but the area between the upper ribs and the wings is more elastic. Hence, when the bird lands and the perch is deformed, the energy is transferred to this region, flipping the petals up and sideways. Once the bird leaves, the linkage of the structural elements allows the elastically stored energy to reset the whole system.

As part of a collaboration with the University of Freiburg and the Institute of Textile Technology and Process Engineering, Denkendorf, Knippers helped to develop a hingeless flapping mechanism inspired by the bird of paradise flower.

The Flectofin incorporates a thin shell-like element (the fin) attached to a central rib. These are made of fibre-reinforced polymers that confer high tensile strength but also low bending stiffness (see From flower to Flectofin, left). This simple structure can be made into a shading mechanism with no hinges and joints. The design is particularly suited for buildings with curved glass facades, which are otherwise difficult to shade.

The concept has even been scaled up to the level of entire buildings, an example being the Thematic Pavilion in Yeosu, South Korea, designed by Knippers Helbig engineers. Here, the gill-like facade is composed of 108 individually controlled fins, each a modified form of the Flectofin. When compression is applied to the opposite corners, controlled buckling deforms the plate, causing it to change shape. Besides enabling the building to adapt to changing light conditions, this design reduces strain loads, allowing the building to withstand high winds.

THE CORE OF THE PROBLEM

The Eden Project in Cornwall may be famous for the biological diversity within its iconic glasshouses, but biology inspired the innovative architecture of its visitor centre and exhibition hall, known as the Core. The building was intended to have a symmetrical, spiral-shaped roof, but architects struggled to formulate a design with the right structural integrity.

The solution came from studying the spiral growth patterns of plants, especially the sunflower. In nature, spiral patterns are rarely symmetrical, but are instead offset. This can be seen in the seed pattern of a sunflower head, made up of two sets of opposing spirals, one set going clockwise and the other anticlockwise.

To pack in as many rows of seeds as possible, the number of spirals in each direction is based on the famous Fibonacci sequence, where each number is the sum of the previous two: hence the sequence starts with 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55... Accordingly, a sunflower head typically has 34 clockwise spirals and 55 anticlockwise spirals. In nature, Fibonacci sequences occur time after time, as they use space so efficiently. In the Core, Fibonacci spirals were used to construct the web of 335 interlocking timber beams supporting the roof, with 21 spirals in one direction and 34 in the other. The result provides a robust shelter, dappled natural lighting and even generates power from photovoltaic panels.

THE FUTURE

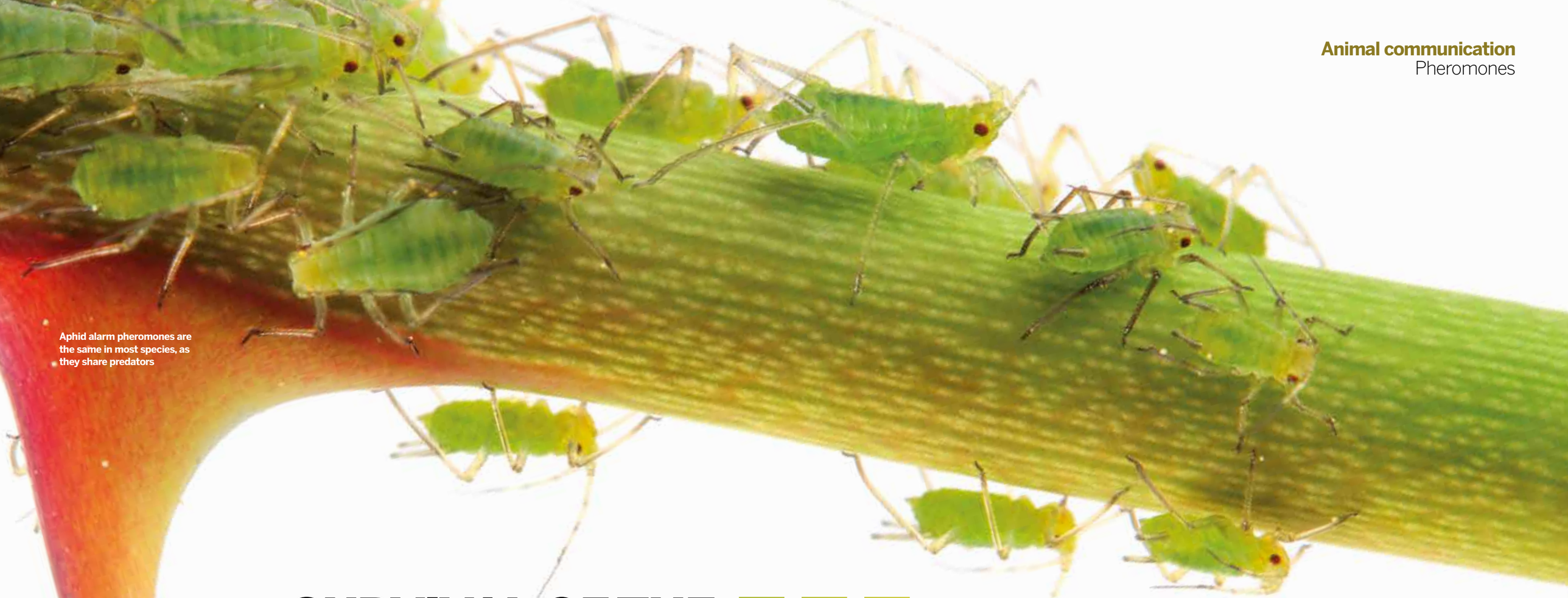
Some architects say biomimetic architecture should go beyond designing buildings and start to consider the world around them too – just as no organism exists in isolation.

"Biomimicry can learn from nature at a system level and be applied to entire neighbourhoods, cities or regions," says the Biomimicry 3.8 Institute's Jamie Dwyer. "Cities need to perform like ecosystems, so we need to ask how every building will purify the air, create soil, store carbon."

The institute is developing a set of ecological performance standards to provide metrics to help developers design urban areas that don't compromise ecological functionality. Dwyer hopes this will help to create "cities that function like the natural landscapes they cover, not only to provide vital ecosystem services, but also so that they are resilient, sustainable and life giving".

The future may seem daunting, but as we plunge deeper into nature's secrets, who knows what solutions we will find next.

Caroline Wood AMRSB is a PhD student at the University of Sheffield, researching parasitic striga plants which devastate food harvests. She blogs at www.scienceasadestiny.blogspot.co.uk



Aphid alarm pheromones are the same in most species, as they share predators

SURVIVAL OF THE smelliest

Pheromones play a key role in many areas of animal behaviour. But how did they evolve? Tristram Wyatt explains how smells became signals

The powerful smell produced by male goats is notorious. But while most of us don't find it attractive, female goats find it highly alluring. The male pheromone sets her hormones racing. Charles Darwin proposed that the smells produced by mammals, such as male goats, could have evolved by sexual selection "if the most odoriferous males are the most successful in winning the females, and in leaving offspring to inherit their gradually perfected glands and odours".

In *The Descent of Man, and Selection in Relation to Sex*, Darwin described many examples of smelly males in the breeding season, including pythons, elephants and even musk ducks. He reported: "During the season of love, a musky odour is emitted by the ... glands of the [male] crocodile, and pervades their haunts." He also noted that male moths had a distinctive smell, but these chemical signals, like those of mammals, were invisible. It was not until the 1950s that they could be identified.

Pheromones are chemical signals used for communication between members of a species. Since the first chemical identification of a pheromone – the female sex pheromone of the silkmoth, bombykol, in 1959 – pheromones have been identified in species all across the animal kingdom.[1] While sex pheromones bring the sexes together in many species, pheromones mediate every aspect of animal behaviour, depending on the species. For example, rabbit pups find the nipple by responding to a mammary pheromone produced by the mother, communication vital for speedy and successful suckling.[2] Bark beetles release aggregation pheromones to attract many other individuals (of both sexes) in order to overwhelm a tree's defences.

Social insects are perhaps the supreme chemical communicators: it has been argued that the path to sociality was paved with pheromones. All aspects of social insect behaviour are mediated by pheromones, including trails that enable sophisticated collective behaviour by foraging ants, and alarm pheromones to gather colony members for mass defence. There are also more subtle effects on colony coordination, such as pheromones produced by honeybee larvae that influence how many workers will nurse them and how many workers will fly out from the nest to forage for nectar and pollen.

An eclectic range of molecules are used as pheromones in different species, which suggests almost any molecule can evolve into a pheromone if it gives a selective advantage. Some patterns are explained by whether the signal is transmitted in air or water; others result from the ways molecules become co-opted as they evolve into pheromones. If the message is transmitted in air, then pheromones tend to be small, volatile molecules, such as 2-methylbut-2-enal (C_5H_8O), the rabbit mammary pheromone mentioned above.

It has been argued that the path to sociality was paved with pheromones

The males of the magnificent tree frog (*Litoria splendida*) secrete a peptide that attracts females

SAM WOO, UC DAVIS

The male silkmoth (*Bombyx mori*) fanning its wings in response to the female sex pheromone released from the female (left)

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Underwater, the equivalent of volatility is solubility, so pheromones can be small, soluble molecules such as amino acids or large, polar molecules. For example, the sea slug *Aplysia* uses the wonderfully named soluble proteins attractin, enticin, seductin and temptin as parts of its sex pheromone.

FROM SMELLS TO SIGNALS

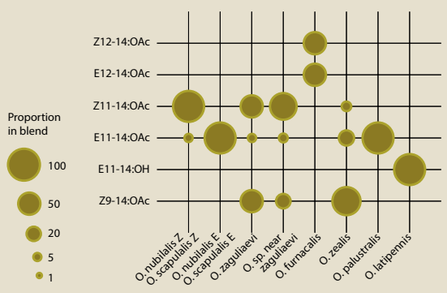
There appear to be two main ways that particular molecules become co-opted and evolve as pheromones. The first way starts by receivers eavesdropping and detecting a chemical cue. This appears to be how hormones leaking from female goldfish became sex pheromones. Over generations, there would be selection for increasing sensitivity in the males as those most sensitive to the molecules would reach the female goldfish first and fertilise her eggs. There would also be selection for greater specificity of the males' receptors to avoid false alarms. Ultimately, there would be selection on the female to produce more of these molecules to be sure of attracting a male, thus creating a pheromone signal.

A second way starts with a pre-existing sensitivity in the receiver that is exploited by the signaller. Female beewolf wasps (*Philanthus triangulum*) detect their honeybee prey by the (*Z*)-11-eicosen-1-ol they give off. The male beewolf produces this molecule as his sex pheromone, thus tapping into a pre-existing sensitivity in the female. Similarly, male moth pheromones released in the final stages of courtship seem to have evolved to mimic the host plant odours detected by female moths to locate suitable plants on which to lay their eggs.

FIGURE 1

Getting the right blend

Closely related species of moths use different blends of molecules in their female sex pheromones[5]



In small social insect colonies, of species such as *Polistes* paper wasps, the queen can physically dominate her tens of subordinates into helping her rather than laying eggs themselves. In species with huge colonies of thousands or hundreds of thousands of individuals, only queen pheromones can pass a message throughout the colony to signal that the queen is fertile, healthy and laying eggs. The queen pheromone induces the daughter workers to remain sterile.

Recent evidence suggests that queen pheromone molecules may be similar long-chain hydrocarbons in bees, wasps and ants,[3] despite each lineage having evolved independently from solitary species. The explanation may be that the social insect queen pheromones have evolved from an ancestral signalling system already present in the earliest common hymenopteran solitary ancestors. The role of the signal in these ancient solitary species may have been as a sex pheromone only produced by fertile females that has been co-opted independently in each lineage for a new function when sociality evolved.

DIVERGING SPECIES

Many accounts of pheromones focus on the fact that they only attract members of the same species. How, then, do these signals change during speciation as new species evolve? With a peptide pheromone, it is possible to create a new pheromone just by mutations leading to substitution of a couple of amino acids. This has happened with the male sex pheromone decapeptide in a pair

The sea slug *Aplysia* uses the wonderfully named attractin, enticin, seductin and temptin

of closely related newt species, *Cynops ensicauda* and *C. pyrrhogaster* in Japan.[4]

However, most pheromones are combinations of relatively simple molecules, and it is the combination that gives specificity. During speciation, there is selection for changes in the combination. For example, the female sex pheromones of moths typically consist of blends of five to six hydrocarbon molecules in the form of unbranched fatty acids, alcohols, acetates or aldehydes. Small changes in enzyme specificity, or upregulation of some enzymes in the biochemical pathway for pheromone production, are sufficient to change the blend or lead to the production of new molecules for the blend [see figure 1].[5] The changes may involve a few or many different genes.

Males of a moth species will only respond to the correct combination of molecules in the right ratios – they thus avoid flying to females of the wrong species. However, there is just enough variability in male response that a few males will respond to new ratios or molecules as changes in blend occur during speciation.

Change in the specificity of male pheromone receptors also occurs during speciation. In the European and Asian corn borer moth species, *Ostrinia nubilalis* and *O. furnacalis*, a change of one amino acid in the binding site of the male's pheromone receptor has been enough to change which molecule the receptor binds to.[6] Changes in the wiring of the brain circuits of the male may also need to evolve, completing the switch to responding to a new blend.

SPIES AND DECEIVERS

When Californian entomologists put out traps baited with bark beetle aggregation pheromones, they were expecting to catch lots of bark beetles. What they didn't expect was that they would catch 600,000 predatory beetles as well.

Pheromone conversations within a species can be detected by unintended spies: the predatory beetles have evolved to be just as sensitive to their prey's pheromones. In some parts of North America, this predation has led to selection on bark beetles with a different aggregation pheromone blend that helps them avoid attracting the predatory beetles.

Pheromones can also be mimicked by deceptive signallers, such as female bolas spiders, which lure male moths by producing a counterfeit blend that mimics the pheromone produced by females of that species. One bolas spider species even produces different blends to lure males of different moth species.[7]

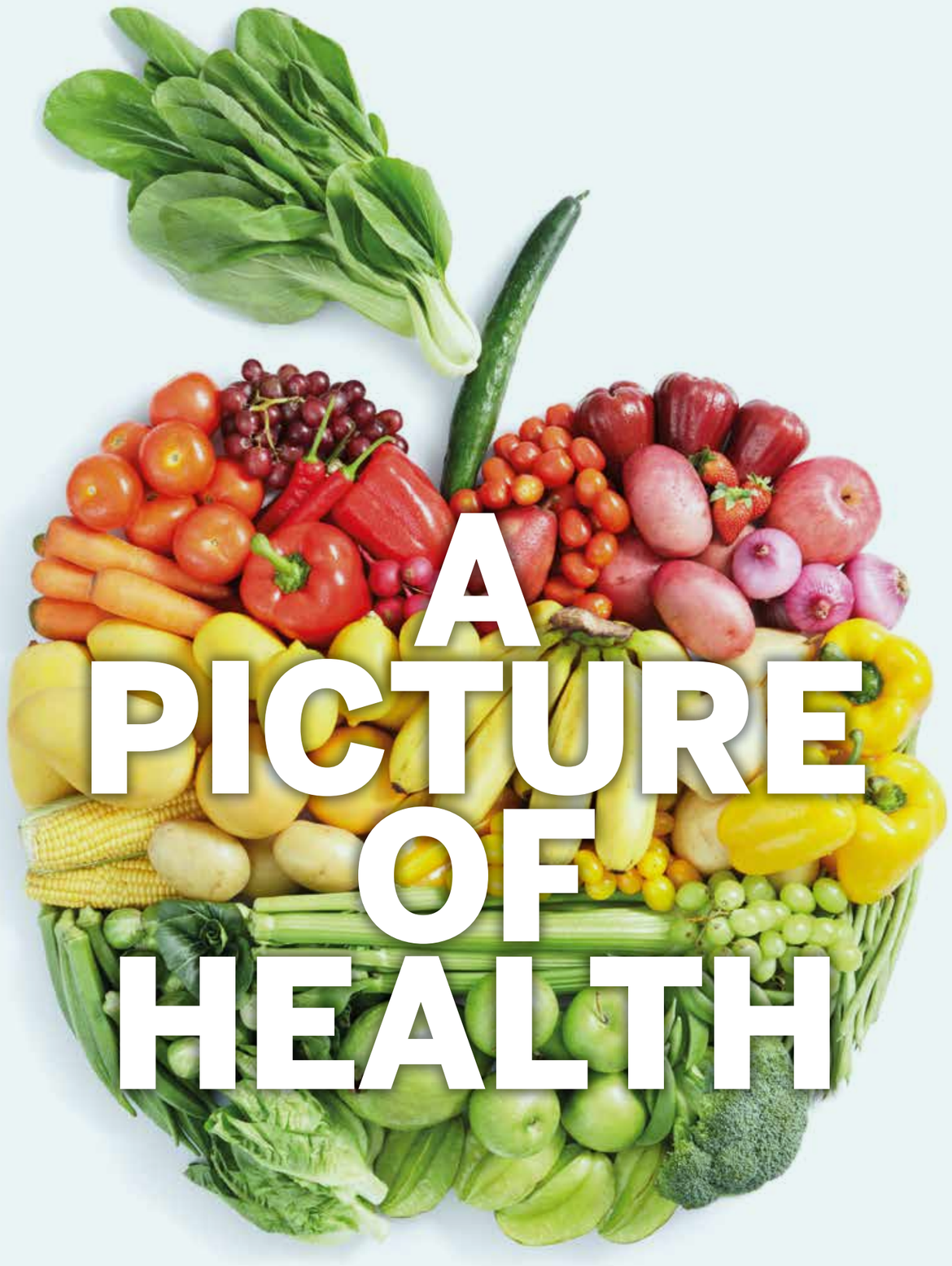
Instead of rewarding pollinating insects with nectar, some orchids mimic the female of a particular species of solitary wasp or bee, luring the male with counterfeited sex pheromones and visual mimicry.[8] The male insect attempts to mate with the flower, picking up a pollen capsule, which he will deliver like a flying DNA courier to another orchid flower of the same species, having made the same mistake again.

HUMAN PHEROMONES?

We spend billions of pounds every year on products to remove our smells and about the same amount on perfumes to add new ones. As we are smelly, like other mammals, it is possible (perhaps even probable) that we have evolved pheromones. In the 1990s, a corporation patented the molecules androstadienone and estratetraenol as 'human pheromones', although to date there is no scientific evidence that such molecules operate as pheromones in humans.[9]

Despite the lack of evidence, numerous studies have used these molecules. It is hard to escape the conclusion that the results represent false positives. It may turn out that we do not have sex pheromones after all. More promising is work on a possible pheromone released around their nipples by lactating mothers that prompts newborn babies to suckle.[2] If a mammary pheromone is found and identified, it would give us the confidence to explore what other pheromones we might have.

Tristram Wyatt is a researcher at Oxford University's department of zoology and an emeritus fellow of Kellogg College, Oxford. He wrote *Pheromones and Animal Behavior*, which won the Society's postgraduate textbook of the year in 2014.



A PICTURE OF HEALTH

Links between diet and good health are notoriously difficult to prove. The latest biomarker technology is changing that, writes Bill Mullen

Barely a week goes by without news of a new superfood we need to eat to stay healthy, or yet more contradictory evidence that one food is good or bad for our health. The cynical academic reader will mutter something about another grant application being submitted, or a company trying to boost sales.

These results are often based on adding a food ingredient to a cell culture plate and seeing a protective effect on the cells when they are challenged by a known toxin. Alternatively, they are based on animal studies, which are closer to human nutrition, but are still far from reality.

Evidence from epidemiological studies has shown that the inhabitants of some countries live longer than others, and by comparing the lifestyle and dietary differences between the two groups, patterns may appear that point to potential causes.

However, trying to come up with hard evidence to support these findings, in a typical nutritional intervention study lasting weeks or even months, often doesn't produce results.

When I studied antioxidants and nutrition, there were a number of other issues that caused problems. Most of the studies use healthy volunteers, and it is extremely difficult to make someone healthier, so these studies were dropped. On the other hand, it is far-fetched to expect that a change of diet can cure an established illness.

Why can't we just take a group of people, feed them one of these superfoods and measure the health benefits? This has been tried on numerous occasions, although only a few studies end up in scientific literature, often showing no measurable effect.

The real problem is that biomarkers used to judge health are often, in fact, biomarkers of disease, normally used by GPs to help to diagnose an illness. Traditionally, the ones most often used are simple tests of blood pressure or cholesterol levels, which are used as markers for heart disease. Using such markers has produced no consistent evidence of any beneficial effects[1, 2] of different diets. Even trying more sophisticated markers normally only used in more advanced clinical settings

The real problem is that biomarkers used to judge health are often, in fact, non-specific markers of disease

The multi-peptide marker can detect pre-symptomatic signs of the disease

provides no good evidence of any beneficial effects.

The problem is that many biomarkers lack specificity for the disease being studied, so their levels can be affected by many factors. One biomarker used for heart disease, for example, is C-reactive protein (CRP). It can also be used as a biomarker for diabetic nephropathy, inflammation and bacterial and viral infection. So if any volunteers in a nutritional study catch a cold, the final result may show that a food was actually bad for heart disease.

Something very different came up in a chance meeting with Professor Harald Mischak of the University of Glasgow. Mischak spent several years developing a new type of biomarker for the clinical assessment of diseases, based on the proteomic analysis of urine samples.

Using subjects similar in age, BMI and so on, he compared two groups, one with coronary artery disease (CAD), for example, and one without. He then analysed and merged the peptide profiles of the CAD samples to form a CAD fingerprint. He did the same with the healthy controls and compared the two sets of data to see if any markers of CAD could be established. The CAD biomarker was based on 238 peptides that differed from the controls. The biomarker was then tested on groups of unknown samples to see how well they performed in identifying which were from CAD patients and which from controls.

These markers have very high specificity (low false positive results) and high sensitivity (low false negative results) for each disease they have been developed for. They produce an output score on a scale of 1, the highest level of disease score, to -1, the highest level of healthy score.

The key advantage of these multi-peptide markers is that they do not rely on the presence/absence or amount of a single compound: the combined score of all the peptides in the marker produces the result. This is a fundamentally different way of thinking about biomarkers of disease. So far, single compound biomarkers have lacked specificity for a disease and are usually only indicators of the later stages of a disease.

The multi-peptide marker can detect pre-symptomatic signs of the disease as well as disease development and progression, and the effect of drug treatment. Certain peptides will score strongly for early stages but weaker for later stages, and vice versa, making the test results more widely applicable and reproducible throughout disease development and progression.

The specificity and sensitivity of these biomarkers means early signs of disease can be detected before any symptoms have developed. Therefore, I believed they could be used in nutritional studies to test the effect of a food on diseases such as CAD, chronic kidney disease (CKD) or diabetes in healthy volunteers.

Biomarkers can help us measure the benefits of nutritional changes more precisely

The olive oil question

Due to the traditional west of Scotland diet being responsible for a high incidence of heart disease, with a low intake of olive oil, we decided that the best place to carry out our study was in Glasgow.

The study was double blinded, the volunteers did not know what oil they were consuming and the analysts processing the samples and the data did not know what was virgin or refined olive oil.

The results of the study were spectacular. Both oils produced significant changes after only six weeks, a change of 0.3 in the CAD biomarker score. There was no change in chronic kidney disease or diabetes biomarkers.

The equivalent change in the CAD scoring had been seen in a study of hypertensive type 2 diabetic patients being treated for two years with a drug. The same change in scoring resulted in a significant reduction in those progressing to kidney failure.[6]

Collaboration with a Portuguese olive oil producer and Professor Maria Bronze from Lisbon University provided the ideal opportunity to test this theory (see study, right). We had two olive oils: one virgin olive oil (VOO), rich in antioxidants; and one refined olive oil (ROO), with very low levels of these compounds. Some studies had shown that these compounds can protect low-density lipoprotein (LDL) from oxidation[3] – a process associated with cardiovascular disease – while others argued against it.[4]

Olive oil is one of the few foods that has European Foods Standards Agency (EFSA) and American Food and Drug Administration (FDA) approval to claim a health benefit. Our task was to see if we could provide evidence of a health benefit from feeding 20ml of these oils to volunteers each day for six weeks. Both oils led to major changes in volunteers' CAD scores (see boxout, left).

Our evidence from the olive oil study shows that by using these clinical biomarkers we can investigate what foods can have measurable effects on our health. There is an obesity epidemic in the developed world, and waistlines in second world countries are fast catching up. This has led to a massive increase in diabetes, with associated increased incidence of CAD and CKD. The application of this technology to health and nutrition research could be a timely development to address this issue. Food is both the problem and the solution.

At present, there is no validated method of testing whether a food product has any beneficial properties.

Food producers could use this technology to provide evidence to the EFSA or the FDA of the beneficial properties of their products. Having biomarker measurements of health benefits will enable producers to promote and improve their products, consumers to make informed choices on which products are the best for their health and governments to give health advice and control food labelling issues.

This new technology could also play a central role in population health management. Diseases such as CAD and CKD are surprisingly difficult to diagnose accurately, usually requiring a visit to a specialist clinician with access to state of the art scanners. With biomarkers for a wide range of diseases, sending off a urine sample for testing would be a simple, cost effective alternative. If the tests are positive, it would be time to see the appropriate specialist clinician for treatment.

On a more proactive front, a visit to the GP for a health check-up could also involve sending a urine sample for testing. Based on the disease scores reported back, the GP or dietician could give lifestyle advice and set goals to help the patient reduce their disease scores. People often give up on diet or exercise because there is no measurable health improvement, apart from weight loss. Having biomarker measurements could be the incentive people need to maintain a healthier lifestyle. Perhaps we may hear at the gym: "Since starting my new diet/exercise plan, my CAD score has dropped 10%."

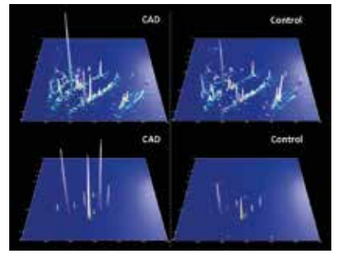
A 'healthy' fingerprint

The relative amounts of proteins and peptides in a person's urine can be used to form a 'fingerprint' of various health conditions, for comparison with samples from healthy volunteers. Using mathematical modelling researchers 'extract' the peptides that are statistically very different between samples from healthy and unhealthy volunteers.

In the case of patients with coronary artery disease (CAD), there are as many as 238 peptides that differ from a healthy sample. These peptides make up the biomarker profile seen in the electrophoresis results in Figure 1.

The ultimate case of CAD would score as +1 and the healthiest a score of -1 (negative for disease). Any score lower than 0.14 is considered healthy.

Figure 1: Comparison of peptide fingerprints in a CAD patient and a healthy volunteer



Dr Bill Mullen is senior research fellow at the University of Glasgow's Institute of Cardiovascular and Medical Sciences.

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Jessica Meir is a member of NASA's Astronaut Group 21, who will visit the International Space Station and could be headed to Mars

NASA/SHUTTERSTOCK

JESSICA MEIR

ONE SMALL STEP FOR A PHYSIOLOGIST...

NASA astronaut and comparative physiologist Jessica Meir tells Tom Ireland about research in extreme environments – and whether she'd accept a one way ticket to Mars

Jessica Meir has always been adventurous, even before she applied to be an astronaut. A keen scuba diver with a private pilot's licence, she had taken a number of space science courses and her research had taken her to a range of extreme environments, including below the Antarctic ice.

In June 2013, Meir beat a record 6,372 applicants to become one of the eight members of NASA's Astronaut Group 21. The class will join 47 other active NASA astronauts and visit the International Space Station, orbiting 250 miles above the Earth at an average speed of around 17,000mph. One of NASA's longer term goals is to send a crew to a near-Earth asteroid by 2020 in preparation for an eventual trip to Mars.

Did you always want to be an astronaut? Or did you want to be a scientist?

The first time I said I wanted to be an astronaut I was five, and in first grade at school I drew a picture of an astronaut when I was asked to draw myself. But my favourite subject as a kid was always biology. Some people think of that as odd and not the straightest path towards being an astronaut compared with, say, being an engineer. There were times when I thought maybe I should be an engineer, but biology was always my passion.

Peake practice

British astronaut Tim Peake is currently helping with a range of life science experiments aboard the International Space Station (ISS). Tim began his six month mission in December, blasting off in a Russian Soyuz rocket and becoming the first British astronaut to visit the station.

Microorganism research
A range of microorganisms placed on the outside of the ISS are being monitored to see which survive. Some will be protected by an artificial Mars soil, to a variety of depths, and some will sit in a Martian atmosphere, rich in carbon dioxide. Others will be left entirely exposed to space. It is thought that biofilm-forming organisms may be better able to survive extreme exposure to UV radiation. The experiments were devised by Professor Charles Cockell, from the University of Edinburgh.

Fatigue testing
Technology is being tested which aims to monitor various measures of wellbeing – such as fatigue or stress – by automated analysis of the astronauts' voices. It is hoped the iVoice system can be applied to help detect fatigue in miners or long-distance drivers.

Brain pressure
Many astronauts complain of temporary problems with their eyesight, thought to be caused by an increase in brain pressure as fluid shifts towards the head in weightless conditions. Marchbanks Measurements Systems has pioneered a non-invasive device which is placed in the ear to measure brain pressure in space. It forms part of the NASA experiment 'Fluid Shifts,' which is looking at the underlying physiology of weightlessness.

How did you move from physiology research to becoming an astronaut candidate?
I was on NASA research programmes while at university, then I went to the International Space University for a year, which was perfect – very interdisciplinary, with aspects of space biology and space medicine, but policy and mechanics, too. I am incredibly fortunate that I found a career that was really fulfilling before becoming an astronaut. My work at the Scripps Institute of Oceanography blended all the things I like – elements of exploration in the Antarctic while studying hard-core physiology of animals in extreme environments. I was equally happy doing that as I am being an astronaut.

What does the application process involve?
There are two paths to becoming an astronaut: military and civilian. Civilian positions are advertised just like all federal positions, on the USAJOBS website. So you just send a CV and some information you hope will catch their eye. The most highly qualified are selected and assessed and, from these people, 120 go for two days of interviews and do basic physical and medical tests. Then around 40 to 50 candidates are selected for the final round, which involves a whole week of medical testing: brain MRIs, a full body scan, colonoscopy, cardiac calcium tests. You need to be in really good medical shape with no underlying conditions.

It's kind of the opposite of an academic interview – it was my scuba diving and private pilot skills I had to push at them. They didn't really care what journals I was published in: they could see I was doing well in what I studied and were more concerned with my operational abilities. I will not be up in space as a scientist – I'll be an operator of someone else's experiment and other equipment.

Tell us more about what you will be expected to do when you go to space – are you there solely to conduct life science research?
In the Shuttle era, you would have 'mission special' astronauts with specific skills, but now we are all trained the same – to be generalists. I work alongside a jet pilot and we do the same training. Right now, we are training for a mission to the International Space Station (ISS).

There are new vehicles being developed, but right now the space station mission is my focus for the next few years.

Do you think about going to Mars?
I'm more of a realist. I am focused on the ISS. It is exciting to think about all the long term goals – would I go? Would I be scared? NASA hasn't really got a plan yet to bring people home safely – they are just not quite there yet. There are private entities that say they are planning a one way trip... I would definitely be interested, but only when NASA has worked out a way of bringing me back.

One of NASA's long-term goals is to send a crew on a mission to a near-Earth asteroid by 2020 in preparation for an eventual trip to Mars. How likely are you to be on such a mission?
Most astronauts' career spans are decided by the radiation dose they have received. It can differ depending on the solar cycle and the altitude of the space station during their mission. But there are many who have done more than one mission. In the Shuttle era, people would fly three or four missions, but now there are only one or two Americans going into space every year. Others go on to work for space companies such as Virgin.

While President Bush was in power, the objective was to go to the moon, but Obama changed that. It is now to land on an asteroid and try to change its course, or bring a section of it into orbit around the moon and explore it there – all to help us to prevent a future mass extinction event.

Meir with fellow NASA aquanauts

© NASA PHOTO / ALAMY STOCK PHOTO

Meir's work as a physiologist has taken her to a range of extreme environments on Earth

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION

What did you study when you were a physiologist?
I studied the diving physiology of mammals and birds – specifically emperor penguins and elephant seals. We used backpack recorders to monitor their heart rate and depth, and what was really successful was this CO_2 electrode that gave us measurements from arteries and veins while they were diving in the wild, which we could correlate with diving behaviour. What was interesting was how far they could push it – how low their heart rate went, how much CO_2 they could tolerate.

It involved diving beneath frozen ice or watching the animals from an observation tube cut into the ice and hanging in the water, but you still have to go out and clean the windows. So it gave me both a mental and physical challenge, which is what I always look for.

For my postdoctoral research, I looked at barheaded geese – again studying hypoxia, but this time due to the altitude that they fly at as they migrate over the Himalayas. My work involved hatching them and raising them so they were comfortable enough with me to train them to fly in a wind tunnel in masks, where I could measure their heart rate and breathing, but also change their inspired air, raising the amount of nitrogen to stimulate hypoxia as if they were at altitude.

It is exciting to think about long term goals. Would I go to Mars? Would I be scared?

Is much of NASA's physiology research about the effects of space on the body?
The research is much broader, although I do work in the physiology group that is looking at the effect of gravity on the body. Interestingly, we've quite quickly got good at countermeasures, and we are now starting to see astronauts coming back stronger than when they left.

You've trained as an aquanaut, as well as an astronaut. What missions have you done underwater?
That is something I did while working at NASA before I trained to become an astronaut. It's an underwater habitat 45 feet down [a few miles off Key Largo, Florida], which is great for coral reef researchers and is used by a lot of marine biologists. NASA got interested in using it as an analogue for space, as it has the small space, small crew, life support systems and all the other psychological aspects and crew dynamics of a space module. We were collecting data for coral research, but also building structures as if we were on a space walk. I went down there for 10 days, but my mission was cut short, as we had tropical storms.

What does an average day involve for you now?
It's completely different to academia, where you have incredibly detailed knowledge about one highly specific area. Here, you have to compartmentalise lots of different skills in different parts of your brain. In research you work out your own system and plan your own schedule. Now I wake up and my day has been planned for me. After this conversation, I'm having a Russian lesson. Then tomorrow I'll be at Mission Control. Then the next day I might be flying a T-38 [a supersonic military jet].

What's been the best experience you've had since joining NASA?
The training has been phenomenal – these are things I'd normally pay a lot of money for! Now I get to do them all the time. You do two years of astronaut training, and to graduate you have to be proficient in a variety of areas. You must complete a space walk in a mock-up of the ISS in a pool. Although I had my pilot's licence, I had never done any military style flying and had to learn to fly a T-38. Then there was a big backpacking trip, robotic arm training, and trips to Japan and Cologne to be trained in their ISS modules. We also do Russian language training, as all members of the ISS speak either English or Russian.

Do you think there is life on Mars?
I think the chances are getting better all the time, especially after the huge announcement in 2015 that there is running water. I've always believed there is other life out there – of course there is: it would be egotistical to think anything else. But perhaps given the scale of the universe and the timescales involved we will never have that knowledge.

Jessica Meir is assistant professor of anesthesia at Harvard Medical School, following postdoctoral research in comparative physiology at the University of British Columbia. She is one of the eight members of NASA Astronaut Group 21.

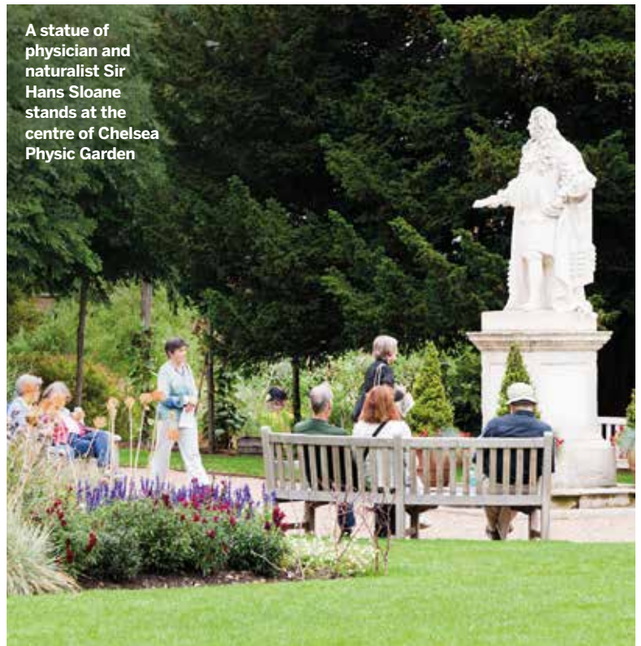
ANCIENT AND MODERN

Sam Lane and Melanie Robb explain how centuries-old 'physic gardens' can contribute to 21st century plant science

Almost 2,000 years ago, the physician Pedanius Dioscorides described hundreds of plant species with medicinal properties in his seminal work, *De Materia Medica.* It led to the spread of botanical knowledge throughout Europe, and in its wake a growth in the documentation, collection and use of valuable plants. Gardens containing medically useful plants began to play an important role as a resource for students, doctors and apothecaries, and the name 'physic' garden emerged[1] in reference to the plants having a physical benefit on the body.

The first formal physic gardens were founded by universities across Italy in the 16th century (initiated by the University of Pisa in 1543), and the rest of Europe soon followed suit. Oxford University was the first to create such a garden in the UK in

Dilston Physic Garden in Northumberland features hundreds of European medicinal plants



A statue of physician and naturalist Sir Hans Sloane stands at the centre of Chelsea Physic Garden

A peaceful spot beside Europe's oldest rock garden at Chelsea

Chelsea is home to numerous plant varieties

TERENCE WALSH; MEGAN TAYLOR; © DAVID BALL/ALAMY STOCK PHOTO

Poppies, from the John Innes library of rare botanical books

JOHN INNES HISTORICAL COLLECTION COURTESY OF THE JOHN INNES FOUNDATION

Plant science in the garden

As well as plants used in ancient medicine, the University of East Anglia's new physic garden will contain plants very relevant to plant scientists today.

Opium poppies (*Papaver somniferum*) were described in the oldest known botanical guide, *De Materia Medica,* and their use in medicine pre-dates written history. Morphine, first extracted from poppies in 1804, was one of the first active chemical ingredients to be isolated from a plant. It is still a common painkiller.

The Madagascar periwinkle (*Catharanthus roseus*) has long been cultivated in herbal medicine. Today, alkaloids extracted from the plant, such as vinblastine and vincristine, are used to treat leukaemia and Hodgkin's lymphoma.

Saffron (*Crocus sativus*) was grown locally (Norfolk) in the early 1600s. The plant's colourful stigmas are used in dyes, spices and herbal medicine. Today biomedical trials are investigating the plant's use in the treatment of common conditions, including major depressive disorder and cancer.

The garden will also feature plants used as model organisms by researchers, such as arabidopsis and tobacco.

The University of East Anglia's physic garden will grow tobacco, used by plant scientists as a model organism

WELLCOME LIBRARY, LONDON

Above: 1751 plan of the Chelsea Physic Garden
Below: *De Materia Medica* inspired the first medicinal gardens

1621. The gardens were also used to study plant diversity and classification, and served a role as pleasure gardens for a period in the early 20th century.

The original physic gardens have all but disappeared, and only a handful of standalone physic gardens are open to the public in the UK today – for example, Chelsea, Dilston, Cowbridge and Petersfield. Many of these gardens still exhibit plants that were traditionally useful for medicine and healing, despite modern research and evidence based medicine indicating that they do not necessarily have a health function today. In recent decades, the focus has shifted to using these collections for scientific research and conservation efforts.[2]

Our Modern Physic Garden at the University of East Anglia (UEA) aims to inspire the next generation of plant biologists, whose work might help address some of the massive global challenges facing the world's growing population: food security and productivity, energy production and adaptation to climate change.

The garden celebrates the historical value of maintaining a collection of useful medicinal plants, while bringing the concept into the 21st century. It enables students, research communities, business communities and members of the public to explore the role of plants in health, wellbeing, art, science, history and the environment.

It highlights how evidence based research on plant based medicines has led to modern pharmaceuticals, while also showcasing plants' use in folklore and herbalism in the past.

We are also keen to diversify what visitors can learn from the garden. Our Modern Physic Garden doesn't just highlight the health benefits of plants, but emphasises their role in providing sustainable food security, clothing and shelter, as well as meeting the energy needs of a growing population.

We emphasise sustainability by using plants supplied by local growers where possible, and some of the narrative of the garden relates to local traditions and uses. For example, there is a long history of saffron growing in Norfolk, and this is told alongside a description of the scientific relevance of the plants to health and wellbeing, their features and their molecular properties (see page 29).

In keeping with the theme of community engagement, a recent project brought together the physic garden, local glass artists and a local primary school to create glass signs based on the properties of some of our most useful plants. This project enabled the schoolchildren to engage with plant science and to combine their new knowledge with a creative output.

A report by the UK Plant Sciences Federation[3] acknowledged that UK plant science is well positioned to respond to the challenges of the 21st century, including food security, climate change adaptation and mitigation, biodiversity conservation and improvements in human health. However, a lack of stable funding and a shortage of skills puts the UK's position as a world leader in the sector under threat[3].

Plants can provide solutions to many, if not all, of these issues, and there has never been a more pressing time to raise awareness of the importance of plant science within and to society.[4] This has been a key driver for the UEA to develop a 'modern' physic garden, concentrating on bridging this gap between communicating high quality plant research focusing on health, wellbeing and sustainability and engaging with the wider community.

Sam Lane AMRSB is a recent biology graduate currently working for a non-profit nutrition organisation in Brussels (BE) and will soon be a trainee at the European Parliament Office in London (2016).
Melanie Robb initially began work at UEA's physic garden as a science communication intern, but now oversees the website and planting of the garden.

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Focus on
Gene editing

Everybody is talking about CRISPR-Cas9, the revolutionary system that makes it cheaper and easier to 'edit' genomes. But do you know how it works?

20

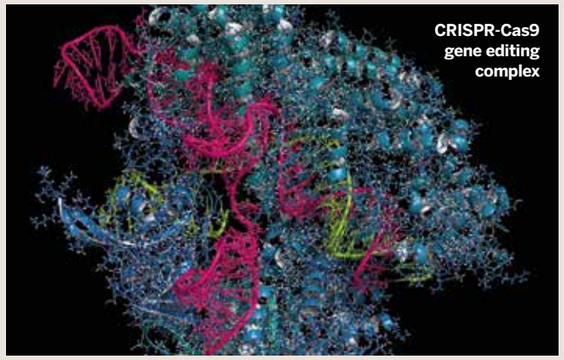
THE NUMBER OF NUCLEOTIDES IN SEQUENCES TARGETED BY CRISPR-CAS9

1-2 Weeks

TO EDIT A BACTERIAL GENE USING CRISPR-CAS9, FROM ORDERING PRODUCTS TO FINAL ASSAY[3]

20

PAPERS ON CRISPR PUBLISHED EVERY WEEK IN 2015



CRISPR-Cas9 gene editing complex

At the end of 2015, hundreds of scientists gathered in Washington to discuss the potential applications of and global attitudes towards gene editing. The debate centred around the revolutionary CRISPR-Cas9 system, which makes it easy, cheap and quick to alter and move genes around.

A few months later, UK regulators received the first application for permission to use the system to genetically modify human embryos.

The technology uses the natural efficiency of the *Streptococcus pyogenes* immune system to cut genomes in precise locations. Developed around three years ago, the method is now the go-to technique for mutating and editing DNA. CRISPR-Cas9 technologies appear to work in pretty much every cell type tested so far, including humans. The technique is more efficient, far easier and much cheaper than older gene editing technologies, such as zinc-finger nucleases and TALENs.

The system has already been used to engineer crops and livestock, and trials are under way that would mean it could be used in gene therapy for human disease within a few years. However, the ease with which scientists could make changes to genomes has sparked widespread concern about its potential applications. These escalated when a team in China announced they had 'edited' the genome of human embryos, albeit non-viable ones.[1]

In September last year, one of the pioneers of the CRISPR technique, Feng Zhang, announced the discovery of another bacterial protein, Cpf1, which he claims may make it even easier to edit genomes.[2]

WHAT IS CRISPR-CAS9?

CRISPR-Cas9 is a system used by bacterial cells to recognise and destroy viral DNA.

CRISPR stands for 'clustered regularly interspaced short palindromic repeats' – that is, short repetitions of base-pair sequences that are interspersed by segments of 'spacer DNA', which are sequences from previous exposures to viral DNA. Cas9 is the name given to the protein that cleaves the invading DNA based on the sequences 'memorised' by the CRISPR system. Researchers can use Cas9's function to break up any section of DNA they like simply by creating a sequence of RNA to form a complex with Cas9. The protein then targets the corresponding DNA sequence in any cell it is introduced to.

References
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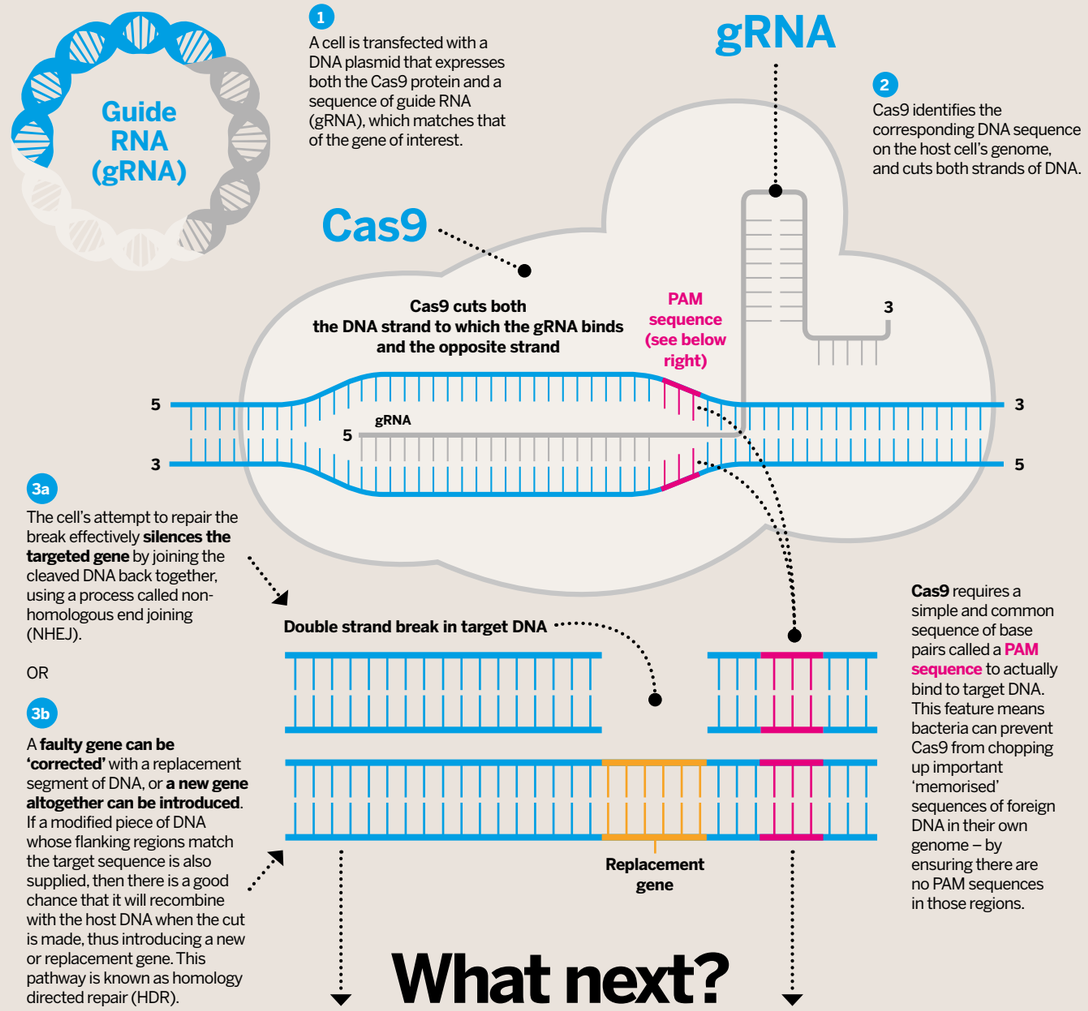
2) bit.ly/1QDhA5b
3) dharmacon.gelifesciences.com/videos/edit-r

CRISPR-Cas9 could be used in gene therapy for human disease within a few years' time

CRISPR-Cas9

How the genome editor works



What next?

FOOD AND LIVESTOCK MODIFICATION
Researchers have already created plants and mammals with edited genomes. It is hoped such technology could help boost productivity and improve food security.

GENE DRIVE
Some genes are more likely to be passed on than others. If an 'edit' is linked to these genes, it will quickly spread through a wild population. That sounds alarming, but could help eradicate malaria-carrying mosquitos.

GENE THERAPY
Genetic disease could be treated by introducing gene editing systems into affected cells. Researchers in the USA are trialling this to treat HIV by knocking out the gene for the specific T-cell receptor that the virus targets.

HUMAN GERM LINE
Modifying human embryos, sperm or eggs would introduce changes to the genome of future generations. Some argue that other techniques, such as embryo screening, can just as effectively prevent genetic disease.

DESIGNER ORGANISMS AND MORE...
In future, could babies be 'designed' with a genome of our choosing? Could amateur biologists do their own gene editing outside regulatory systems?

Members

A SNAPSHOT OF OUR MEMBERS AT WORK AND LEISURE

Hunting for honey's antimicrobial secrets

DR LORNA FYFE FRSB
Passion Research on honey
Other interests Climate change

I am a senior lecturer in microbiology and immunology at Queen Margaret University, Edinburgh. My research is on the antimicrobial activity and composition of honey.

My life as a biologist started at secondary school in Portobello, Edinburgh, inspired by my biology teacher, Mrs Erna McEvoy. My passion is research on honey, which I have only relatively recently studied, having previously investigated the antimicrobial activity of plant essential oils.

I regularly give public talks on my research findings and collaborate with Dr Gordon McDougall of the James Hutton Research Institute, Dundee. We have identified a number of honeys that have potent antibacterial activity independent of sugar, hydrogen peroxide and polyphenol content. We are currently trying to isolate this hitherto unknown antimicrobial agent in honey and determine if it can inhibit antibiotic resistant bacteria.

This research has also made me more aware of the plight of our bees. I believe we need to create bee sanctuaries to protect and to care for them.

My other interest in life sciences is in climate change and how this will affect the distribution of infectious diseases and, of course, the survival of bees.

I believe the Society will give me an opportunity to meet and network with people who also have a passion for my subject area. It is an honour to be a Fellow.

Dedicated to the future of life sciences in the UK

DR REBECCA LUMSDEN MRSB
Works in Science policy
PhD in Cancer cell biology

I am head of science policy at the Association of the British Pharmaceutical Industry. Our members supply 90% of all medicines used by the NHS, and are researching and developing over two thirds of the current medicines pipeline.

My path to this role started with science teachers at school, and continued at Bristol University, where I studied biochemistry with study in industry, before going on to the University of Cambridge to do a PhD in cancer cell biology at the Babraham Institute.

I moved into science policy as I am passionate about maintaining the UK as one of the best places in the world for the life sciences.

My job covers a wide range of opportunities and issues that affect R&D for pharmaceutical companies and contract research organisations, from pre-clinical research to phase 1 clinical studies.

This makes my role challenging and exciting, as there is no 'usual' day. I could be speaking with research councils, regulators or government to address specific challenges for our sector, or working collaboratively with the wider life sciences sector on opportunities that affect everyone, including making the case for the science budget.

I joined the Society as I work with it professionally on the use of animals in research and I see the excellent work it does on a day to day basis. As a biologist by training, it makes sense to become a member, contribute my experience and take advantage of the opportunities this brings me on a personal level.

In search of solutions to global challenges

DR JESSICA BEDDOW MRSB
Qualification MSc in marine biology
Current work Finding ways to improve animal health

Having joined the Royal Veterinary College in 2014 as a research assistant, I entered a collaborative project that focuses on vaccine development for porcine respiratory pathogens. In my current position as postdoctoral researcher within the group, I work alongside some exceptional researchers in finding practical applications for improving animal health.

The thing I love most about science research is the potential for finding new and improved solutions to problems that contribute to global challenges, especially animal health and environmental concerns.

At school, I relished all areas of biology and found it difficult to choose a specific area of study. Following a degree in zoology, I spent some time as a research assistant in a fish and fisheries research group in Australia. I later secured a Fishmongers' Company scholarship to study for an MSc in marine biology, where I discovered my curiosity for molecular microbial ecology.

I have been encouraged and inspired by so many people, from school teachers and university lecturers, to public figures and great scientific communicators such as David Attenborough, Desmond Morris and Richard Dawkins. I am excited to keep up to date with progress, courses and careers in biology as a member of the Society.

Ultimately, I hope to make a contribution to the many great challenges we face on Earth today. In the meantime, I enjoy keeping fit, baking cakes and growing food on my allotment.

Unlocking research for wider benefit

DR BEATRIX SCHLARB-RIDLEY FRSB
Studied In Tübingen and Cambridge
Research background Photosynthetic electron transfer

I am director of innovation and impact at the British Antarctic Survey, with a passion for seeing research outcomes make a difference to global challenges.

I trained originally as a biochemist. My early research was fundamental in nature, examining surface interactions of photosynthetic electron transfer proteins. I was keen to investigate potential applications of this research, and did so first in the medical field (testing anti-cancer activities of peptides derived from these proteins), and later in bioenergy and bioremediation.

Through a business fellowship I discovered my passion for catalysing technology and knowledge transfer: I found it immensely gratifying to see step changes brought about through new connections between academia and industry, and enjoyed seeing the socio-economic benefit of research.

This led me to my current position, where I develop and implement innovation strategies for polar research. I am fascinated by the breadth of expertise in science and engineering that the British Antarctic Survey has to offer, and am committed to ensuring that our expertise and assets add value beyond the polar regions.

In particular, I am keen to see the amazing biodiversity of these environments understood, protected and used sustainably for the development of novel biomaterials, pharmaceuticals, enzymes and other products.

To deliver this, we work in partnership – I look forward to engaging with members of the Society on this exciting journey.

Programming and proteins

MAX HEBDITCH AMRSB
Interests Physical aspects of biochemistry
Currently Doing PhD at The University of Manchester

As a result of a misspent youth watching science documentaries and reading everything I could get my hands on, I decided I wanted to be a scientist. It was my A level biology teacher, John Owen, who convinced me to study biology at university.

I completed my MBiolSci degree in biochemistry at the University of Sheffield, with my master's spent in discovery sciences at AstraZeneca. Along the way, I spent summers working for a biotech company producing tool antibodies, and on a Wellcome Trust scholarship to study the role of long non-coding RNA in regulating cancer.

Having always enjoyed the more physical aspects of biochemistry, I moved into the chemical engineering department at The University of Manchester for my PhD to study how non-specific protein-protein interactions affect the formulation stability of biopharmaceuticals.

The most enjoyable part of my PhD is its interdisciplinary nature. I split my time between measuring protein interactions in the lab and programming a web server for the biopharmaceutical community.

Biopharmaceuticals are fascinating and full of potential. Protein based therapeutics are increasingly important to the future of human health.

Training and personal development

Discounted courses for Society members

An Introduction to Exhibition Design
10 March, Charles Darwin House, London
For biologists involved in public engagement and outreach.

Webinar: Introduction to Social Media
17 March
How to use LinkedIn, Twitter, blogging and other online tools.

An Introduction to Grant Writing
23 March, Charles Darwin House, London
Techniques for writing successful funding proposals.

SysMIC Online Course
Registration opens in April
A comprehensive course in systems biology for researchers.

Project Management: An Introduction
14 April, London
For those new to project management.

An Introduction to COSHH for Technical Staff
21 April, Newcastle
COSHH regulations explained.

Commercial Awareness
4 May, BioCity Scotland
For scientists working in industry and postdocs/PhD students considering a career in industry.

Achievements

Have you been honoured in your field or won an award recently? Or do you know a member or Fellow whose work deserves to be celebrated? We'd like to know about it! Email **sophia.mccully@rsb.org.uk** with details.

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New, Transfer & Chartered Members

JANUARY 2016 ELECTION

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CBiol FRSB
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Biofeedback

Back to earth

The British Society of Soil Science (BSSS) is grateful to Joe Turner for highlighting concerns about soil degradation and the need to strengthen British soil science to help address this ('On Shaky Ground', *The Biologist* 62(2) p8). We agree that there has never been a more important time to promote soil science and its importance in addressing key global issues, and yet this comes at a challenging time for the discipline.

There are now few undergraduate degree programmes or courses in soil science in the UK, and in recent decades it has been difficult for qualified graduates to enter the soil science profession.

However, technical soil science skills and technologies continue to be developed in universities and across the agricultural and environmental industries, and the multidisciplinary nature of soils is opening opportunities for young scientists to pursue a career in soil science.

Turner states that "most of the more experienced members of the BSSS are at or near retirement age". This may well have been the case a couple of decades ago, but today 25% of our members are students. Furthermore, we are developing initiatives such as 'Working with Soil' to pass on essential soil science knowledge and important practical skills to future professionals, and organising events for early career researchers to discuss their science and aspirations.

Such enthusiasm is essential as we prepare for the World Congress of Soil Science in Glasgow in 2022.

Mr Turner's suggestion that the Royal Society of Biology should have a role in promoting soil science is welcomed by the BSSS, and as well as our two Societies connecting on this, we also look forward to exploring ways of working with any members who have an interest in soils.

Professor Liz Baggs
The British Society of Soil Science

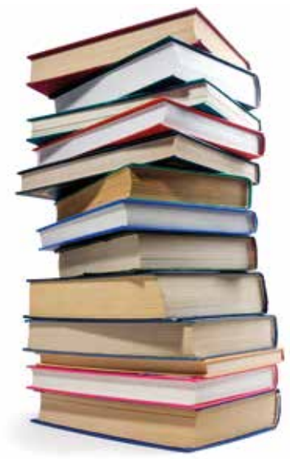

'There has never been a more important time to promote soil science'

Tome comforts

Tim Oates is a hero for addressing the "profound antipathy to textbooks" in his article 'Textbooks – are they an endangered species?' (*The Biologist* 62(5) p7).

It is truly unbelievable that the 'technocrat-manager' cohort who direct such folly can display such ignorance. Centuries of knowledge, understanding, thoughtful objective research, classical literature, philosophy, science, medicine and wisdom reside in the written word: the human story of civilisation, no less. Trendy 'educationalists' are trying to exclude schools, colleges, universities, researchers and intellectually motivated people everywhere from a truly priceless oeuvre and turn us into mindless screen-gazers. The notion of erasing textbooks from the world of learning is truly prehistoric.

Cedric R Richmond FRSB



Naturalists' selection

It was disappointing to find an article in *The Biologist* repeating the erroneous description of Darwin as 'ship's naturalist' on The Beagle ('A World of Adventure', *The Biologist* 61(6) p20). J W Gruber and H L Burstyn have firmly established that if anyone was the official naturalist it was the ship's surgeon, Robert McCormick. Darwin was aboard as a guest of Captain FitzRoy.

The captain felt the need for a gentleman companion because he was concerned that the social isolation experienced by commanders of naval vessels might affect his mental stability.

Natural history was incidental but, in Burstyn's words, it "provided the captain with a polite fiction to explain his guest's presence and an activity attractive enough to lure a gentleman on board for a long voyage".

J J D Greenwood FRSB

Contact us

Send your comments to Biofeedback, Royal Society of Biology, Charles Darwin House, 12 Roger Street, London WC1N 2JU or email biologist@rsb.org.uk

The Biologist reserves the right to edit letters where appropriate.

Reviews

Mighty oaks from little acorns grow

THE TRIUMPH OF SEEDS
Thor Hanson
Basic Books, £17.99

When it comes to bestsellers, botany often struggles to compete with zoology. This refreshing exception is a eulogy to the power of flowering plants via seeds, a subject literally close to our hearts regardless of our awareness of the fact. After all, we often eat (cereal), drink (coffee) and wear (cotton) flowering plant products. They also have industrial applications, and have been instrumental in the rise and fall of empires and civilisations.

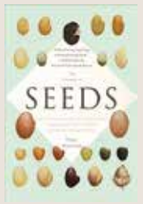
The symbolism of these apparently dormant structures – which can reconstitute whole plants and life anew after decades or even millennia – is not lost on author Thor Hanson. Starting with seeds as food, he explores their diversity, evolution, economics and uses.

There are unabashed product placements (for Almond Joy chocolate bars and Coca-Cola™), references to the author's family and interesting historical anecdotes in what is sometimes a schmaltzy, personal narrative.

As well as being entertaining, the book may make you surprised at and grateful to the plants and various co-evolutionary pathways that have delivered everything from chocolate to the design of fighter jets.

Besides the non-technical chapters, the book has notes, references and a botanical checklist so the reader can explore topics further.

Onion seeds



This will be more than a useful primer for botanists, as well as for gardeners, foodies, conservationists and others interested in the sheer magic of seeds both practically and philosophically.

RAJITH DISSANAYAKE AMRSB

THE INVISIBLE CLASSROOM: RELATIONSHIPS, NEUROSCIENCE & MINDFULNESS IN SCHOOL
Kirke Olson
W W Norton and Company, £14.99

Those of us involved in education, be it undergraduate or postgraduate, know that we must build a relationship with our students before we can really teach them anything. I also suspect that we have all had at least one student we could not seem to reach no matter how hard we tried. The temptation is, eventually, to leave them to their own devices and assume we failed or they were not willing to make the effort.

This book argues, however, that if we think about and understand better how students respond to the classroom environment, we may be able to reach and teach them more successfully.

I did not like a lot of this book. It was a struggle to read as the language is often new age, preachy and unscientific. However, somebody once told me that you should read things you don't like or agree with once in a while. If you can get past the language, there is sense, and some science, to be found.

The author links studies in neurobiology, psychology and mindfulness with many years' teaching experience to show how the behaviour of students (and teachers) is a product of emotions and biology. The central message – that if we understand our students' underlying emotional state better, then we can be more effective teachers – is one we can all take on board even if the book itself is hard going.

DR OLIVER JONES CBIOL MRSB

NEXTINCTION
Ralph Steadman and Ceri Levy
Bloomsbury, £35.00

The self-styled 'gonzo-conservationists' are back with a fresh take on the avian extinction debate, following the remarkable success of their previous collaboration *Extinct Boids* (2012). The two friends – cartoonist and caricaturist Steadman and writer and filmmaker Levy – offer a quirky and lavish visual take on bird species currently teetering on the edge of global extinction, listed as critically endangered by BirdLife International for the IUCN Red List.

As ever, Steadman can't resist adding a few of his own mythical creations. However, there is a serious nature to this work, as it carries the looming extinction crisis to a wider environmentally conscious public, beyond the world of hard scientists and conservation policymakers, who sometimes struggle to communicate widely.

Some reviewers might baulk at the book's irreverence and immaturity but, although it does detract and distract after a while, the simplicity of the medium is powerful. The writing lacks some rich historical contextual observations in the individual species' tales (for that is what they are, stories about nature and people over time), which would have given the text a more robust feel. The incorporation of emails/phone calls/diary entries as a sideshow is a touch lazy and self-indulgent, but at the same time immediate, fresh and engaging. It also documents and illuminates the creators' journeys. This is a book to dip into regularly to feel both sadness and hope.

DR ROB LAMBERT

Cataloguing plant life

FLORA OF GREAT BRITAIN AND IRELAND VOLUME 2: CAPPARACEAE–ROSACEAE
Peter Sell and Gina Murrell
Cambridge University Press, £125.00

The first of the five volumes documenting the vascular plant flora of Great Britain and Ireland was published in 1997, with subsequent volumes in 2006 and 2009. This most recent volume deals with four orders and one subclass, notably Capparales, Ericales, Diapensiales, Primulales and Rosidae. These comprise 18 families, 148 genera and 1,122 species, and include 65 subspecies, 221 varieties, 53 formae and 93 hybrids. The numbers alone are overwhelming and reflect the high degree of detail, not to mention the immense dedication of the authors and their collaborators in preparing this substantive and definitive work.

As well as native species, naturalised, introduced and hybrid species are included. In addition, infraspecific taxa – for example, subspecies, varieties, and forms – are described. The detail provided on individual plants includes Latin and common English names, as well as colour, shape and form of stems, inflorescence, flowers, petals and fruits. The inclusion of information on ecology, habitat and geographical contexts is especially welcome, adding a broader and environmental dimension to plant description. All of these data will facilitate plant identification, as will the many black and white line drawings provided in the glossary, in which definitions of botanical terms may be found.

Data sources are included bibliographically for those requiring original records. What is particularly significant is the intellectual canvas of plant biodiversity this book presents – plant life in the relatively small area of Great Britain and Ireland is amazingly diverse. So, too, are its history and geography, and threats to its continuance.

Documenting the basic constituents is the basis of this book. If there is no recorded detail of plants, how can conservation measures be implemented? As with many academic books, the price may be high, but it remains a poor reflection of the time and effort invested by the authors.

DR A M MANNION

This volume deals with four orders and one subclass of plant flora

Primroses, *Primula vulgaris*, from the Ericales order

INTERDEPENDENCE: BIOLOGY AND BEYOND
Kriti Sharma
Fordham University Press, £16.99

It is a rare treat to indulge in reading a work that switches between philosophical reasoning and empirical biology with eloquent mastery. This is just what Sharma does, illuminating the concept of interdependence from its everyday usage to focus in on the micro-scale network of processes that are contingent on interactions of organisms with one another and their environments.

Sharma refers to familiar biological processes and relationships to illustrate that contingentism is a useful philosophical approach that underpins not only ecological, regulatory (for example, enzyme production, action and inhibition) and hierarchical (such as the roles of cells, tissues and organs with systems) interdependences, but further explores ontological interdependence – the view that 'things only exist as things dependent upon other things'.

Sharma urges the reader to continually take interdependence as more than an everyday truism or the term 'it's all connected', and to view interactions with a sense of wonder at their specific functionality, elegant simplicity and awe inspiring diversity.

Contingentists are unlike either dualists, who may elevate the mysterious to the kingdom of the eternally inexplicably sacred, or physicalist monists, who assert that everything, however complex, is ultimately explainable in terms of physical laws.

Neither is contingentism merely idealism, which argues that all phenomena arise from thoughts, awareness or consciousness.

The argument for contingentism is that in trying to explain the ultimate existence of things, we do not have to either determine them as something to be conquered or sacrosanct; we may not be able to explain their existence, yet we can describe the relationships between phenomena.

Sharma examines the role of blood and other cells in hierarchical interdependences

Interdependence: Biology and Beyond can't exactly be described as light reading, yet the chapter summaries and examples drawn from the familiar world of biology make this book accessible to most graduate level readers. For the less experienced philosophical thinker, this volume succinctly summarises alternative viewpoints with clarity – indeed, skim reading parts of the fourth and fifth chapters after the introduction may assist this reader with identifying the elements of contrasting or competing theories.

I feel much more at ease within the realm of biology and, although I like the challenge of stepping outside my comfort zone, I would describe my full appreciation of matters philosophical possibly in a dualistic sense: my understanding appears to tend towards an unfathomable, potentially 'holy' asymptote.

As such, I fully appreciate how relatively painlessly Kriti Sharma has enabled me to narrow the gap.

ALEXANDER WALLER CBIOL MRSB

Apps and online

A roundup of science apps, software and websites

ZOONIVERSE
www.zooniverse.org
This website is the world's largest people-powered research platform, where researchers with a question can use the site's traffic to assist with data analysis.

Whether it is asteroids or antelope, galaxies or giraffes, the site is useful for biologists with large amounts of data or media and enthusiasts hoping to help with research.

There are numerous projects available covering a wide range of topics, most involving categorising or classifying images. Current bioscience projects include identifying plankton, classifying bat calls or investigating humpback whales' tails. One completed project enabled researchers to analyse more than 2.6 million images of tissue for evidence of cancer cells.

The site is remarkable easy to use for those wishing to help on projects. For researchers, the process involves signing up and following instructions to build a project from templates.

There is a lot of educational material available allied to many of the projects, but it took me some time to get to this – I was too busy classifying animals of the Serengeti.

ADAM TAYLOR CBIOL MRSB

REPOSITIVE
http://repositive.io
Genomics is a data intensive science, and a big problem facing the field is the need to access data across institutions in order to advance research.

However, many human genomic datasets are not openly available – primarily due to the sensitive nature of clinical data and potentially identifiable information in the genome. There are datasets that can be accessed for research purposes, but only if you know where to find them. Repositive is a new online platform for researchers seeking human genomics data or collaborators. It is also a social enterprise, spun out of the charity DNAdigest, which aims to make it easier to find, access and share data in an efficient, ethical way.

Although it is in its early stages, users are very excited about how they can use Repositive to save time when searching for genomic data.

SURAJ RAI

PRIMATE COMPARATIVE ANATOMY
Daniel L Gebo
Johns Hopkins University Press, £55.00

This book covers just about everything you need to know about non-human primates. Despite the name, it includes phylogeny, adaptation, dietary aspects and musculoskeletal mechanics, as well as anatomy. The author acknowledges that *Homo sapiens* are also primates and the final chapter presents human anatomy in comparison with that of the great apes.

The text is separated into 10 chapters and after the first (phylogeny and adaptation) is the marvellously titled chapter 'The Wet-Nosed Primates', which includes the Lemuridae, lorises and indriids, among others. Chapter three is all about the dry-nosed primates such as tarsiers and capuchins, plus the spider monkey and the wonderful siamang gibbon. These two chapters indicate the progression of the primates from relatively primitive forms to the great apes and, of course, dry-nosed humans.

Comparative anatomy starts in full from chapter four, but the real insights in comparison start with a closer look at head forms in chapter five. Here, we see the various forms that define types of primate and their particular lifestyles. For example, on page 71, cranial orbit size is said to correlate with whether a primate is active during the day or night, and the relative size of the brain's cerebellum is linked to the levels of balance achieved by different primates.

Locomotion and diet are critical aspects of comparison, with the latter related to dentition and the former to prehensile tails, extra-elongated forelimbs (as found in gibbons) and, for the apes, a shoulder that can perform circumduction (full-circle rotation of the arm above the head).

Perhaps the most fascinating diagram is on page 156, which shows the extremely diverse feet of primates, reflecting their lifestyles and abilities to match their various habitats. Looking at the figure, you would think the impressions are of feet from animals of different orders altogether, but they are all primates.

With references at the end of each chapter, author Daniel Gebo has produced a text that can only be described as invaluable to the researcher, academic, conservationist, primatologist or student of evolutionary studies. A dream of a book.

PAT SANG CBIOL MRSB

Tarsiers are dry-nosed primates

CUCKOO: CHEATING BY NATURE
Nick Davies
Bloomsbury, £16.99

If ever there was a text to inspire a prospective field biologist, then this is it. Nick Davies has produced an utterly absorbing account of his research over the past 30 years into the life of the cuckoo and its hosts.

The cuckoo is the only obligate brood parasite among UK birds. Davies unravels the processes involved in the 'arms race' between the cuckoo and its host, demonstrating with impressive clarity how natural selection has helped mould both physiology and behaviour. It is a gripping detective story, told superbly well, detailing how questions were asked, clues unfolded and conclusions reached, and exploring how the female cuckoo is able to mimic the specific song patterns, plumage, behaviour and egg colouration of her hosts.

Personal accounts from Davies – of nest hunting forays, the imaginative use of fake eggs to test hypotheses and detailed descriptions of the various habitats involved – combine well to lead the reader through the thought processes of an excellent field biologist.

The story is interspersed with literary and historical references to cuckoos, which add a broader dimension to the scientific investigations. The delightful watercolour illustrations by James McCallum complement the text extremely well and the photographs are excellent.

This is an easy book to read and will inform and enthral both the experienced ornithologist and those with a casual interest in natural history. While much is known about this particular host-parasite relationship, not all questions have been answered, leaving scope for the next generation of field biologists to investigate another chapter in the story.

DR ALAN WOOLLHEAD

The cuckoo mimics other birds

A tome to tackle a burning issue

Fire on Earth: An Introduction
Andrew Scott *et al*
Wiley Blackwell, £39.95

Fire is a major factor in the dynamics of many ecosystems. Its incidence, regularity and intensity are influential in determining the biotic components and their adaptations, as well as in biogeochemical cycling. Given the uncertainty surrounding the effects of global warming on fire occurrence and the relationship with the carbon cycle, a book examining the role of fire on Earth is timely.

There are four parts, each with four or five chapters. Part one opens with an examination of the nature of fire: how it begins, fire types, the impact on vegetation and products of fire, the relationships with erosion/deposition and climate, how fire is monitored (notably satellite imagery), and scales of occurrence. It examines the historical and geological record, with much detail on charcoal occurrence and the reconstruction of fire histories. The latter are the subject of the next three chapters: 420 million years of fire history, plus a specific chapter on the Quaternary Period.

The effects of global warming on fire occurrence is a hot topic

Part two focuses on the biology of fire, with chapters on pyrogeography (patterns of fire in time and space), and fire in relation to plants, fauna, ecosystem processes and human induced environmental change. The latter is re-emphasised in part three: fire history and human history are intertwined and have contributed to defining the Anthropocene (not yet formally demarcated, but considered here to have opened with industrialisation).

A further topic is fire management. Part four deals with wildland fire occurrence and its management. Practical issues such as monitoring, measuring and quantifying are considered, along with predicting, suppressing and controlling wildfires.

Each part has an extensive reference list reflecting the worldwide significance of wildfire and varied scientific approaches: tables, diagrams and colour photographs are abundant, and there is a welcome companion website with a host of useful teaching/demonstration material. This improves the value of this multidisciplinary book, which should appeal to teachers, students and researchers.

DR A M MANNION

Branches

Events calendar
Feb–Oct 2016

BEDS, ESSEX AND HERTS

SEE AND LISTEN TO NIGHTINGALES AT PAXTON PITS
SATURDAY 14 MAY

Paxton Pits Nature Reserve is a wildlife habitat covering 77 hectares of lakes, riverside, meadow, reedbed, scrub and woodland, situated in the Great Ouse valley between St Neots and Huntingdon. The reserve is famous for its nightingales and cormorants, and is host to a wide variety of other birds, insects, mammals and flora. Cost is £2.50 including refreshments.

SELF-GUIDED TOUR OF CAMBRIDGE POLAR MUSEUM
SATURDAY 1 OCTOBER
10:00–12:00 (JOINT EVENT WITH THE EAST ANGLIA BRANCH)

The Scott Polar Research Institute is a world leading information centre for the study of polar and cold regions.

The institute's museum contains exhibits on everything from penguins to paintings, Inuit art to explorers' diaries, and everything else about exploration, science and survival at the extreme ends of the Earth.

A place on this free event can be booked online. For further information contact Mary Parsons – R1mparsons@aol.com

DEVON AND CORNWALL

AGM, LUNCH, TOUR AND NERVE CELLS TALK
SATURDAY 27 FEBRUARY 12:00

Sir Andrew Huxley and Sir Alan Hodgkin received a Nobel Prize for discovering how nerve cells transmit signals at the Marine Biological Association in Plymouth. Come to hear, and see, how this discovery was achieved. Lunch £8.50. Students and guests welcome.

Please register your attendance with Chris Fry, branch secretary. Contact devoncornwall@rsb.org.uk or call 01395 278556 by 22nd February.

EAST ANGLIA

GUIDED TOUR OF BAT'S INDUSTRIAL PLANT BIOTECH LAB
WEDNESDAY 17 FEBRUARY
10:00–13:45

An exciting opportunity to visit British American Tobacco's industrial plant biotechnology lab based at Cambridge Science Park (CB4 0WA). Book online or contact eastanglia@rsb.org.uk

NORTHERN

LECTURE AND BRANCH AGM
SATURDAY 9 APRIL 11:45

The Northern branch meeting, with presentations from experts in the field of ecosystem services, will take place in Durham at 13:30. The talk will be preceded by a brief AGM at 11:45 followed by lunch. Further details will be posted online and will be available from the secretary.

FOR DETAILS www.rsb.org.uk/events

Branch reports

DEVON AND CORNWALL

MICROGRAPHIA
24 OCTOBER 2015

A fun day learning about the history of microscopy

In 1665 Robert Hooke published *Micrographia*, the first fully illustrated book on microscopy – a whole new world of tiny things. To celebrate the 350th anniversary of the book and its beautiful illustrations, Exeter Cathedral hosted our day of microscopy and drawing.

The book was presented in a glass case so we could see the detail of the drawings and text. Ellie Jones, the cathedral's archivist, explained its importance and how it was being conserved.

The University of Exeter provided modern microscopes and slides, giving everyone the chance to compare what we can see today with the tiny images that Hooke saw. PhD students Charlotte Walker and Emma Rundle from the Marine Biological Association provided an antique microscope and information about the history of microscopy in marine research.

Professor Gero Steinberg from the University of Exeter gave a lecture on the development of microscopes and Dr Felicity Henderson from the university's English department gave a talk on Hooke and his book.

The event was linked to the Big Draw, a national celebration of drawing that takes place annually in October. Visitors of all ages attempted to draw their own versions of tiny insects and plants and marvelled at the skill of Robert Hooke.

It was a delight to receive so many positive comments from members of the public who had never looked down a microscope before.

We would like to thank Exeter Cathedral, the University of Exeter and the Marine Biological Association for their help and enthusiasm.

MARY JENKING CBIOL MRSB

Small is beautiful: microscopic wonders are revealed in Exeter

Structural biology and sobering statistics

EAST MIDLANDS

AGM AND DEFEATING CANCER LECTURE
12 NOVEMBER 2015

Talk on the history and future of treating disease

More than 90 people made their way to the Great Hall at the University of Nottingham for the lecture 'Defeating Cancer – Why Is It Such a Challenge?' As it stands, one in three of us will suffer from the disease and one in four of us will die from it – a sobering statistic presented by Professor Andrew Fry from the University of Leicester.

The disease's name originated in 400BC when Hippocrates gave an incurable condition the name cancer (karkinos in Greek) – alluding to the crab like appearance of a tumour surrounded by the blood vessels 'feeding it'.

After the First World War, doctors noticed the reduced white blood cell count of mustard gas survivors and began experimenting with chemotherapy. Nitrogen mustard was given intravenously – a terrifying thought back then, but cytotoxic mustargen is still used today to kill rapidly dividing cells in leukaemia and lung cancer. The side effects of such agents are all too familiar and not surprising, because many of our normal cells are dividing too. For every minute we sat in the audience we were making 12,000 million new gut cells, 300 million new red blood cells, and new hair deep in the follicles of our skin.

Natural chemotherapeutic agents such as taxol (derived from yew) and the vinca alkaloids (Madagascar periwinkle), work in a different way because they affect microtubules – intracellular structures of particular interest to Professor Fry. These drugs prevent the pulling apart of the chromosome copies on the mitotic spindle, thereby preventing cell division.

Molecular biology has allowed great understanding of how mutations affect the start/stop signals in cancerous growth. Advances in structural biology have also enabled more successful design of drugs that can inhibit the proteins driving the cancer. Furthermore, rapid sequencing of a person's genome will allow treatment to be targeted to the mutational profile of each individual patient.

What of the future? The ambition is to achieve a 75% survival rate following a cancer diagnosis, as compared to the current 50%. Early diagnosis is paramount – perhaps blood tests can reveal the oncogenes that are shed into the blood, or 'breathalysers' can detect the cancerous molecules in a person's breath?

Professor Fry is grateful to Worldwide Cancer Research, Cancer Research UK and Hope Against Cancer, which fund the research in his laboratory.

ROSEMARY HALL MRSB

Sequencing genomes will increasingly allow cancer treatment to be targeted to the mutational profile of each individual patient

SCIENCE AND NONSENSE IN DRUG AND ALCOHOL POLICIES
19 NOVEMBER 2015

A critique of government drug policy with Professor David Nutt

By his own admission, Professor David Nutt polarises opinions. During an entertaining, thought-provoking and informative lecture delivered to more than 300 people at the University of Exeter, Professor Nutt provided evidence of complicity, media misreporting and ignorance underpinning the Government's position that illegal drugs are dangerous and cannot be used under any circumstances, including in clinical research.

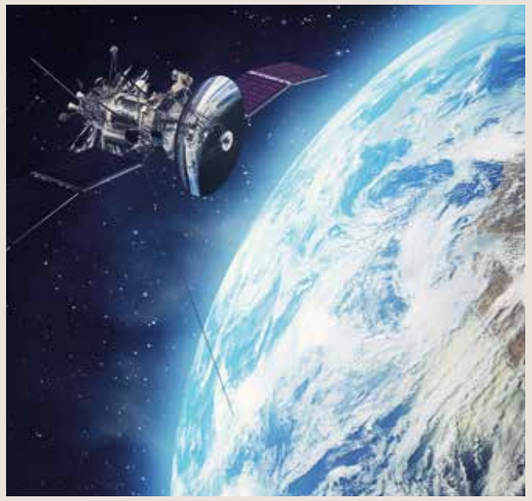
Sacked in 2009 from his post as chairman of the Advisory Council on the Misuse of Drugs by the then Labour home secretary Alan Johnson, Nutt has been an outspoken advocate for evidence-based drugs policy, rather than the seemingly irrational approach taken by successive administrations.

Nutt presented compelling data on the accelerating incidence of liver disease, clearly illustrating that alcohol is the most dangerous drug in terms of affecting the individual who consumes it and those close to people who abuse it, as well as society in general.

'Magic' mushrooms

Conversely, he highlighted the vilification of MDMA (ecstasy as it was also known) by the mass media, and presented evidence of miscommunication in cases where mephedrone, formerly a 'legal high', was confused with methadone (a heroin substitute) to exaggerate its danger to society.

Nutt's research is focused on the clinical utility of 'illegal' drugs – psilocybin from magic mushrooms as a treatment for depression and cluster headaches, and MDMA for post traumatic stress disorder. Gaining access to these drugs for clinical research can take years, and is set to get worse. The Psychoactive Substances Bill, which is likely to gain royal assent this year, will ban the sale of psychoactive substances



Data from satellites is used to monitor changes in the environment

Our world's future can be seen from space

KENT, SURREY AND SUSSEX

MONITORING BIOLOGICAL DIVERSITY FROM SPACE

15 OCTOBER 2015

How technology can keep track of our changing planet

Human activities – through climate change, shifts in land use, and the release of nitrogen and phosphorus into the environment – are all altering our biosphere. One in every 10,000 species is reportedly lost per year, while in the sea the number of dead zones, where dissolved oxygen levels have dropped too low to support most marine life, has roughly doubled each decade since the 1960s.

In a talk to students, staff and Society members at Sutton High School, Dr Nathalie Pettorelli, from the Institute of Zoology at ZSL, discussed how data from satellites may be used to monitor these changes.

Dr Pettorelli began with the meaning of the term biodiversity and the impact of human-induced change on the number and ratios of species, and on human lives, particularly the lives of the poorest segment of a population.

She went on to discuss how biodiversity can be monitored and the value of satellite-based observations in this process. Landsat satellites operating in the visible, infrared and microwave regions of the spectrum offer a reproducible and sustainable means of deriving environmental information on large or remote areas of the world at a significantly lower cost than that of field monitoring.

Satellite imagery has been used to detect and map anthropogenic disturbances in desert environments, including oil exploration in the Sahara.

It has also been used for monitoring penguins in Antarctica via the discolouration of the snow by their excrement, and for predicting the timing of red deer seasonal migration and their reproductive success.

DR DAVID WARE FRSB

regardless of harm and benefit (including nitrous oxide, which is widely used for pain relief). This could end essential research work and needlessly delay new therapeutic drug development. Is this the worst moral law for more than 400 years?

The full talk can be found on the University of Exeter website: www.ow.ly/UXokd

DR IAN M VARNDELL CBIOL FRSB

NORTH WALES

ERDDIG GARDENS VISIT

10 OCTOBER 2015

Orchard trip provides a sweet day out and 148 types of apples

Branch members and their guests met at Erddig Gardens on a sunny day, and were led to a vast display of apple varieties in the orchard's collection – 148 in total. The apple crop had already been picked and was ripening in greenhouses ready for sale.

Head gardener Glyn Smith gave a brief history of the origins of domesticated apples, from European crab apples (*Malus sylvestris*) to the modern day sweet apples (*Malus pumila* spp.).

Although the Erddig apple collection holds 148 distinct varieties, the identification of apples is still a bit of an art, rather than a science. Apples are hermaphrodites, but self incompatible to their own pollen, hence the requirement of cross pollination by other pollination groups, determined by overlapping flowering periods. But, as Glyn remarked, you could hold early flowers in the fridge and get fertilisation.

Human selection and crossing of apple varieties have led to the 'sweetest' apple, Golden Delicious, as well as supermarket varieties bred for rough handling and colour uniformity – often at the cost of taste. The apple taste is influenced by the presence of tannins, from almost nothing in Golden Delicious to the almost inedible cider apple varieties.

Glyn finished the visit by giving a tour of the garden. He discussed its history, the future of its funding and the teaching and training of future horticulturists. Members and guests finished an enjoyable day with an excellent lunch in the trust's restaurant.

Thanks to John Baker, a valued volunteer at Erddig, for arranging the visit and talk.

PETER THOMPSON CBIOL MRSB

Head gardener Glyn Smith gave a talk on the history of domestic apples

NORTHERN

BRANCH CHRISTMAS CELEBRATION

5 DECEMBER 2015

Festive gathering and a look at photo competition winners

Members of the Northern branch and their guests celebrated the award of a royal title to the Society at a Christmas dinner in the pleasant surroundings of the Lindisfarne Centre at St Aidan's College, Durham University.

Before the excellent festive meal we were fortunate to view a display of the winning entries in the Society's latest photography and drawing competitions, together with the book prize winners.

It is a few years since we last had a Christmas gathering and it's hoped that the success of this event will lead to many more to come.

DR MICHAEL ROWELL CBIOL MRSB

An eye-opening talk

THAMES VALLEY

AGM AND LECTURE AT WELLINGTON COLLEGE

14 OCTOBER 2015

A chance to network and find out about ophthalmology

The meeting was hosted by Wellington College, Crowthorne. Members, their guests, teachers and students enjoyed pre-meeting drinks and a buffet provided by the biology department.

Attendees enjoyed informal networking along with hearing our guest speaker, Vaughan Tanner, senior ophthalmic surgeon from the Royal Berkshire Hospital, Reading.

Mr Tanner gave a fascinating talk, with excellent graphics, on surgical advances and techniques in eye surgery.

The advance of sub-2mm microincision cataract extraction with multifocal and toric lens implants was described. This new technique significantly reduces spectacle dependence following cataract surgery.

The surgeon's lecture covered the development of sutureless small incision vitrectomy techniques for the repair of retinal detachment, macular hole and other vitreoretinal diseases.

Mr Tanner also explained how the many new retinal drug treatments have significantly improved vision for many patients suffering from age-related macular degeneration, diabetic retinopathy, retinal vein occlusion and other retinal problems.

Our thanks go to Wellington College and Mr Tanner for the opportunity to learn more of developments in ophthalmology.

DR JOHN HASPINEALL CBIOL FRSB

Ophthalmic surgeon Vaughan Tanner, left, and Ray Gibson CBiol FRSB from the Thames Valley branch at the meeting

Members of the scientific community met MSPs at the event in Edinburgh

SCOTLAND

SCIENCE AND THE PARLIAMENT EVENT

11 NOVEMBER 2015

Leading politicians give their views on future of science

The 16th Science and the Parliament event, organised by the Royal Society of Chemistry on behalf of the scientific and engineering community in Scotland, took place at the Our Dynamic Earth exhibition space in Edinburgh.

The annual event aims to promote engagement between members of the scientific community, MSPs and other policymakers in the Scottish Parliament and Government.

The Scottish general election-themed event started with a warm welcome from Professor Alan Alexander, general secretary of the Royal Society of Edinburgh (RSE), and Professor Dominic Tildesley, president of the Royal Society of Chemistry. Professor Neva Haites set out the outstanding achievements of the RSE and how it strives to enable evidence-based science to inform politicians and to shape policy.

Rhiannon Cleghorn and Rebecca Brown from Lossiemouth High School described their recent trip to Botswana, where they delivered hands-on lessons to 10 to 17 year olds on hydrogels despite the limited infrastructure.

In a series of presentations and discussions, a range of MSPs set out their vision for the future of science and engineering in Scotland. Contributors included Dr Alasdair Allan (minister for learning, science and Scotland's languages), Kezia Dugdale (leader, Scottish Labour Party), Liz Smith (Scottish Conservative Party), Willie Rennie (leader, Scottish Liberal Democrats) and Patrick Harvie (leader, Scottish Green Party).

In recognition of excellent academic performance, the RSB Scotland branch awarded prizes to the top performing students in Higher biology, Higher human biology, Higher biotechnology and Advanced Higher biology for 2015. The top biology student in Scotland, Ines Alvarez Rodrigo, also received an award in recognition of academic excellence and engaging the wider public in biology.

JACQUELINE NAIRN FRSB

SOUTH WALES

SYNTHETIC BIOLOGY AND SYNTHETIC LIFE PANEL DISCUSSION

16 NOVEMBER 2015

Compelling introduction to a complex scientific issue

New applications and developments in synthetic life could have a considerable

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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

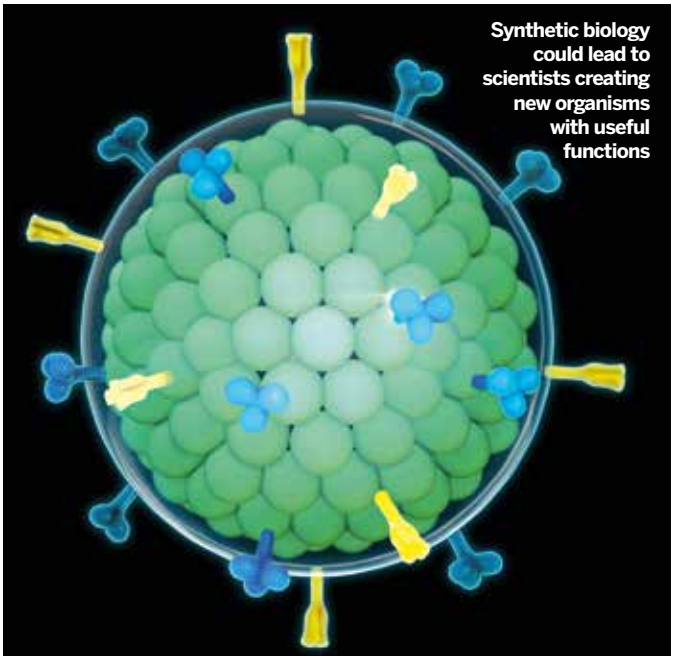
impact on humans, as well as the environment. Therefore it proved to be an excellent topic for a rousing panel discussion. The conversation covered many aspects of this fascinating field, including the basic concepts of synthetic biology and synthetic life, where current efforts are focused, and the technology and methodology involved.

The panel also touched on potential applications, and their societal and ethical implications. Fundamentally, the discussion provided a broad introduction for many people to synthetic biology and the complexity of the term.

The discussion panel was comprised of a number of local academics from a range of scientific disciplines, including chemistry, biochemistry, and engineering. This diversity led to an interesting overview of the subject, which was chaired by Dr Beatrix Fahnert FRSB, chairperson of the South Wales branch.

The event ended with a cheese and wine reception, which allowed networking and further discussions to take place. More than 80 people attended, and all left with a better understanding of synthetic biologies.

DR CLAIRE PRICE MRSB AND CSABA SÁROSI AMRSB



Synthetic biology could lead to scientists creating new organisms with useful functions

WEST MIDLANDS

AGM

4 NOVEMBER 2015

DNA profiling lecture was a highlight of annual meeting

Society members and their guests enjoyed an interactive talk on forensic DNA profiling delivered by Dr Elaine Green, Dr Andrew Reid and Dr Adele Heath at Coventry University.

The branch committee's annual report is on the branch page of the Society's website.

If you would like to see the draft minutes from this year's AGM, or have any queries, please contact the branch.

PAMELA SPEED CBIOL MRSB

Forensic DNA profiling, the focus of the West Midlands branch's lecture

BIOLOGY WEEK POSTER COMPETITION

21 NOVEMBER 2015

Youngsters display understanding of key biological issues

The event rewarded students from schools across the West Midlands for their work on posters tackling important scientific questions. Topics covered included food production, antibiotic resistance and biofuels.

The judges, Dr Steve Russell MRSB and some of Aston University's second year students, selected winners in several age categories. The winners of the age seven to nine category were: Gianluca Fudger, Ciaran Gould, Samuel Bradburn, Rosie Richardson, Isabelle Tompkin, and Mine Aralik, from Blessed Edward Oldcorne Catholic College, and Hannah Shuttleworth from Norton Canes High School.

Sarah Chapman, Roxanne Francombe and Eleanor King-Turner from Warwick School took the prize for ages 10 to 11, while Chloe Richards, Jade Howes and Chelsey Wright from Norton Canes High School took the top spot in the 12 to 13 category.

DR STEVE RUSSELL MRSB

Crossword

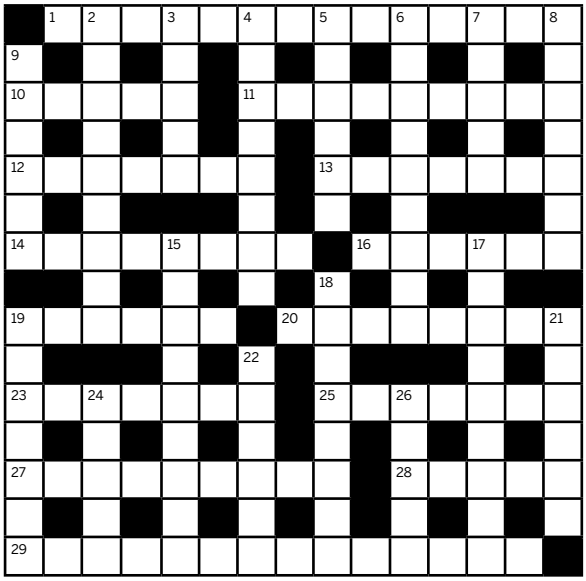
Beat our biology brain teaser for a chance to win a £25 book token

Across

1 So python shaped? The head of snake is (14)
10 Botox injection ingredient (5)
11 Got inside out (9)
12 Hint of gold gets chaps in mine (7)
13 He is the second one. She isn't one at all (7)
14 Once in trouble and where troublemakers can end up (4,4)
16 Appendage fish uses for example turning on river (6)
19 Pass on type of chromosome (6)
20 This and I could turn to parenting (8)
23 An alien variety (7)
25 Coach comes back dirty (7)
27 Biochemistry possibly developed from her working with this (9)
28 On surface of skin a small opening (5)
29 Notice city gets redeveloped (14)

Down

2 With a long axe start to hack out honeycomb like this (9)
3 Colour can hide even bits of grey (5)
4 Calmly see lady take time to change (8)
5 Automatic turning up to acquire useful bit of information (6)
6 Moving quickly then I hit snag (9)
7 Thorn from Sierra conifer (5)
8 Setting out to snare politician (7)



Volume 63 No 1
compiled by Doug Stanford

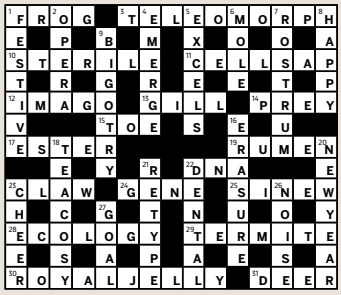
9 One subject involving an unusual reaction (6)
15 Company finding out and sharing private information (9)
17 Good looking girl lost heart, it's to do with love (9)
18 Angry copper ending on beat, it goes against the grain (8)
19 Form I start to carve is great piece of art (7)
21 Cultivate royal personage found on board ship (6)
22 Force amphibian just above the surface (6)
24 Confess I'm tad untidy (5)
26 Openings in biology at some international companies serving as a starting point (5)

This issue
Across answers are from the world of biology and are clued solely by a cryptic indication. Down clues provide the normal combination of a definition plus a cryptic indication.

How to enter
To be in with a chance of winning a £25 book token, please send us your completed puzzles by Monday 29th February. 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 the winners of the December/January issue crossword: Dr Clive Halliday CBiol MRSB and David Walker MRSB (Billericay). Book tokens are on the way.

Last issue's solution
Vol 62 No 6



Museum piece

Biological exhibits from around the world

#18 The 30ft tapeworm

Meguro Parasitological Museum, Japan

The Meguro Parasitological Museum is not the place for tourists hoping to find priceless Japanese artefacts. Opened in 1953 by medical doctor Satoru Kamegai, the museum has amassed more than 60,000 parasite specimens, with around 300 of the most lurid of them on permanent display.

The museum's centrepiece is a mounted tapeworm measuring almost 30 feet (8.8 metres) in length.

The *Diphyllobothrium nihonkaiense* specimen grew to 3,000 segments long in the gut of a man who had eaten raw salmon. It only revealed itself to its unfortunate host when it outgrew his entire intestine.

It is not the longest worm to be pulled from a human but still shocks visitors to this small museum in the Tokyo ward of Meguro. A 30 foot long ribbon can be unravelled to help people get a sense of scale.

The museum is housed in a private research facility and claims to be the world's first museum dedicated to parasites. Unsurprisingly, there seem to be few contenders.

As well as free entry, the museum offers a variety of study programmes, lectures and prepared parasite specimens for educational purposes. The museum shop even sells parasite merchandise, including tapeworm t-shirts and fridge magnets.

The Meguro Parasitological Museum is open Tuesday to Sunday, 10:00–17:00. See website for exceptions. www.kiseichu.org

A 30ft tapeworm on display at Meguro's museum of parasitology

MICHAEL TURTLE, WWW.TIMETRAVELTURTLE.COM

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Join

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.

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