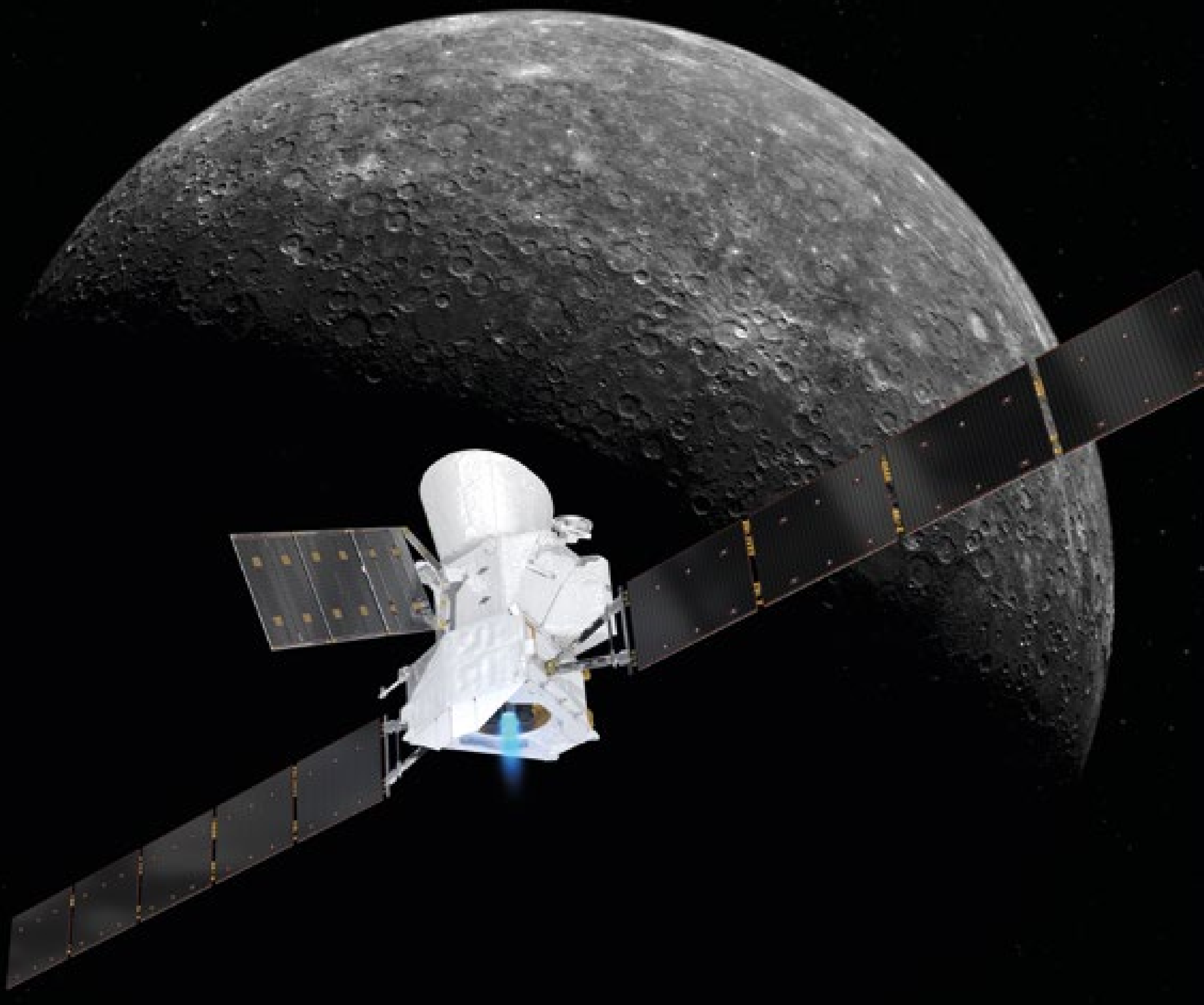
CATALYST

Edition 32



In this issue:

Welcome

Welcome to another edition of Catalyst - aimed at young people, we're proud to bring you cutting edge research that sparks debate.

This edition we've got articles on: Europe and Japan's first mission to Mercury, what happens to the brain through the teenage years, why birds' beaks are getting longer, and we hear from England's Gold medal winning netball coach. We hope you enjoy this edition. If you have any ideas for future topics you'd like to see covered, get in touch via our email: **catalyst@stem.org.uk**

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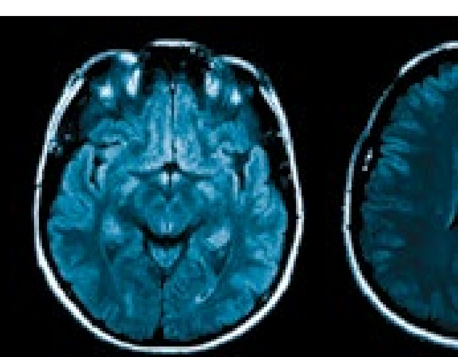

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Career journey with
Jools Murray

From science to netballing Gold with England's winning coach.

How do you go from a science degree to winning Gold at the Commonwealth Games? Jools Murray, the winning England team's Lead Strength and Conditioning Coach, tells us how!

Q How has your life been since winning Gold with England's netballing team?

A After winning, it was all work and it's only been the past wee while that things have calmed down. I still get a smile on my face when I think about what we achieved as a team and know it will be something I carry with me for life.

Q What is your job title?

A Senior Strength & Conditioning Coach for England Netball & EIS UKSCA, MSc.

Q We hear playing Frisbee helped your career?!

A When I was at the University of Edinburgh, I studied physics and competed for the Great Britain Women's Ultimate Frisbee team. The university provided me with support through free physiotherapy and strength and conditioning.

Q How did you get into sports coaching?

A When I finished my degree, I felt lost. I wasn't smart enough to go into physics and get one of the cool jobs! While discussing the fitness training I had done to get ready for World Championships my mum said she wished she had someone like me to get her training; I realised I am someone who believes in the benefits fitness and sport can bring to people's lives.

I worked to achieve my accreditation in strength and started studying a Masters in Strength and Conditioning (S&C). I was introduced to Alex Wolf, who was the Head of S&C for the English Institute of Sport (EIS), and he mentioned they had a work placement coming up with the GB Rowing Team. After a successful interview, I joined him working on the GB rowing programme; it wasn't until that point that I truly understood S&C.

"Without a good understanding of science, it would be impossible to work in high performance sport where the margins for success or failure are so small."

"My job is to improve athlete performance by developing specific physical qualities and to put in place injury prevention strategies – all based on current research."

Q How important is science in your career?

A Very. Not everybody realises that studying science can open many doors for you. In this area of high impact sport, it is particularly important.

My job is to improve athlete performance by developing specific physical qualities and to put in place injury prevention strategies – all based on current research.

Biology

Physics

Chemistry

Biology supports understanding of the body and how it responds to resistance training, physics dictates the laws associated with movement and forces produced around joints, and chemistry helps us to understand the mechanisms at play during all of this. Analysing real time data is becoming even more science based as technology has progressed to allow us to track movement and understand the demands being placed on the body. Without a good understanding of science, it would be impossible to work in high performance sport where the margins for success or failure are so small.

My background in physics has given me a unique edge in a very competitive field. There have been some critical pieces of work I've been able to offer sports that puts me ahead of the rest.

Q Talk us through an average work day

A Every day has different sessions that need to be delivered and their delivery varies on how the athletes are doing; changes from the coaches, any newly developed issues, what came before and what's to come after. Without a strong understanding of my area of expertise, I wouldn't have the flexibility to adapt.

Q What sort of personality/passions do you need in your career?

A You need to be passionate about what you do as the demands of the job are very high. You have to have a love of learning, be able to keep abreast of current research, challenge your methods and want to continuously improve.

Q What advice would you give to someone considering this career?

A Working in sport is a wonderful opportunity to meet fascinating people and have unique experiences. Be prepared for the opportunity for big success as well as big failures. You will definitely need to be resilient as it is high performance sport after all; second place just doesn't cut it!

"Not everybody realises that studying science can open many doors for you."

You can follow Jools on twitter and facebook.

@Jools_Coach

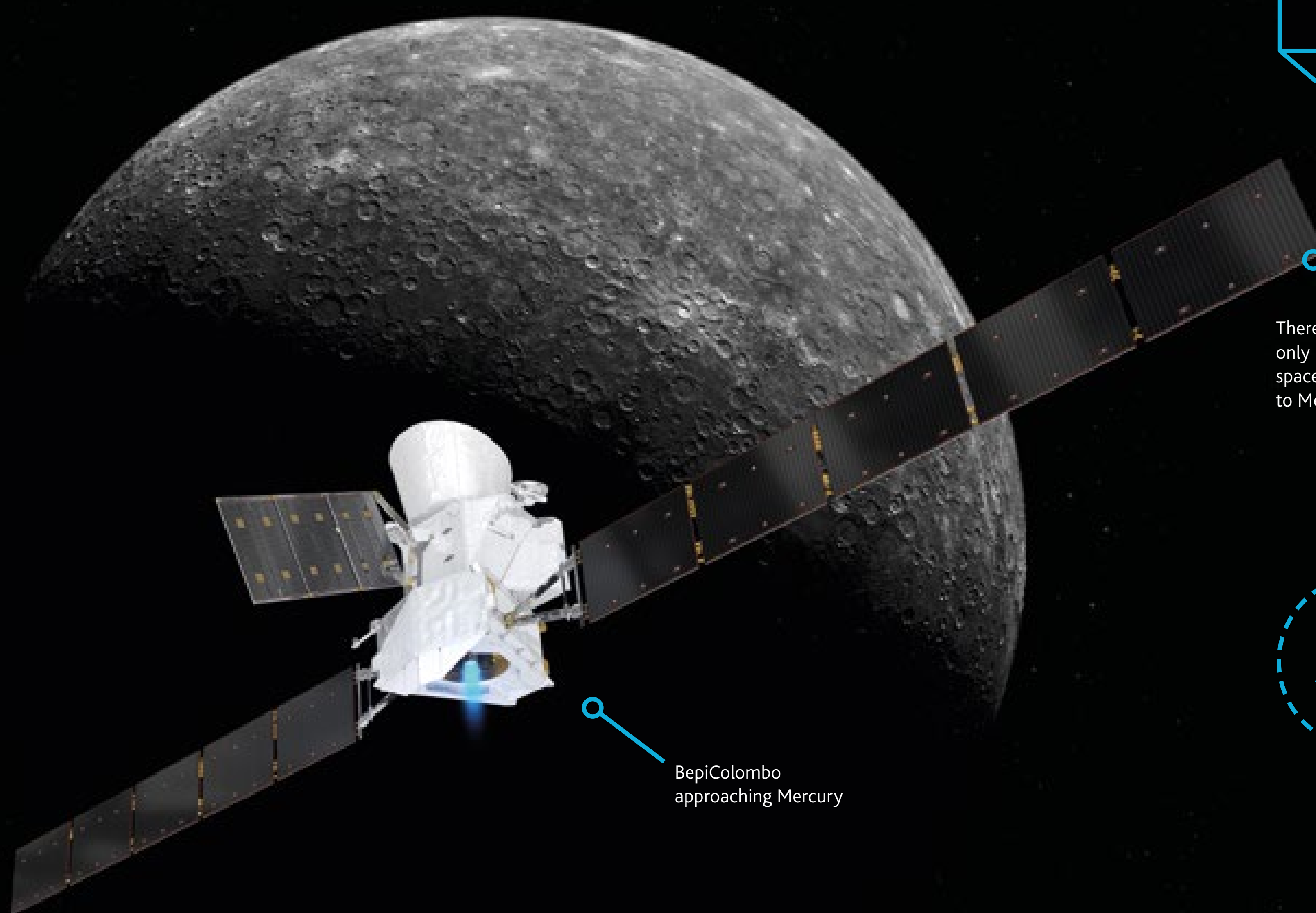
/joolscoach

Europe and Japan's first mission to Mercury!

By Dr Suzie Imber
Associate Professor in Space Physics,
Leicester University

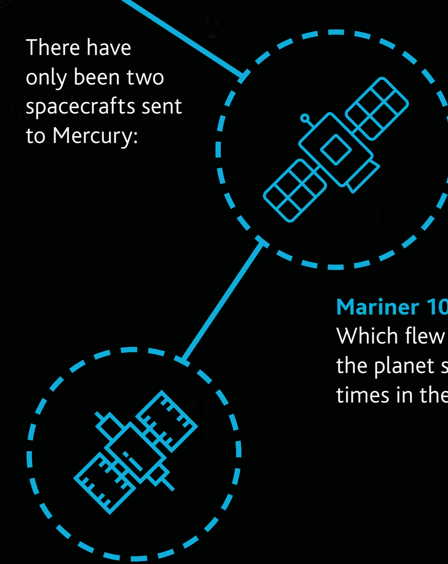
BBC Astronauts winner Dr Suzie Imber talks about Europe and Japan's first joint mission to Mercury – our Solar System's least explored planet.

Associate Professor in Space Physics Dr Suzanne Imber from Leicester University holds a research grant to study Mercury's magnetosphere, using data from NASA's MESSENGER mission, the first spacecraft to orbit the planet Mercury.



BepiColombo approaching Mercury

There have only been two spacecrafts sent to Mercury:



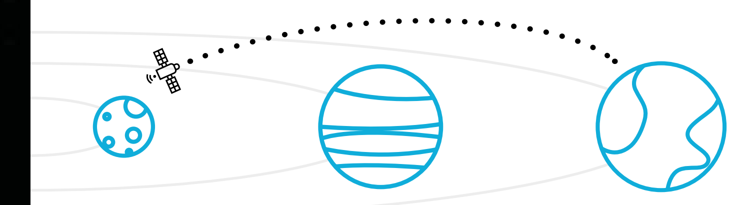
Mariner 10
Which flew by the planet several times in the 1970s

MESSENGER
Which arrived at Mercury in 2011 after a 7 year journey

In October this year, the joint European Space Agency and Japanese Aerospace Exploration Agency will launch the BepiColombo mission to Mercury. This is only the second successful mission ever launched to this small planet. The mission will tell us about the composition, evolution and dynamics of Mercury's environment and will provide new insights into the formation of the inner planets in our solar system.

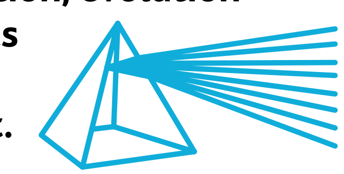
Since both Mars and Venus have been orbited by multiple spacecraft and even Jupiter and Saturn have both had orbiting satellites, you might expect that missions to Mercury are not unusual. However, there have only been two spacecraft sent to Mercury: Mariner 10, which flew by the planet several times in the 1970s, and MESSENGER, which arrived at Mercury in 2011 after a 7 year journey, and was deliberately crashed into the planet at the end of its lifetime in 2015.

So why have we not sent more probes and orbiters to Mercury? It's not because Mercury is far away – it would take a matter of months to reach the planet if a spacecraft was launched directly towards it.



Getting to Mercury is easy - stopping and orbiting this small planet close to the Sun, is the hard part! The Sun's gravity acts to pull the spacecraft towards it, so in order to stop, the spacecraft has to be going in the same direction and travelling at the same speed as the planet Mercury, in order to be captured by Mercury's weak gravitational field.

The BepiColombo mission to Mercury will tell us about the composition, evolution and dynamics of Mercury's environment.



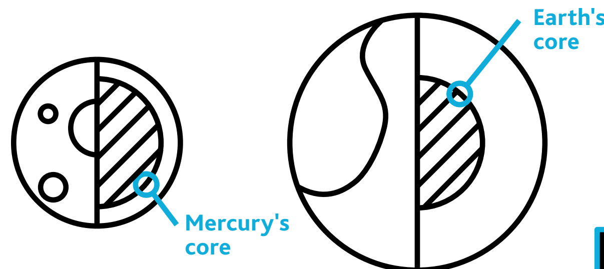
The trajectory required to get the spacecraft close to Mercury was first developed by the Italian scientist Guiseppe (Bepi) Colombo in the 1960s. His technique was to use the gravity of the planets to alter the trajectory of the spacecraft to get it to the inner solar system tracking the orbit of the target planet. In order to enable BepiColombo to reach a stable orbit around Mercury, it will receive a total of nine gravity assists, one from the Earth in 2020, two from Venus, in 2020 and 2021, then six from Mercury itself, between 2021 and 2025.

The mission consists of two separate orbiting spacecraft: the Mercury Planet Orbiter (MPO) and the Mercury Magnetospheric Orbiter (MMO). The MPO will study the surface features and composition of Mercury and the MMO will study the magnetosphere; the region of space dominated by the planet's magnetic field.

Mercury's magnetic field is full of mysteries – firstly it's a surprise that such a small planet possesses a magnetic field at all, and then NASA's MESSENGER spacecraft confirmed that the magnetic dipole of the planet doesn't behave in the way we would expect.

Sewing insulation blankets on ESA's Mercury Transfer Module. The insulation is to protect the spacecraft from the extreme thermal conditions that will be experienced during the mission. >

Mercury is the densest planet in the solar system and has a mysterious structure, with a core that extends to 85% of its radius, unlike the Earth where the core only extends to 50% of the radius. Furthermore, with the discovery of water ice at the bottom of deep craters near the poles, coincident with dark, organic material of unknown origin and composition, there are many questions that remain to be answered!



Mercury's surface emits X-rays, caused by the interaction of the surface particles with radiation from the Sun. At the University of Leicester, we have designed and built an X-ray telescope known as MIXS, which will continually point at Mercury's surface and measure the emitted X-rays; the properties of which will tell us the composition of the planetary surface. The MESSENGER mission had a similar instrument, but our instrument on BepiColombo has a much higher resolution – it's like going from a single huge pixel on the planetary surface to a digital photo with thousands of pixels. Understanding the surface composition will help us to answer questions about the formation of Mercury, its evolution over time, and even the delivery of ice and organic material by asteroid impacts early in Mercury's life, some of which are still present at the bottom of deep craters on Mercury. Furthermore, by targeting material around large craters, lifted from under the surface by the largest asteroid impacts, we will be able to determine the sub-surface composition of the planet – a measurement that is extremely difficult to carry out without landing and drilling into the surface itself.

There is one more target for our instrument – not something that the instrument was originally designed to measure, but a discovery made by NASA's MESSENGER mission that MIXS BepiColombo will be able to pin down with greater accuracy.

Energy and momentum from the solar wind are transferred to Mercury's magnetic field where energy builds up and up until it must be released. This explosive release of energy accelerates particles towards the planet, which travel down magnetic field lines to high latitudes. On Earth, these particles impact the atmosphere and cause it to glow, generating the aurora, or northern and southern lights. The same process is believed to happen on Mercury. We recently observed this X-ray signature using MESSENGER data, and look forward to much higher resolution data from our instrument on BepiColombo. Mercury is the most extreme planet in the solar system, experiencing the most severe space weather events in the solar system, and the auroral signature we will observe will help us to understand the physics of the magnetosphere, which in turn may help us to predict what might happen during a severe space weather event at the Earth.

BepiColombo was shipped to its launch site, in Kourou, French Guiana, in May 2018. It will undergo a series of activities and tests before its launch. The mission has a six-week launch window spanning October/ November, 2018, and will be launched on an Ariane 5 rocket.

Becoming a Bioengineer

2018 is the Year of Engineering – a chance to celebrate the wonder of the world of engineering, and the inspiring individuals who inhabit it. We speak to Bioengineer Dinalie Karunaratne about the exciting field she works in.

Q What does your job as a Bioengineer involve?

A I design and develop implants and instruments for joint replacements. Bioengineers are fundamental team members for developing new medical product concepts. We do this by getting feedback from surgeons, determining how best to test them and assessing the efficacy and risk of these designs. As a Bioengineer, the safety of the patient is always my first priority, which means I have to understand what the patient needs and be realistic about both the potential and the limitations of the device I'm developing.

Q What exactly is Bio/Biomedical engineering?

A Bioengineering and Biomedical engineering focus on developing technologies, products and services to solve clinical problems. This can cover anything from Band-Aids to prosthetic limbs, from toothbrushes to space suits. Even if biology is not your strong suit, the engineering involved is no different to any other industry: there is a problem, and you are trying to solve it. It just so happens that the problem you're trying to solve is a medical one.

Q How are bioengineers changing the world, and what future technologies do you imagine?

A The need for healthcare will be ever-present: on the one hand we have people living and staying active for longer, their bodies continuously playing catch up with their lifestyle. On the other hand, there are whole communities where accessible, affordable healthcare is out of reach, so healthcare problems for bioengineers are not going anywhere.

3D print implants have already been made possible. Computer-assisted surgery is already being used. Bigger and better technologies are required for patients who have increasingly high expectations of treatment outcomes. Using digital solutions to enhance healthcare e.g. through real-time data retrieval from smart devices, can help tailor treatment to individual patient needs. Cheaper, more accessible technologies are required to reach a larger number of patients, meaning research into new manufacturing methods is a significant area of development.

Bioengineers develop anything from Band-Aids to prosthetic limbs, from toothbrushes to space suits.

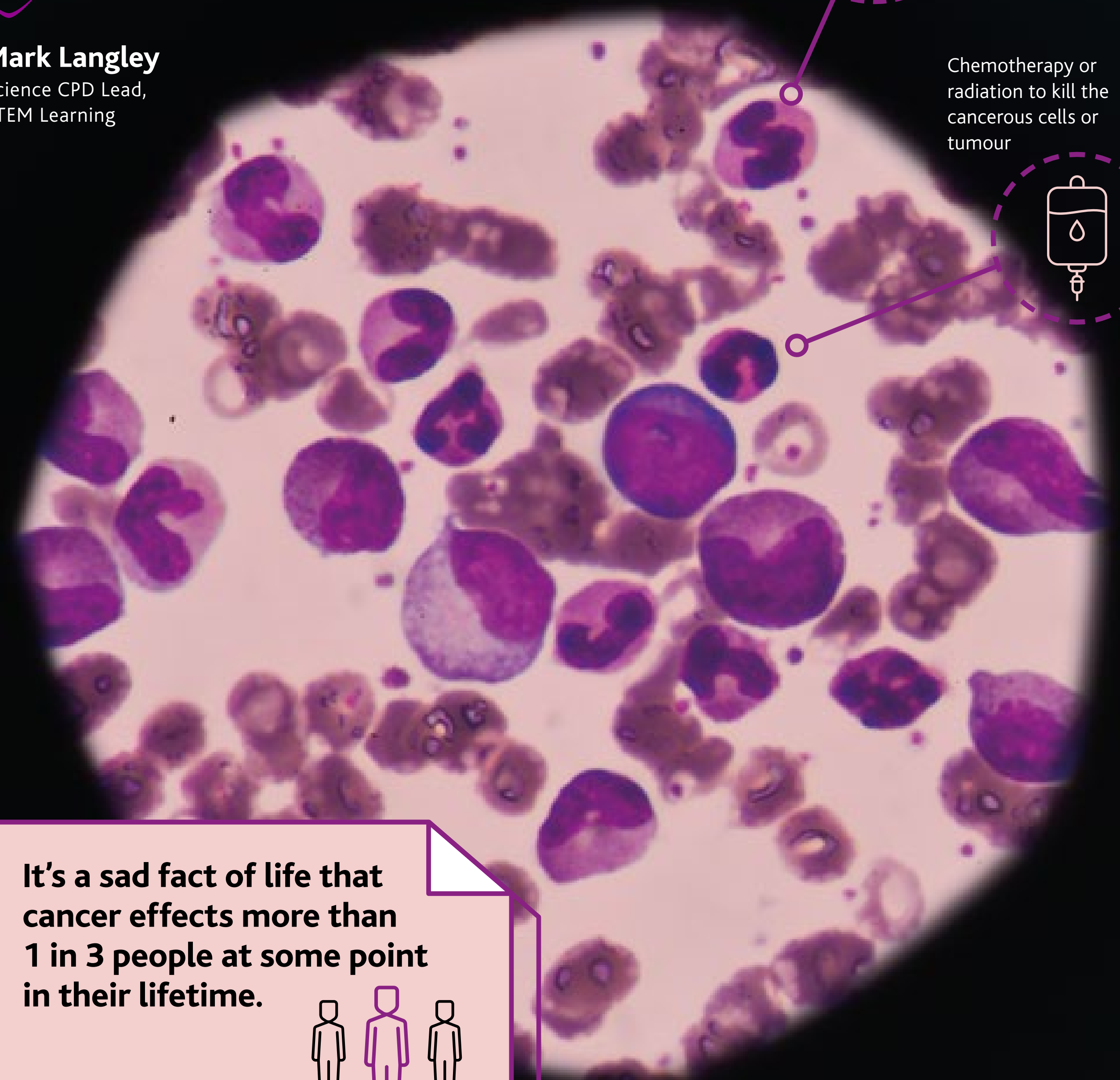
Q What does it take to be a bioengineer, how do you get into it?

A There is one common trait amongst all engineers – an eagerness to solve problems. An affinity for science is necessary too, as this forms the foundation for an engineering degree or apprenticeship. This does not mean that you need to ace every maths, physics and biology exam. There are different routes into engineering – choose the one that plays to your strengths. Some medical device companies offer apprenticeship schemes which offer great early hands-on experience. University is the traditional route, which offers the chance to explore different aspects of engineering. Many bioengineers come from other areas eg mechanical, materials and sports engineering. It is a universal language with transferable skills… No one way is correct.

Reach out to medical device companies directly as some run work experience programmes, which gives insight into the profession and a chance to engage with engineers.

Proton beams: high end physics to treat cancer

Mark Langley
Science CPD Lead,
STEM Learning



Treatment for cancers revolve around:

Surgery to cut out the damaged tissues

Chemotherapy or radiation to kill the cancerous cells or tumour

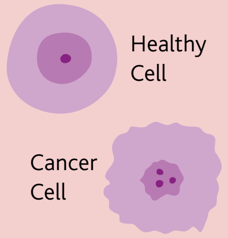
It's a sad fact of life that cancer effects more than 1 in 3 people at some point in their lifetime.

Radiation can come in many forms, but x-rays are very commonly used in medicine, both in lower levels of exposure to identify abnormalities such as through CT (computerised tomography) or more classic x-ray images, or in higher levels to kill cancerous cells.

To kill a cell with radiation, you have to supply enough energy to disrupt the process of cell growth and mutation - by damaging the DNA in the cell to where it can no longer repair itself and divide. The most common treatment is to use x-rays, which are produced by a beam of electrons hitting a metal target and exciting the electrons close to the nucleus of the metal atoms to a higher energy level. As the electrons return to their ground state, they emit energy carried by photons of light, with the wavelength and frequency in the x-ray band (around 10-10 m and 1018 Hz).

These photons of light carry a lot of energy. They are targeted towards the tumour and pass through the surrounding tissues until they reach the tumour, then pass out through the tissue on the other side. The problem is that they don't just leave all the energy in the tumour, but also deposit energy in the cells either side. This is a problem, as to get the high dose to kill a cancer cell, you might also do damage to healthy cells either side. This can be reduced by targeting beams onto the tumour from lots of different angles, but still healthy tissue can suffer.

Killing cancer cells with radiation can also damage healthy cells.



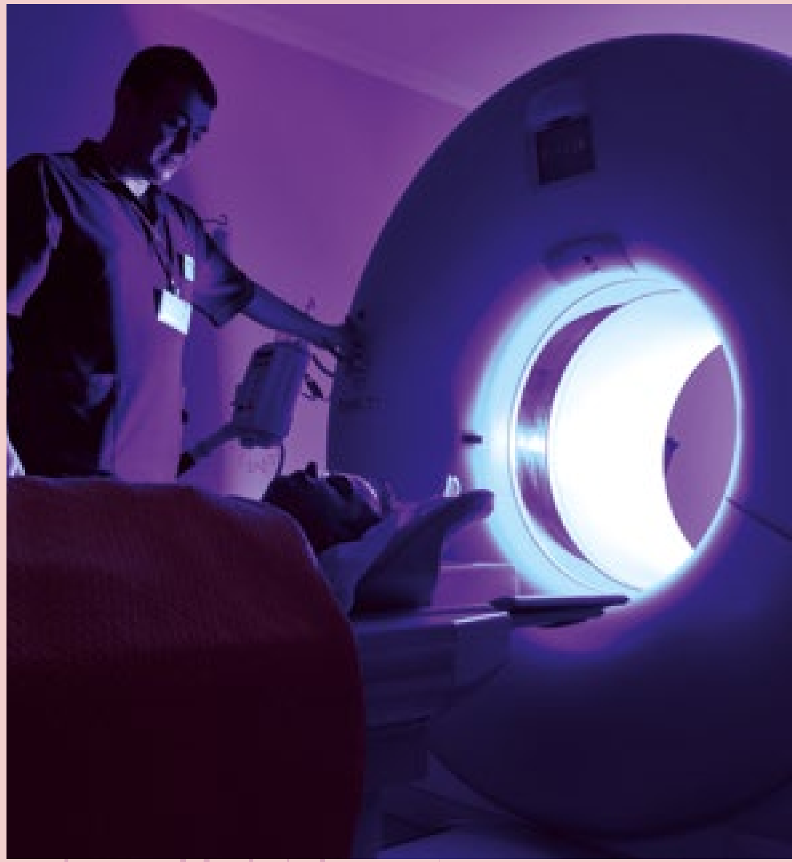
An alternative to using high energy photons is to use other particles. One that is being used successfully is to take a proton and accelerate it to almost the speed of light, giving it lots of energy. Then the proton is passed through tissue until the tumour is reached. However, due to a quirk of physics, the energy of the protons can be tuned so the Bragg Peak (where they lose most of their energy) can be calibrated to dump the energy into just the tumour without damaging the tissue either side.

A proton has very little mass and the amount of energy that can be carried by a particle is limited - so for even greater effect, larger particles, such as a carbon ion (which has a nucleus of six protons and six neutrons) can carry more energy and do even more damage to a cell per particle.

So, why are there so few proton or heavy-ion treatment centres in the UK? Currently there are only a couple of centres open, though there are plans to open more. However, each centre requires a large particle accelerator, such as found at CERN in Geneva. Unlike conventional x-ray machines, which are compact, not much bigger than the patient, the technology required for ion therapy is massive, though it is getting smaller.

Particle physicists have been developing machines all over the world to smash together high-energy particles - most of which are colliding protons with each other. As a proton is made up of three smaller particles, called quarks (two up quarks and one down quark in the case of a proton). When protons collide at high energy they can annihilate (destroy each other, leaving nothing but pure energy), creating new particles as the energy of the collision recombines to matter (as in the famous equation $E=mc^2$). Medical physicists are less keen on creating new and weird particles, but using the technology to help diagnose and treat patients.

In the UK, at Clatterbridge there is a facility that uses low-energy protons to treat eye tumours very successfully, which are otherwise difficult to treat in the more conventional ways. Proton beam therapy certainly will help with the treatment of cancers and, as we develop more centres across countries, the outcomes for patients with cancer will improve, but there are financial implications. Proton and ion beam therapy machines are not cheap, costing millions of pounds to build and maintain - and that economic cost has to be weighed up against the overall effectiveness of the treatment. Many cancers spread and, even with the best treatment, cannot easily be stopped. So the idea of prevention (such as stopping people smoking and better air quality) and early detection (such as breast and prostate screening) is really important. This means better and more accurate diagnosis techniques, as well as public health measures, can tie in to improved treatment. Unfortunately, given the nature of cancer, it will never stop being a killer and its unlikely there will ever be a cure, but with improved technology, we can improve lives.



By Dr Lewis Spurgin
Evolutionary Biologist from
the University of East Anglia

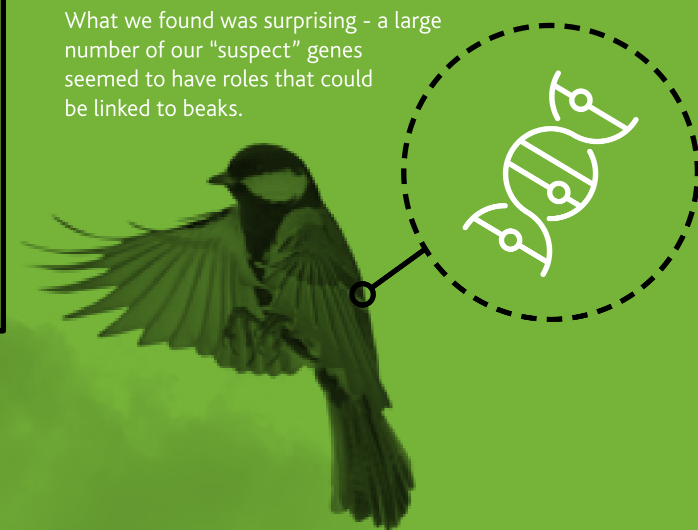
Why birds beaks might be getting longer

Evolutionary biologists have been studying bird beaks since evolutionary biology existed. Charles Darwin himself was famously struck by variation in the beaks of Galapagos Island finches, which were since named "Darwin's finches" after the great man.

Across the Galapagos, different finch species can be found within and across different islands, each bird with a different beak shape. These finches have become an iconic example of how species evolve by natural selection - as the availability of food changes on different islands over time, so the beaks of the birds adapt to exploit the food as efficiently as possible.

I have been lucky to be involved in a research project looking at the DNA of great tits in the UK and the Netherlands. Our question was simple: if we compare the DNA of great tits living in these two different countries, what can this tell us about their ecology. Natural selection leaves statistical "footprints" in our DNA, which we can use to make predictions about the past lives of different bird populations.

We screened the DNA of lots of birds from England and the Netherlands, and used statistics to identify genes which might have been under natural selection between these two countries. What we found was surprising - a large number of our "suspect" genes seemed to have roles that could be linked to beaks.



There were genes known to control face shape in humans, and genes that have been found to affect beak shape in Darwin's finches. But what about in great tits? Luckily, we had measured the beaks of some of the same birds that we used in the genetic analysis. We found that, sure enough, the genes that were most strongly associated with beak length were the same genes we had found to be under natural selection between the UK and Dutch populations. This led us to wonder whether there were differences in the beaks between UK and Dutch great tits, and if so, why?

It turned out that there was indeed a difference between the beaks of these birds, and that ornithologists were already well aware of this! UK great tits are actually described as a separate "subspecies" compared to populations across the rest of Europe. And the difference between the UK and mainland European subspecies is - you guessed it - that UK birds have longer beaks.

UK birds have longer beaks than those sampled across Europe.

With the help of some of our great natural history museums, we measured the beaks of bird specimens sampled from across Europe. We found the same pattern - the UK birds had longer beaks than everywhere else. We also found that, in our UK population, beaks appear to have become longer over the last few decades. This made us think that selection for longer beaks in the UK might have been a pretty recent process, and potentially even ongoing.

If the difference between UK and Dutch great tits was because of recent natural selection for longer beaks in the UK, we had a clear prediction - UK birds with longer beaks (or rather, birds with "genetically longer beaks") would perform better in terms of survival and reproduction compared to short beaked birds. This was where having a well-studied species like a great tit really came into its own. We had data on the number of offspring produced for almost all of the birds that we had performed our genetic analyses on. We found that, just as we had predicted, UK birds who had the genetically longer beaks produced more offspring than genetically short-beaked birds. The same pattern didn't hold in the Netherlands, suggesting that there really was something about the UK that was causing great tits to evolve long beaks.

Humans are not just causing animals and plants to go extinct - we're also causing them to evolve.

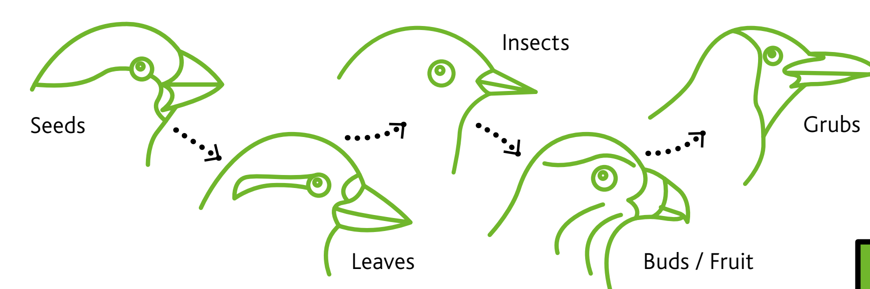
There was one crucial piece missing from our evolutionary puzzle - why would birds evolve long beaks in the UK but not the rest of Europe? This is where we need to be careful. The UK and mainland European environments differ in lots of ways. Nonetheless we wanted to at least try to find out what might be going on in UK great tits. So we took a rather crude approach, and polled some expert ornithologists. Why, we asked, might UK great tits have evolved longer beaks than their mainland European neighbours?

The top answer in our poll, rather surprisingly, was that the differences might be the result of the UK habit of bird feeding. In the UK we put out far more bird food compared to the rest of Europe, and there is some evidence in other bird species that having longer beaks might be an advantage in areas with high levels of bird feeding. So we tested the idea that longer beaked great tits spend more time at feeders compared to shorter beaked birds. To our astonishment, this turned out to be the case. The pattern was messy, but significant. We can't prove that bird feeding in the UK has caused great tits to evolve longer beaks, but it's certainly an interesting idea, and one that's worth following up.

Most people think of evolution as a process that takes millions of years. It's certainly true that the big differences we see among animals and plants take a very long time to evolve. But if natural selection is strong, evolution can also be a very rapid process. Scientific research is showing that the impact of humans on the natural world is more complicated than we previously realised. We're not just causing animals and plants to go extinct - we're also causing them to evolve.

Darwin's Finches

Charles Darwin collected some finches when he visited the Galapagos Islands. It is often said that the Finches were key to the development of Darwin's theory of evolution.



Naming the elements!

Professor Mark Lorch
Faculty of Science and Engineering,
University of Hull

How do elements get their names? Some are historic, but when a new element has been discovered, scientists can find themselves with a fight on their hands to decide the name. Fortunately, the International Union of Pure and Applied Chemistry (IUPAC) has a set of rules which act as a referee.

But there hasn't always been an organisation overseeing the names of the elements. Most of the names have complicated and contorted origins. The periodic table is a truly global tool, and this become even more evident when we start looking deeper into the naming of the elements it comprises.

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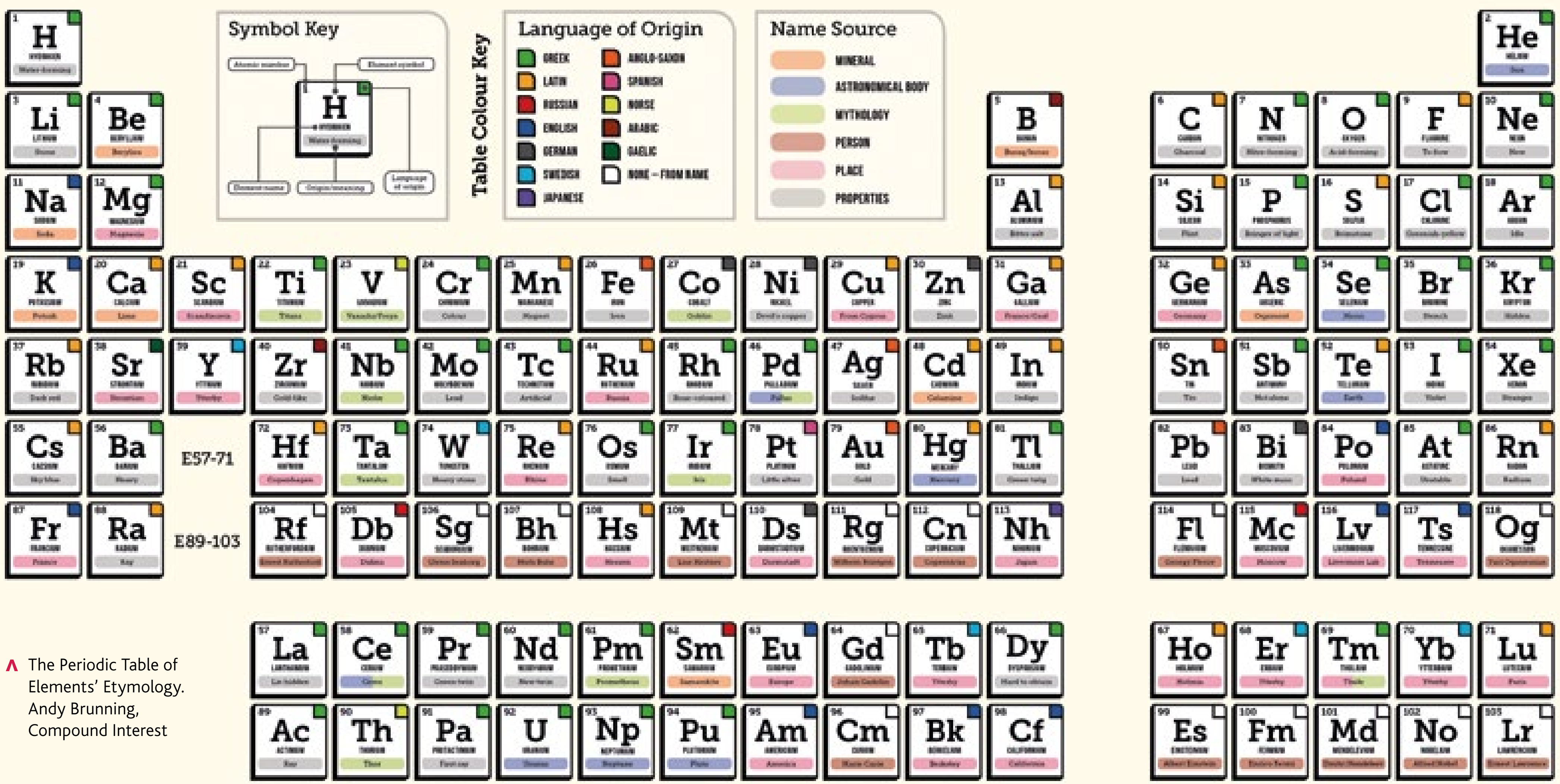
Periodic Table: Element Name Origins



∧ The Periodic Table of Elements' Etymology. Andy Brunning, Compound Interest

Let's break that down

When you get into it, there's more to the names of elements than you may think. Here are some interesting facts about the origins of some names found in the periodic table…

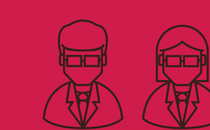
Two of the elements stink! Bromine means "stench" and osmium means "smells". France also appears twice on the periodic table in the form of francium and gallium (from Gaul) and its capital city, Paris, gets a mention (in the form of lutetium).

Three Sanskrit words – eka, dvi and tri, meaning one, two and three – were prefixed to elements and used as provisional names for those that had yet to be discovered. Eka- is used to denote an element directly below another in the table, dvi- is for an element two rows down and tri- is three rows beneath. Russian chemist Dimitri Mendeleev first used this naming method to fill in the gaps in his early periodic table - so element number 32 was known as eka-silicon until it was discovered and named germanium in 1886. Similarly, rhenium was known as dvi-manganese until 1926.

Four of the elements are named after planets: Earth (in the form of tellurium), Mercury, Neptune and Uranus. A further two are named after dwarf planets (Pluto and Ceres), one after a star (helium from the Greek for the sun - Helios) and another after an asteroid (Pallas) all feature on the periodic table.

Five elements are named after other elements: platinum comes from the Spanish platina which actually means "little silver" and nickel is from the German for 'devil's copper'. Radon is derived from radium, zirconium has its roots in the Arabic zarkûn meaning "gold-like" and molybdenium is from the Greek for lead, molybdos.

Eight elements were first isolated from rocks quarried in the small village of Ytterby in Sweden. Four of those elements are named in tribute to the village (ytterbium, erbium, terbium, yttrium) – not bad for a small town!



15 are named after scientists, only two of whom were women: Marie Curie and Lise Meitner are immortalised in curium and meitnerium.

18 elements have had placeholder names derived from the Latin for the elements atomic number, for example ununoctium, now oganesson. This was introduced to stop scientists fighting over what their discoveries should be called. Nobody wants a repeat of the three-decade-long "Transferium Wars" which raged from the 1960s between competing American and Russian laboratories over what to call elements 104, 105 and 106… the arguments weren't resolved until 1997!

42 element names are derived from Greek; 23 from Latin; 11 from English; five are Anglo-saxon, five German, five Swedish, three Russian, two Norse and one apiece for Japanese, Sanskrit, Gaelic, Arabic and Spanish.

118 elements appear on the periodic table, but that doesn't mean the table is finished. Laboratories around the world are busy smashing atoms together in an attempt to forge new, even heavier elements.

Who knows what future elements will be called?

The green blooded lizards that are confounding scientists

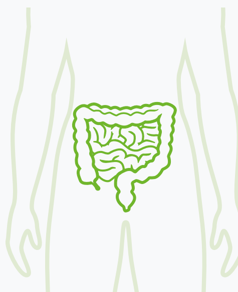
By Anita Malhotra
Senior Lecturer in Zoology
(Molecular Ecology), Bangor University

Some lizards have green blood that should kill them – and scientists can't work out why.

If you were to see certain New Guinea skinks lose their tails, you'd notice that their blood isn't the usual red colour we're used to but rather a virulent shade of green. What's even more bizarre is that the substance that's responsible for the green colour of the lizards' blood (and bones, tongues, muscles and mucous membranes) would be toxic in other animals if they carried it in such large amounts.

Exactly why these skinks are filled with this toxic substance and why it doesn't kill them is something of a mystery. But new research published in Science Advances makes an important step towards answering these questions.

Whereas the red colour of most animals' blood comes from the oxygen-carrying pigment in red blood cells called haemoglobin, the green colour in the New Guinea skink blood comes from a kind of bile pigment called biliverdin. It is formed as red blood cells break down and is held in the plasma, the liquid that makes up most of the blood. In large quantities, it masks the red colour of haemoglobin completely.

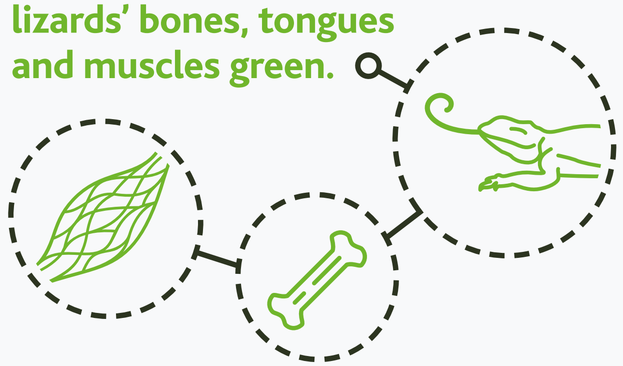


Humans and other animals produce biliverdin too, but we excrete it into the intestine where it is eliminated from the body before it builds up to toxic levels. In humans, biliverdin causes jaundice at concentrations 40 times lower than found in the green-blooded skinks, who apparently suffer no ill-effects.

We don't know how the lizards are able to withstand so much biliverdin in their system. In some fish with green blood, biliverdin is tightly bound to a carrier protein which inactivates it and prevents its elimination from the body.

Scientists have put forward several reasons why it might be beneficial to have so much biliverdin in the body, including making them taste bad to predators, or as an extreme form of camouflage. But most of these ideas are not convincing when applied to the New Guinea skinks. For example, feeding trials using native New Guinea birds and snakes have suggested that they are actually perfectly edible even with the biliverdin.

Biliverdin also turns the lizards' bones, tongues and muscles green.



A more plausible explanation is that it may help to control the proliferation of blood parasites such as malaria, which are prevalent and debilitating in lizards. More recent experimental work on other animals has suggested that bile pigments, including biliverdin, may act as antioxidants. These protect the body from damaging molecules known as free radicals and have an important anti-inflammatory effect.

The green colour in the New Guinea skink blood comes from a kind of bile pigment called biliverdin.

Another way to get an insight into why this feature evolved is to compare the green-blooded animals to close relatives with red blood. This is a challenge as skinks are among the most diverse families of lizards – and these particular skinks come from a relatively understudied set of animals in a remote part of the world.

In fact, it wasn't even known for certain whether all five species of green-blooded skinks, which had been placed in the same genus Prasinohaema (Greek for "green blood"), really were each other's closest relatives. Their green blood seems to be the only characteristic that they share. If they are all closely related, then the evolution of green blood would have been a single unique event. This would make it difficult to choose among multiple possible causes and to know how applicable they were to other organisms with green blood.

Repeated evolution

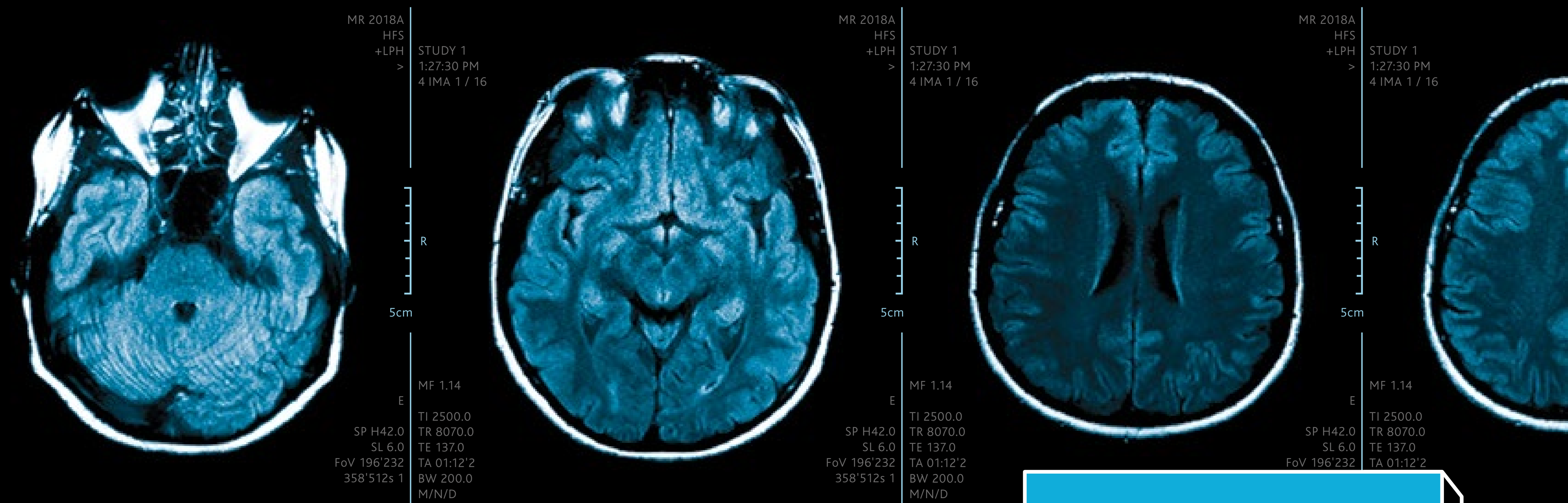
The new research from scientists at Louisiana State University shows definitively that these lizards are not a closely related group. To do this, they built a highly robust evolutionary tree of over 50 species of Australasian skinks using thousands of genetic markers shared by the lizards. This revealed that their unusual characteristic has evolved at least four times independently, and all the related species with normal blood that share a common ancestor with green-blooded species are also found only in New Guinea.

To fully understand how the green-blooded lizards evolved this bizarre condition, we would need more in-depth studies of the specific gene mutations responsible. But now that we know that it has evolved repeatedly it gives scientists more power to disentangle the reasons why. What's more, it suggests that there is indeed an underlying adaptive advantage for the retention of high levels of biliverdin, as it would be extremely unlikely for such an unusual condition to evolve multiple times by chance.

This conclusion is exciting, partly because it reveals how little we still know of the astonishing diversity of life and its peculiarities. But in addition, given that biliverdin seems to play an important role in some important human problems involving inflammation, including septic shock and wound healing, it suggests that understanding the role it plays in the blood of the skinks may have very direct benefits for us all.

The workings of the teenage mind

By Sarah Jayne Blakemore
Professor of Cognitive Neuroscience, University College London shares her research

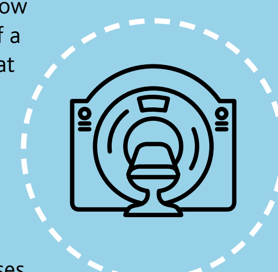


Ever wondered what is happening to your brain as you become an adult?

As a teenager have you found that the need to become an independent adult and fit in with friends increases your risk-taking?

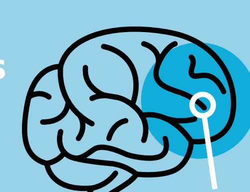
Research by Professor Sarah-Jayne Blakemore shows it is part of normal development, which can be evidenced using science and shouldn't carry a stigma or lead to negative stereotypes about teenagers being impulsive, taking excessive risks or being self-preoccupied. Rather, the way teenagers behave needs to be better understood, as it is an adaptation that is essential to the brain maturing and developing and human teenagers becoming independent adults.

As she explains about her research, 'When I started out at university 25 years ago, we knew very little about how the human brain develops. I was taught that the brain is mature by mid-childhood. Magnetic Resonance Image (MRI) scanning, which allows us to look inside the living brain and measure its structure and activity, has developed since then and added a huge amount to our understanding. We can track how the brain changes across the whole of a person's lifespan. What it shows is that what I was learning in my textbooks was completely wrong. The brain continues to develop throughout childhood and adolescence and even into the 20s and 30s, for some brain regions. During adolescence, white matter increases, grey matter decreases, the brain isn't fully formed at the end of childhood at all. We think these changes are caused by important neurological developments that enable the brain to be moulded and influenced by the environment.



Magnetic Resonance Image (MRI) scanner

One of the brain regions that changes most substantially during adolescence is called the prefrontal cortex.



Prefrontal cortex

One of the brain regions that changes most substantially during adolescence is called the prefrontal cortex. It is an interesting area. In proportion to our body size it is bigger in humans than in any other species. It is involved in a whole range of high level thinking such as making choices about how to behave, making plans, and thinking about the possible consequences of our actions. It is also involved with stopping us from doing or saying something rude or inappropriate, and has an important job in making us aware of other people's minds and emotions.

"We're only just starting to look at how individual differences in both genetics and environment influence brain development."

MRI studies of the physical structure of the brain have shown this area changes dramatically during adolescence. Big changes happen in the grey matter, which processes information and makes connections within the brain. In the prefrontal cortex grey matter increases in volume during childhood, peaks in late childhood and then later in adolescence reduces. This is an important process, because grey matter contains connections, called synapses and this reduction in grey matter volume when the prefrontal cortex is developing is thought partly to correspond to getting rid of unwanted synapses that are not active.

We also track changes in the teenage brain using functional MRI to look at changes in brain activity at different ages. In my lab, we're interested in the social brain: the network of brain regions that we use to understand other people and to interact. One of the findings that has been found in our lab and in other labs

The brain continues to develop throughout childhood and adolescence and even into the 20s and 30s.

around the world, is part of the prefrontal cortex, the medial prefrontal cortex, in the midline of your head, is particularly active in adolescents when they think about other people. It's more active in adolescents when they make social decisions and think about other people than it is in adults. We think that might be because adolescents and adults use a different mental approach, the brain changes the way it makes social decisions.

It has been shown that adolescents take more risks than children or adults, and this is especially true when they're with their friends. There is a drive to become independent of parents and to impress friends. Some scientists have suggested this might be partly due to the development of a part of the brain called the limbic system. The limbic system deep inside the brain is involved in things like emotion processing and reward processing. It gives you the rewarding feeling out of doing fun things, including taking risks. In adolescents the limbic system is hypersensitive to the rewarding feeling of risk-taking, compared with adults. At the same time, the prefrontal cortex, which stops us taking excessive risks, is still very much still developing.

It's important to say that most of the data we have comes from averaging results across teenage brains, but there is no average teenage brain. There is no average teenager. The individual differences are much greater than the averages. We're only just starting to look at how individual differences in both genetics and environment influence brain development, but overall brain research has shown that the adolescent brain goes through big changes and development in the teenage years.

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