Diamond Light Source is the UK’s national synchrotron science facility. It’s a huge building shaped like a ring, and is comparable to a giant microscope. Diamond speeds up electrons to near light speeds, producing light 10 billion times brighter than the Sun. These bright beams are then directed off into laboratories known as ‘beamlines’; here scientists use the light to study everything from viruses to fossils and jet engines. Diamond is one of the most advanced scientific facilities in the world, and its pioneering capabilities are helping to keep the UK at the forefront of scientific research.

Inside Diamond Magazine brings you research highlights and thought-provoking insights, showcasing the wonders that lie within the walls of the synchrotron.

Front cover image: Equine haemoglobin protein crystals were grown by work experience students Mohammed and James during their week in Diamond. They mixed purified equine haemoglobin, the red blood protein from horses, with a variety of different chemicals to see if they could encourage the protein to form crystals. These pictures show delicate star-shaped crystals which, whilst pretty, may not be the best form for X-ray studies. Protein crystals grow in many shapes and researchers can use commercially available chemical screens to help them find the best conditions to produce protein crystals which diffract well in X-ray beams.
We do not always need a spacecraft to explore the solar system.

One of the amazing things scientists can do at Diamond is to recreate conditions of other parts of the Universe. Recently they used this remarkable ability to peer into the salty waters hidden underneath kilometres of ice on Enceladus, one of Saturn’s moons.

In September, NASA ended the Cassini mission in spectacular fashion, crashing the spacecraft into Saturn. For twenty years, Cassini brought us closer to our gas giant neighbour and its moons. The probe made astonishing discoveries about one of them: Enceladus. This small moon has plumes of gas erupting from its surface, it has a rocky core covered in a thick layer of ice, and in between lies a deep, salty ocean. It is one of the most promising places to look for extraterrestrial life.

Enceladus is one of the few places in the Solar System where liquid water is known to exist. Stephen Thompson, experimental astrophysicist, says “Water is essential for life to exist. We are trying to look at the different forms of water you can get and how they alter the chemical and physical properties of planetary bodies and how they might support microbiological life.”

Spacecraft aren’t our only way of exploring the solar system, and Stephen leads a team of experimental astrophysicists based at Diamond and Keele University (UK), who have been recreating the conditions in Enceladus’s salty ocean right here in Harwell.

They have been using Diamond’s astounding bright light to investigate one of the more mysterious properties of water – its ability to form clathrates when water is cooled under pressure. Clathrates are ice-like structures that behave like tiny cages, and can trap molecules such as carbon dioxide and methane.

The conditions on Enceladus may be just right for the formation of clathrates, and understanding more about how they form could provide clues about what is happening in Enceladus’s ocean.

In order to predict where the clathrates may be on Enceladus, experiments on Earth have to mirror real conditions as closely as possible. Thanks to the Cassini probe we know that Enceladus’ ocean is full of magnesium sulphate (salt). For the experiments at Diamond, scientists filled tiny tubes with water, and different amounts of magnesium sulphate. The tubes were cooled down, and then carbon dioxide (gaseous carbon dioxide) was fed into the frozen water, where it became trapped in the clathrates that formed in the tubes.

Shining Diamond’s high energy X-rays into the tubes allows the scientists to examine what was happening, using a technique called X-ray Powder Diffraction. The X-rays are deflected by the contents of the sample tube and in doing so tell the researchers a lot about how the molecules of water, gas and salt are interacting.

Previous experiments with clathrates have used pure water, and the scientists thought that the presence of the magnesium sulphate would change the way that clathrates form. This is indeed happening. The salt interferes with the clathrate formation in much the same way that putting table salt on a slippery path in winter melts the ice.

The researchers also found that the salt causes subtle changes that make clathrates more likely to sink in Enceladus’s ocean. Some microbes on Earth make use of carbon dioxide, and if clathrates filled with carbon dioxide are sinking to the bottom of the ocean, that may be a good place to start looking for signs of life.

Their work will guide others studying Enceladus, helping pin down what might happen and rule out what cannot. All very helpful when you are studying an ocean seven times further from the Sun than we are.

The advantage of using Diamond is that lots of experiments can be done in a short time, lots of information gathered very quickly. PhD student Emmal Safi from Keele University analyses a lot of data. “I’m the first person to see the results,” she says “and get to see something that we didn’t expect to see.”

Sarah Day, Senior Support Scientist at Diamond, is excited to be able to match results from experiments here on Earth with what we already know about Enceladus.

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There is also the bonus that clathrates are very important on Earth too. Millions of tonnes of methane are tied up in clathrates in the deep oceans and arctic permafrost. Understanding their behaviour could be very important as climate change warms up these previously frozen regions.

Ultimately, we will need to send another spacecraft to Enceladus to find out whether these experimental results really match up with what’s happening on the moon, and whether there’s life in its salty waters. As Stephen puts it “all bets are off until we go there and look directly into the ocean.”

Stephanie Aran, one of Saturn’s moons is surrounded by an icy crust. Beneath the surface lies a hidden ocean containing water, carbon dioxide and various salts. This mixture holds out the tantalising prospect that life might have evolved in the oceans, and alien organisms might be living underneath the ice. But finding them might be another matter.

Imagine a life-hunting space probe landing in the middle of Antarctica. It would be easy to conclude that Earth is lifeless as that region is frigid and unfertile. Yet we know our planet is teeming with life. Any future visitor to Enceladus needs to know where to look.
Polio is a particularly nasty disease. Highly infectious, it mostly hits children under five and can lead to permanent paralysis and death. Efforts to control polio represent one of the huge successes of modern medicine.

A worldwide vaccination campaign has dramatically reduced the number of cases from around 350,000 in 1988 to 37 reported in 2016, according to the World Health Organisation. It has almost been eradicated. Almost. It still lingers in a few places, and as long as it does, it has the potential to spread through the world’s children once again.

Now, a new type of vaccine has been developed that has the potential to see off this disease for good. Developed by a UK wide team led by Dave Rowlands at Leeds University and made in plants by the team of George Lomonossoff at the John Innes Centre, Diamond played a crucial role in demonstrating that it really does do what the researchers hoped.

The most effective current polio vaccine is based on a weakened form of the virus and is given as oral drops. Easy and painless. However, this vaccine has a number of potentially serious drawbacks. It is made from active polio virus so needs a constant supply of this dangerous pathogen. It occasionally reverts to an active form of the disease as it passes through the vaccinated child and has caused disease this way. It also needs to be kept refrigerated making it tricky to transport to the world’s most inaccessible areas which are, typically, the places it is needed most.

Researchers set out to eradicate this disease forever.

The polio virus is a simple icosahedron made of protein building blocks. The scientists started by putting genes from a mutant form of polio into tobacco plants. The basic technique has been around for decades and was successfully used in a similar way to produce a foot and mouth vaccine in insect cells. As they hoped, these genes persuaded the tobacco plants to produce proteins in their leaves, which then formed into synthetic virus-like particles.

According to Dave Stuart, Professor of Structural Biology at Oxford University and Director of Life Sciences at Diamond, “it’s not a virus, it’s a pretend version of the virus, it’s completely safe because it doesn’t have the genetic information, it can’t replicate.” But it is designed to trigger an immune response to protect against disease.

The next step was to see whether these synthetic particles really did look like the real virus, and this is where Diamond enters the picture. The technique they used was cryo-electron microscopy at the electron Bio-Imaging Centre or eBIC. Frozen samples were imaged in an electron microscope to produce very detailed, highly magnified pictures of the particles which turned out to look just like the real thing. [See also Malaria story, pages 12-13 in this issue.]

Then the scientists subjected their particles to a whole series of tests. They turned out to be stable at room temperature so did not need refrigerating. They cannot revert to an active form of the disease like the current vaccine. And finally, growing it in tobacco plants removes the need to produce the active polio virus.

This new synthetic vaccine manages to overcome the disadvantages of the current vaccines. Human trials are the next step but as always with science, a note of caution is needed. This is a proof of principle and there is some way to go before it could become a working vaccine.
Artificially coloured 3D X-ray image of a prehistoric micro-organism

This image of a 1 millimetre high foraminifera was generated at Diamond’s longest beamline – the 250 metre Diamond-Manchester Imaging Branchline I13-2. Images of these single-celled organisms, which have been present in our oceans for over 500 million years, help researchers to determine how warm our planet was in the past. This information is used to make climate change models more accurate. These incredibly detailed images can be hard to analyse, so Diamond provides a suite of high-performance computers (the ‘data beamline’) to help researchers with their work.

Artificially coloured image by Elizabeth Read, Department of Earth Sciences, University of Cambridge (UK) and Andrew Bodey, Diamond Light Source. The original image is one of the winners of the Micropalaeontological Society Image Competition 2017.
What Does Diamond Do? Four short stories of scientific innovation

Exploring the Silver Lining
Clouds are made up of water droplets and at the heart of each is a speck of dust, commonly coated with a thin, oily film.

What did Diamond do?
Scientists took samples of this oily film and bounced X-rays off them using the Surface and Interface Diffraction beamline I07 to see how they reacted with ozone gas. They discovered to their surprise that this highly reactive atmospheric gas had no effect on the films.

Why does it matter?
Clouds can either warm or cool our planet depending on their type and altitude, so understanding them is important for studying climate change. There is still a lot we do not know about cloud formation, in particular the details of the chemistry of the particles and their oily films. A small chemical change can have a big impact on climate.

What about the future?
Further studies could help climatologists improve our ability to understand and tackle climate change.

Unpicking Legionnaire’s Disease
Legionnaire’s disease is an infectious, life threatening form of pneumonia.

What did Diamond do?
Scientists worked out the structure of a protein called WipA using X-ray crystallography on beamlines I02 and I04, as well as a similar facility in Hamburg. This protein is one of many produced by the Legionella bacterium to infect and take over some of the body’s cells, causing the disease. It turns out to have special features which could allow scientists to develop treatments specifically targeting this bacterium.

Why does it matter?
Legionnaire’s disease can be lethal to vulnerable people such as those with lung conditions or the very old. It can be a particular problem during hospital outbreaks. Tackling it involves understanding how the bacterium causes infection and exposing its vulnerabilities.

What about the future?
Further studies could help climatologists improve our ability to understand and tackle climate change.

Racetrack memory
The demand for computer memory keeps growing, driving research into new ways to cram more information into ever smaller spaces.

What did Diamond do?
One potential technology is a little like storing information in microscopic carriages running along equally small tracks. A new and improved version of this racetrack technology has been studied at Diamond showing that doubling up the tracks, or nanowires, produces big improvements. The electrical current required was down tenfold, and the amount of power reduced by a factor of 100.

Why does it matter?
This new technology has the potential to store far more information in the same space as current technologies and be dramatically cheaper.

What about the future?
This study has shown that the principle works, further research is now needed to see whether it really can become an alternative to current computer storage.

Lithium Battery Safety
We depend on lithium batteries to power our portable technology but when they fail they can catch fire.

What did Diamond do?
Battery failures are quick and unpredictable making them very difficult to study. A new device invented at NASA can cause a battery failure on demand, and scientists used Diamond to study this rapid phenomenon. They used beamline I12 which has a high speed X-ray detector for recording and studying very swift events, up to 2,000 images per second. They saw how a pinpoint failure spread quickly to the rest of battery, producing the intense heat that causes fires.

Why does it matter?
With billions of lithium batteries in use around the world, making them safer is a priority.

What about the future?
Now that researchers have a better understanding of how these failures occur they hopefully can find ways of preventing them happening.
In 2007 Helen Saibil was at a conference in Australia. Amongst the presentations there happened to be talks on the parasites malaria and toxoplasma and how they infect mammalian cells, causing disease. Helen is a structural biologist and whilst listening she began to realise that her newly acquired skills - she was doing electron tomography of cells - might allow the researchers to see things they had never seen before.

Electron tomography reveals structures in the interiors of cells in great detail. What she hoped was that it could be used to look into the malaria parasites inside red blood cells [See images below] to get a better understanding of what they do there.

Helen approached one of the speakers, Mike Blackman, then at the National Institute for Medical Research at Mill Hill in London, and so began a training collaboration. One that has produced the remarkable pictures of malaria parasites breaking out of infected human red blood cells on this page.

Helen Saibil and her colleagues used electron-tomography to peer into malaria infected cells, looking at the parasites hiding and multiplying inside. The technique produces exceedingly detailed pictures able to reveal very tiny features, but it has one big drawback: Electrons cannot penetrate deep into the sample so it only works on very thinly sliced samples, much thinner than an individual cell. As a result it cannot be used to look at entire cells, or in this case red blood cells containing malaria parasites.

Enter Diamond’s X-rays. One of the many things the Diamond synchrotron can do is to produce a very, very intense beam of X-rays that can easily travel through the full depth of a cell and out the other side. This allows the researchers to build up a picture of an entire cell, complete with parasite, in unprecedented detail. Beamline B24 uses a very fine beam of X-rays to see very tiny objects, single cells and smaller. The frozen experimental samples are kept extremely cold and thin to allow the X-rays to pass through them. The sample is slowly rotated in the beam while the detector takes a series of X-ray images. A computer then combines these into a final 3D image. One key feature of cryo X-ray tomography, cryo X-ray tomography, is that it is especially good at picking up cell membranes, the thin fatty films that surround the cell and many of its internal components. This is particularly important, it turns out, when studying malaria.

The malaria parasite gets into the body via the bite of an infected mosquito. It finds its way into the bloodstream and enters the red blood cells. Once inside it wraps itself up in a bag of membrane which effectively hides it from the body’s immune system. It then starts to multiply. Eventually the new parasites break out of their protective membrane coat and then break the blood cell’s outer membrane passing into the blood and on to infect other red blood cells. This break out, or egress, is an essential part of the parasite’s life cycle.

If it can’t break out the infection cannot spread.

All that was needed now was malaria infected blood cells to study. It is difficult to grow suitable samples in the lab, but Mike Blackman’s team had a great deal of expertise in doing just that, and the Saibil group knew exactly how to prepare thin, frozen samples of the cells. These were put into the beamline and “it worked beautifully from the first try” said Helen Saibil. For the first time, they could see all the cell membranes in intact, infected cells, during the process by which the parasites break out of the blood cells. This perspective is not obtainable with any other technique. It isn’t a straight line from here to a treatment for the disease, but being able to see the parasite as it emerges from hiding might reveal its vulnerability.

This technique is relatively new but these spectacular malaria pictures have shown its potential. Principal scientist Liz Duke and her team on B24 are constantly working to improve it. Liz says “it is an amazing feeling when you can see something that has never been seen before.” She believes that the method provides a way to see biology in action that could help understand all sorts of important processes. How drugs affect cells, how other parasites and viruses enter the cell and how the plastic microbeads now polluting our environment interact with all types of microscopic life. A window into the unknown.

Seeing the Invisible

Malaria in Action

The mosquito is the deadliest animal on Earth, responsible for more human deaths than any other. This is because it carries infectious diseases, the most dangerous of which is malaria. Around one million people a year die from the disease and there are between 300 and 600 million people infected at any one time. Malaria is a particularly difficult disease to tackle, partly because it hides away from the immune system inside red blood cells.

Malaria parasites inside red blood cells, showing the way they emerge from the cell. Left: the parasites (blue) are wrapped in their own membrane coat (yellow). Right: after breaking out of their membrane compartment, but before breaking out of the red blood cell.

Diamond Light Source and Bristol University London.
The first rung on the ladder to research science glory is usually a PhD; three years or more of sweat and toil as the most junior member of a research team. Followed by writing a long, complex, technical thesis that will be read by just a handful of people. This is, though, essential evidence that you have learned your craft and are ready to move to the next stage of your career.

Diamond hosts a large number of PhD students, more than 70 in September 2017, in a myriad of different research projects and we got three of them together to find out what they make of the whole process.

The projects Lois, Chris and Hayley work on could not be more different, yet there was much that they shared. The process of doing a PhD is exciting, breaking new ground, becoming independent. And freedom, freedom to delve deep into a project. Hayley recalled a senior academic saying that if you need to spend a week or a month just sitting in the library reading then that is a perfectly legitimate thing to do. She went on: “Where else would you find a job where someone pays you to sit in the library and just read.” Smiles and nods all-round the table.

Each PhD is very different and very specialised yet all three agreed strongly they have so much potential. Chris’s work is, for example, only applicable to a handful of synchrotrons around the world. Yet he said “the qualities I want in my diamonds are also the qualities that giant computer companies want to build diamond quantum computer chips. Everything is interlinked.”

“And more flexible” chimed in Lois, “you’re told that you’ll be a chemist or a physicist forever, yet it’s a lot more interchangeable than you’re led to believe.”

Then there is working with others. Hayley was very clear that being at Diamond brought a big advantage. “The best thing about being based at the synchrotron is that I get to meet so many different people: archaeologists, physicists, chemists, biologists, earth scientists and engineers.”

One of the biggest challenges of a PhD, all three agreed, was also one of its advantages - you have a lot of autonomy.

“Thinking by yourself is hard, it’s OK to be wrong, the important thing is to try and improve,” said Hayley.

There is support from colleagues and your supervisors, but ultimately it is up to you. “Taking the project into your own hands”, said Lois. Adding, “at school you’re spoon fed. It’s been really great going where I want to go with the project.”
Finding the Weyl Fermion

Unravelling an 85 year old enigma

The 1920’s was a remarkable period for physics around the globe. Theoretical physicists working on the new theory of quantum mechanics were throwing out novel suggestions at an incredible pace. This had the experimentalists scurrying to keep up. New discoveries were made about matter at a fundamental level. However, not every prediction was backed up by experiments and some of these fell by the wayside.

One of these neglected ideas was that of the Weyl fermion, one of the many subatomic particles that are the building blocks of everything around us. Its existence was predicted in 1929 by the German mathematician Hermann Weyl. However, it consistently failed to show up in experiments no matter how hard researchers looked. As a result it gradually slipped into obscurity. This is the story of how an almost forgotten particle was discovered in an unexpected place, and how its discovery could lead to radical new electronic devices.

Step forward to the 2010’s, researchers are beginning to explore the properties of some curious crystals made from a combination of the elements tellurium and arsenic, known as tellurium arsenide. The atoms in this crystal are arranged in an orderly fashion like those in all crystals. Imagine billions of neatly stacked building blocks. But with one rather odd feature, the crystal lacks a special point called an inversion centre. Imagine the atoms in most crystals lined up like soldiers on parade. Each positioned exactly behind the one in front. In these crystals though, known as Weyl semi-metals, the ranks are slightly shifted to one side (see picture with the green and blue circles). The soldiers/atoms now look into the gaps between the ones in front. The result is Weyl semi-metals, lack of what is called an inversion centre which gives them their special characteristics.

Three teams, one in the US, one in China and one in the UK examined these crystals using a technique known as ARPES (Angle-Resolved Photoemission Spectroscopy). The UK group, led by Yulin Chen used Diamond’s I05 beamline (also see article on ARPES pages 18-19 in this issue). Relatively quickly they began to see a feature that showed the presence of the elusive Weyl fermion. This was the same result perceived by the American and Chinese groups.

The ARPES technique uses light to knock electrons out of a solid and these electrons carry information about where they came from. So by measuring the properties of the electrons very carefully the researchers can learn something about the original material.

As the data emerge from the experiments, a powerful computer analyses them and throws them up on a computer screen. A common way of doing this produces a circle, or a closed-curve, on screen, its shape and size revealing details of the way electricity can move through the sample. However, this time an open arc instead of a closed curve appeared, which starts and ends at two special, Weyl, points. This was the giveaway, it is the tell-tale signal of the elusive Weyl fermion.

A theory nearly ninety years old was shown to be true and was hailed as the physics breakthrough of the year 2015 by the Institute of Physics amongst others. There is, though, more to it than just experimental proof of an old idea.

The curious crystals of tellurium arsenide, known as Weyl semi-metals, were poorly understood until this discovery yet have some intriguing properties. They are many millions of times more sensitive to magnetic changes than the materials in current computer hard drives. This means they have the potential to store vastly more information per disk. The Weyl fermions themselves can carry electrical charge moving much faster than electrons in normal materials potentially leading to much zipper electronics. The unusual arcs that connect the Weyl points have a unique property that, if combined with other exotic materials, could make them ideal for quantum computing – a technology believed by many to be the future of computing. I05 beamline is now inundated with applications to work on these so called Weyl semi-metals, a sure sign that scientists believe they are on to something.

Subatomic particles

Modern particle physics has discovered a zoo of particles that are the building blocks of matter. Quarks combine to form protons and neutrons. These combine with electrons to form atoms which in turn combine to make up the world around us. There are also more exotic particles which, like lego bricks, have their own unique characteristics but can also be grouped together in categories, the two main types are fermions and bosons.
The discovery of electricity must be a contender for the most important scientific breakthrough of all time. Our world is totally dependent on making electricity, the flow of electrons, work for us, yet there are many electrical subtleties we don’t fully understand. Knowledge is power, so Diamond has a sophisticated tool dedicated to exploring the secret life of the electron.

Modern electronics exploits the different ways electrons flow through a myriad of different materials. Trace amounts of elements such as gallium or boron are added to silicon to produce computer chips, solar panels, LED lights, cameras and many, many other devices. They do different things because the electrons move through them in different ways. Unsurprisingly, this is of huge scientific interest and Diamond has a beamline, I05, dedicated to this research. It uses a technique called angle-resolved photoemission spectroscopy, ARPES for short which relies on a principle called the photoelectric effect.

What is it?

The photoelectric effect is the phenomenon where light shining on some materials can knock electrons out of the atoms like a snooker ball from a pack. The process effectively converts light into electricity and has many uses such as cameras, solar panels and light meters. A common use is in fibre optics for telecommunications or computer networking. Pulses of light travel through the cables at very high speed, representing digital ones and zeroes, but need to be turned back into electrical signals when they reach their destination; a photoelectric device does that job.

The History

There is a great science trivia question; for what work did Einstein get the Nobel Prize? The answer is not relativity, but the photoelectric effect for which he was awarded his Nobel in 1921. The photoelectric effect encouraged new thinking about physics that led to quantum mechanics. Light was known to be waves, travelling like ripples in a pond. But Einstein’s work showed that it also behaved as discrete particles, like little projectiles. It was this conundrum, known as wave particle duality, which was eventually explained by the development of quantum mechanics; the theory that describes the behaviour of subatomic particles and one of the most successful scientific theories of all time. Our modern, computerised, connected, world is underpinned by quantum mechanics.

ARPES at Diamond

ARPES is all about working out how mobile electrons are inside a sample material, and gets that information by exploiting the photoelectric effect. The exact speed and direction with which electrons emerge from the sample are related to their behaviour inside. And it is this information that can help researchers understand how all these materials work, and to find better ones.

The sample is put in a chamber and a fine beam of ultra-violet (UV) light generated by the synchrotron is shone on it. This knocks electrons out of the sample which go flying off in all directions. A series of sensitive detectors collect tens of thousands of these electrons per second, passing the information to computers for processing. These in turn give the scientists the information they are after, including the energy of the electrons and the angle at which they emerged from the sample.

Most of I05’s work involves looking at new materials created by chemists to see how the electrons move inside them, and linking that to their electrical properties. Examples could be new superconductors, computer chips, or novel materials for future electronic devices.

Though, it is, never that simple. The electrons do not travel far in air so the sample chamber operates at ultra-high vacuum, up to ten thousand billion times lower than atmospheric pressure. This also helps remove any contamination in the chamber, helping to keep the samples clean. But that’s not all. Some of the samples need to be studied at low temperatures, so the sample can be chilled to just 6 degrees above absolute zero. And if that weren’t enough, the I05 beamline has a very small light spot, less than a tenth of a millimetre in diameter - one could measure samples so small as to be almost invisible to the naked eye. Therefore the sample chamber incorporates an optical microscope to allow the researchers to line up their sample accurately.

On top of this the samples need to be able to be rotated in all three dimensions plus moved backwards and forwards, up and down, and side to side; even gradually heated and cooled. The result is probably the most sophisticated sample chamber of its type in the world.
A Birthday with Ten Leading Lights

Science is about people! For the 10th anniversary of Diamond Light Source we’ve picked out 10 scientists who have used the synchrotron to innovate, bringing science forward.

Paul Shearing
Reader in Chemical Engineering and Materials at University College in London

He has pioneered the use of multi-scale imaging and in situ methods in his field of electrochemical engineering. He is primarily specialised in batteries and fuel cells, and has been using Diamond Light Source since 2010 to improve the outlook for future energy storage.

Caroline Peacock
Professor of Biogeochemistry in the School of Earth and Environment at the University of Leeds

She is a prominent biogeochemist who has been using the beamlines here at Diamond Light Source since its creation ten years ago. Her most recent work concerns the mobility and fate of biocatalystial elements in marine sediments, and for this research the synchrotron is paramount.

Guillaume Beutier
Researcher at Science and Engineering of Materials and Processes at the Grenoble Institute of Technology (France)

He observed the very first light beam at Diamond in 2006. Since then, he has been a prolific user of synchrotrons in France as well as Diamond. His research centres on developing novel synchrotron techniques and he is particularly interested in monitoring strain in nanocrystals.

Alexander Korsunsky
Professor of Engineering Science at the University of Oxford

His research focuses on understanding the nature of material deformation across the length scales, and enhancing the integrity and reliability of engineered and natural materials and structures, topics on which he has published extensively.

Craig Boote
Senior Lecturer at Cardiff University’s School of Optometry and Vision Sciences

He has worked extensively at Diamond over the last ten years, publishing more than 30 journal articles using Diamond beamlines. He is particularly interested in glaucoma – a group of diseases which result in damage to the optic nerves and vision loss - that has been called the “sleuth thief of sight”. He conducted studies from mapping collagen fibres that make up the eyeball’s white coating on beamline I02 and I03 to examining the structure of the cornea on I22.

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He observed the very first light beam at Diamond in 2006. Since then, he has been a prolific user of synchrotrons in France as well as Diamond. His research centres on developing novel synchrotron techniques and he is particularly interested in monitoring strain in nanocrystals.

Eleanor Schofield
Head of Conservation & Collections Care at the Mary Rose Trust in Portsmouth

Her particular expertise is to bring her knowledge as a materials scientist to the conservation team, helping them to find out what they can discover about the changes occurring in the Mary Rose ship as sulphur moves around and oxygen seeps into the wood – indicating reactions that would otherwise not occur. Amongst other projects there is also the exploration of 12 of the approximately 1,200 iron cannon balls from the wreck, to work out which conservation strategies will work the best.

Peter D. Lee
Professor of Materials Imaging at the University of Manchester;
Assistant Director for Physical Sciences, Research Complex at Harwell

He has worked in the area of X-ray imaging of materials for over 25 years, both in academia and industry. He uses Diamond Light Source’s high energy X-rays to image how the microstructures in materials evolve over time. He builds process replicators that simulate the formation and use of natural (e.g. magma flowing in a volcano) and man-made materials (e.g. aerospace materials to ice-cream) on the synchrotron, revealing changes in their inner structure in 4D (3D plus time) from the nano to full component scale.

Jonathan Grimes
Associate Professor in the Division of Structural Biology at the Nuffield department of Clinical Medicine at the University of Oxford

As a structural biologist he uses the capabilities of Diamond Light Source to investigate the way that viruses replicate. His extensive structural experience led to his appointment as a Diamond Research Fellow where he has a strategic role in advising on the development of data acquisition and analysis software used by the Macromolecular Crystallography (MX) beamlines.

Katherine Morris
Professor of Environmental Radioactivity at the University of Manchester

Katherine Morris has dedicated her research to understanding how radionuclides behave in complex environmental systems. This means she and her groups are understanding how radioactive waste interacts with components of storage containers, but also predicting how it might interact with the environment when a storage facility eventually degrades.

Tanya Ronson
Post-doctoral Research Assistant at the University of Cambridge

Tanya Ronson is a prolific user of the synchrotron, having 40 publications alone containing data derived from Diamond. Her main area of expertise is metallo-supramolecular chemistry, with a particular focus on the development of nanoscale cages that can be used in catalysis and purification techniques. Her continuing efforts at Diamond are helping chemists to understand the fundamentals of molecular recognition and self-assembly.
It all starts in the electron gun (1), where a piece of tungsten is heated up producing a huge number of electrons. These are then hurled down a linear accelerator, or linac for short (2). Powerful electric fields inside the linac speed the electrons up until they emerge into the booster ring (3). Here, more electric fields accelerate them to close to the speed of light, like parents spinning their children on an impossibly fast playground roundabout. Finally, these superfast electrons are fed into the storage ring (4), a giant circular racetrack for electrons. At points in their journey around the ring they are made to turn high speed corners, a process that forces them to give off incredibly bright light. This light is directed down beamlines, where the scientists do their research.

Each beamline has three sections, called hutches. The optics hutch (5) filters and focusses the light. The experiment hutch (6) is where the light meets the sample. The control cabin (7) is where the scientists control and monitor their experiments.

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Celebrating Diamond’s 15th anniversary and 10 years of research and innovation

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