NATURE MADE EASY
HOW THE SCHOOL OF CHEMISTRY IS REVOLUTIONISING THE WAY WE LOOK AT MOLECULAR COMMUNICATION

STUDYING ABROAD: HOW TO MAKE THE MOST OF YOUR TIME AT BRISTOL
ONWARDS AND UPWARDS: WHERE NEXT FOR BRISTOL'S CHEMISTRY GRADUATES?
Welcome

One of the most common questions that we get asked by students and parents alike is “what can you do with a degree in chemistry?” The answer is – almost anything you choose to apply your curiosity and skills to. In the following pages, you can read about the paths that recent graduates have taken into finance, teaching and a deeper exploration of a subject that is as varied in scope as the people who study it.

In our first edition of 2016, we share the stories of students and researchers who have been able to highlight cultural and scientific insights with their peers in China, Japan, India, Canada and Germany, thanks to Bristol’s links with other prestigious institutes across the world.

Our groundbreaking facilities and techniques mean that our chemists are continually pushing the boundaries of science, which you’ll also discover in this edition – from ultra-fast chemical reactions to record-breaking chemical synthesis.

It’s certainly shaping up to be an exciting year. We hope you find something that piques your interest too.

Nick Norman
Head of the School of Chemistry

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YOUR SAY

We want to hear from you! If you’ve anything you want to tell us about your experiences at Bristol University, or if you have any thoughts about Chemistry Explored, then please email us at chemistry-explored@bristol.ac.uk.
The latest news from the School of Chemistry

Back to the future

Bristol leads the way in radiocarbon dating with groundbreaking new facility

What do the Dead Sea scrolls, deep sea corals and mammoths all have in common? The answer lies in a powerful technique that gives us the ability to count carbon atoms very precisely – radiocarbon dating.

First proposed 70 years ago, this technique has revolutionised our understanding of human history and ancient ecology, enabling scientists to date samples up to 50,000 years old.

Radiocarbon dating measures the amount of one particular carbon atom, or isotope, out of the three which exist in all living things – carbon-14, the only radioactive isotope of the three (carbon-12 and carbon-13 are stable). When an organism dies, the amount of carbon-14 present starts to decrease due to radioactive decay.

Fast-forward to the present day where most carbon dates are now determined using a technique called accelerator mass spectrometry (AMS), which allows scientists to measure accurate dates on very small samples of less than 1 milligram. It can detect one carbon-14 atom in more than 1,000,000,000,000 other carbon atoms!

This groundbreaking technique is now available to researchers throughout the University of Bristol at the new Bristol Radiocarbon Accelerator Mass Spectrometry (BRAMS) facility.

The heart of BRAMS is a state-of-the-art MICADAS (Mini Carbon Dating System) accelerator mass spectrometer invented by the Laboratory of Ion Beam Physics at ETH, Zurich. The 4.5 tonne system is the first in the UK, and is specifically designed to measure radiocarbon dates on large numbers of samples and enables determinations of smaller amounts (tens of micrograms) of precious gaseous and solid materials, including isolated pure compounds.

Research led by Professor Richard Evershed and Dr Tim Knowles

BRISTOL’S ORGANIC GEOCHEMISTRY UNIT

Mass spectrometry enables scientists to determine molecular ions and fragmentation patterns, to provide information about almost any materials including biological samples that were, until a few years ago, impossible to obtain by other approaches.

The new BRAMS facility extends the extensive range of mass spectrometric based techniques in Chemistry’s Organic Geochemistry Unit (OGU), where researchers are engaged in investigations aimed at addressing key questions in archaeology, biogeochemistry and paleoclimatology.

For more information about the OGU and its research go to bristol.ac.uk/chemistry/research/ogu/
Dynamic Dora
From art school to the School of Chemistry

An innate curiosity about biological mechanisms has led Dora Tang from her early days in art school to a fellowship at the renowned Max Planck Institute of Molecular Cellular Biology and Genetics in Germany, via the School of Chemistry’s Centre of Organised Matter.

Dora was, until recently, a Postdoctoral Research Associate who had been working with Chemistry’s Professor Stephen Mann, investigating physicochemical conditions which may have driven the transition from non-living matter to living systems in the Earth’s early history.

“My research interests have taken a few twists and turns over the last 10 years,” she says. Working with Professor Mann’s group saw Dora interact with biochemists and physicists across Bristol, in their joint efforts to incorporate biological functionalities into artificial cells. In 2014, Dora joined Bristol’s BrisSynBio network, a multidisciplinary research centre that focuses on biomolecular design and engineering aspects of synthetic biology.

Dora’s research will be developed further at the Max Planck Institute of Molecular Cellular Biology and Genetics in Dresden, where she will lead a new multidisciplinary group in dynamic protocellular systems.

SIGHTS AND SCIENCE IN INDIA
See the world with the School of Chemistry

Overseas travel is one of the major benefits of a science degree, where the opportunity to attend and present at conferences allows researchers to not only exchange ideas, but also experience different cultural and academic approaches.

Marcin Odachowski was one of eight PhD students who had the chance to meet with fellow chemistry students in India, as part of a postgraduate National Organic Symposium Trust (NOST) conference in Bhubaneswar, India, in December. The symposium, organised by India’s National Institute of Science Education and Research (NISER) and attended by over 250 academics and students, included talks and presentations around organic chemistry. Attendees were also given time to explore the sights of Bhubaneswar.

“Visiting India was a fantastic experience,” says Marcin. “I was very happy to meet some great people who have excellent research facilities and are passionate about what they do.”
Aiming high

The School of Chemistry receives equality award for a further three years

The School of Chemistry is proud to have been awarded an Athena SWAN Bronze Award for a further three years for its ongoing commitment to gender equality.

Established in 2005, the Equality Challenge Unit’s Athena SWAN Charter encourages and recognises commitment to advancing the careers of women in higher education and research. The University of Bristol was one of the first universities to successfully earn a Bronze at institutional level. Chemistry’s accolade continues the University’s upward trajectory towards creating an environment in which women are supported to thrive.

Education Coordinator Dr Beth Anderson collected the award at a prestigious ceremony at Oxford University where the Athena SWAN panel commended Chemistry’s approach to giving due consideration to family commitments when planning academic timetables.

Chemistry is now aiming for silver and ultimately gold with further initiatives aimed at enhancing gender equality across all working practices.

FROM BRISTOL TO JAPAN

East and West, working together in the name of science...

Dr Geri Echue has just started a two-year postdoctoral fellowship at the National Institute for Materials Science (NIMS) in Tsukuba, Japan. The fellowship, which encourages highly qualified researchers to collaborate with their peers in Japan, was partly enabled by a Memorandum of Understanding between the University of Bristol and Japan’s International Center for Materials Nanoarchitectonics.

Geri completed her PhD at Bristol in 2013, exploring the preparation of functional nanostructured materials based on Perylene Diimides (PDIs) in the group of Professor Charl Faul. Her work at the Supramolecules Group in NIMS is a continuation of this research, developing liquid-crystalline materials for novel application.

On life in Japan, she says: “I am really enjoying it here; it has been easy to integrate into the working culture and settle in, despite the language barrier!”

A TASTE OF CHINA

Students from the School of Chemistry presented research to an international audience last November

Postgraduate students from Bristol’s EPSRC Centre for Doctoral Training in Chemical Synthesis had the opportunity to exchange ideas with their Chinese counterparts at a series of symposia at Chinese universities in November.

The Shanghai expedition saw Bristol’s students first present their research to an audience of over 200 at the 16th annual Tetradedron Asia Symposium. The group went on to tour three universities, giving a series of talks, watching presentations and exchanging opinions over dinner with their peers at Shanghai Jiao Tong University, Shanghai Institute of Organic Chemistry and Zhejiang University, Hangzhou.

In the words of one Bristol student: “It was an entirely gratifying experience; having the privilege to present there was both daunting and rewarding. Being exposed to so many ideas has given me new drive in my own PhD.”

To find out more about the Equality Challenge Unit, go to: ecu.ac.uk
Navigating the slopes in Canada

Madeleine Iafrate recently returned from a year abroad in Vancouver as part of her undergraduate degree. Here she recalls the highs and lows of her scientific adventure…
People often tell me that I must be pretty brave to have taken a year abroad. I see where they’re coming from – travelling halfway around the world by yourself to a city you don’t know and settling down there for nine months is quite an intimidating thought. But that’s exactly what I did.

When I was researching all the links that Bristol has with universities all over the world, I was immediately struck by two choices: the University of Texas at Austin, and the University of British Columbia (UBC) in Vancouver. Both are highly regarded for chemistry globally.

The social opportunities were also important to me. I am a very keen cyclist and skier with a good ear for music. Both cities have a thrilling music scene, but in the end, it came down to a choice between cycling and skiing, and skiing won. So I packed my bags for Vancouver, which also appealed because it’s rated as one of the world’s best cities, and off I went in September 2014.

The ability to tailor my courses to my interests during my year abroad, and the opportunity to pursue a research project for the first time was a huge eye-opener. I was able to look more deeply into science that caught my interest, which made me think really hard about how and where I might use my qualifications to make a difference in the future.

I became much more conversant in modern research by attending postgraduate lectures with the PhD candidates at UBC, even though I was much younger than them.

Somehow, I still managed to find some time for skiing at the world-renowned Whistler Blackcomb resort. I had managed to make a fair few friends by the time ski season started, thanks to the friendly environment at the University and where I was staying. I even skied with my research group.

The only slight downside was leaving Canada and coming back to the reality of having to finish my distance learning course, but then that’s part of the deal.

If I were to advise other students thinking about taking this route, the most important thing I’d emphasise is that it’s really important to work hard every step of the way. Do not listen to anyone who claims that the first year is easier than the rest – every year counts. Make the most of every opportunity, work hard and the rewards will pay off.

Studying abroad is a great way of expanding your horizons

Every year, about 500 Bristol students spend either a year or a semester studying abroad at one of our partner universities. Chemistry typically arranges exchanges for up to 20 students in Year 3 of a four-year Chemistry with Study Abroad degree, in either the USA, Canada, Australia or Singapore. We also hope to arrange placements in Japan and New Zealand in the near future.

Placement students become full-time (albeit temporary) students of the host university and so will sit exams, take tests, give presentations, and be marked by the local staff just as the local students are. Students can expect to conduct a research project with a local research group while also taking part in Year 3 Bristol distance learning courses.

If you budget well and watch your expenditure, you can enjoy your year abroad for the same cost as a year in Bristol, since you only pay 15 per cent of the usual £9,000 fees and nothing to the host institution. You will need to cover the costs of a return flight, visa and insurance, and, of course, accommodation, although there are occasions where local education authorities can help.

And if you don’t fancy a whole academic year abroad but still want to experience life outside of Bristol, the International Office can help with summer placements.

For more information about studying abroad through the School go to: bris.ac.uk/chemistry/courses
What do Pope Francis, Angela Merkel, Kurt Vonnegut and Margaret Thatcher have in common? They all qualified in chemistry – proving that a degree in science can take you anywhere. Here are some Bristol graduates who have realised their dreams...

From lab to boardroom

Since graduating in 2015, Harry Destecroix has set up two businesses, eager to impart his wisdom to other entrepreneurs and apply his knowledge to further science.

Harry's PhD saw him working on the design and synthesis of new sugar sensing molecules called Synthetic Lectins. His research led him to create Ziylo, a start-up company which now employs six people working on developing a new sensing platform for monitoring carbohydrates.

This year Harry founded a second company, NS Science, which aims to build a new research facility to provide lab space to biology, chemistry and physics companies in central Bristol.

Fit for industry

Sophie Osbourne graduated in 2014 with an MSci in Chemical Physics with Industrial Experience, which saw her work at the Schlumberger Gould Research Group, investigating enhanced oil recovery, and carried out her final year project on the secondary electron emission of thin diamond films. She's now a Graduate Consultant with nuclear safety and environmental consultants Hydrock NMCL.

"Every day of my job brings something different," she says. "I've been involved in projects for clients across the nuclear industry, from organisational capability of new build organisations to modifications of decommissioning reactor safety cases, and everything in-between."

Skilling up

Deadlines, timetables and complex research are all core components of an undergraduate degree in chemistry. They’re also skills which are highly valued by employers – something that Ashley Earl was able to capitalise on after finishing his MSci in Chemistry.

Ashley’s final year research project comprised studying how surfactants can be created to have a reduced environmental impact.

"My project involved collaborating with a small company based in Bristol and that gave me a great idea of what it’s like to work with a client," says Ashley, who now works as a Technical Assistant in the Chemistry and Life Sciences Practice Group at the patent and trademark specialist firm Gill Jennings & Every in London.
A head for figures

The financial industry attracts a significant proportion of chemistry graduates, whose numerical skills mean they are well versed in problem solving, delivering presentations and working as part of a team.

Ben Chung decided to pursue a career in management consultancy after his MSci in Chemistry with Industrial Experience, which gave him an insight into the world of research and development, finance, marketing and procurement. He now works for the global firm KPMG on projects involving operational and financial transformations of businesses from multiple sectors.

Those who can teach

Since completing her BSc in Chemistry last year, Louise Hussein has been launched straight into the world of teaching as part of her PGCE at Kings College London. A scholarship from the Royal Society of Chemistry means she has the benefit of extra tuition too.

“Passing my knowledge on to the next generation is so rewarding. Children have so many questions about the world which are often left unanswered, and being able to use my expert knowledge to explain the phenomena we observe everyday has been extremely gratifying.”

In it for good

Collaborating with other scientists from across the disciplinary spectrum is one of the many opportunities afforded by a stint with the School of Chemistry. For Richard Oakley, it proved vital to his career.

After finishing his PhD at Bristol in 2009, Richard spent two years studying at Switzerland’s École Polytechnique Fédérale de Lausanne (EPFL), followed by a 10-month posting with the Royal Society of Chemistry. He’s now a Senior Funding Manager at Cancer Research UK (CRUK).

“Bristol’s multidisciplinary approach has proved vital since I’ve been at CRUK, where I work with researchers from all disciplines, helping them to write the best application they can,” he says.
Think of a functional system – biological, mechanical, chemical or physical – what is the key factor that binds it together? The answer is communication. Whether it’s a natural organism or a computer hard drive, the individual components need to interconnect and work with each other for the sake of the whole. In other words, they need to talk to each other.

In biology, molecules perform the function of internal communication. In chemistry, a similar functionality can be achieved – but with a greater degree of control thanks to science’s ability to design systems inspired by nature that cleverly deconstruct, mimic and simplify.

Professor Jonathan Clayden and his group of organic chemists are particularly fascinated by the possibility of creating molecular formations that communicate in novel ways.

Using a family of proteins called G-protein coupled receptors (GPCRs) as inspiration, they design artificial molecules to do the same job as their much more complicated natural equivalents.

Shape shifters
“GPCRs are nature’s way of talking through walls,” says Professor Clayden. “All cells have a membrane that defines what is on the inside and what is on the outside, but since cells need to communicate with their environment, messages still have to pass through that membrane.”

GPCRs pick up chemical messages through messenger molecules, which fit neatly into a pocket within a GPCR, causing it to change shape as a result. This shape-shift is then detected by other proteins on the inside of the cell.

“Biology uses shape changes to communicate information in all sorts of molecules, from haemoglobin in the blood to retinal in the eye,” explains Professor Clayden. “But chemists are only just cottoning on to the potential for similar communication strategies in artificial molecules.”

The Clayden group uses synthetic chemistry to build relatively simple, but quite long molecules called ‘foldamers’, which spontaneously fold into a very specific shape, often a helix. They then attach a molecular structure to each end of a foldamer, so that it will respond specifically to a chemical signal.
Leaps and binds
This helical switch happens within a fraction of a millisecond, communicating a chemical signal over a distance of several nanometers. “That may sound a short distance to you but it’s a giant leap for a molecule,” says Professor Clayden, whose group has used the technique to create molecules that respond to pH or to the presence of sugars, amino acids or light. They even managed to create artificial receptor molecules that function in water by using common metal ions such as copper or zinc to help the chemical messengers bind.

They are now looking to mimic the GPCR system even more closely by designing molecules that send information through artificial membranes. They’re also exploring the possibility of making molecules that could send chemical signals in response to light by mimicking the way proteins in the eye work.

“We steal a lot of ideas from nature,” says Professor Clayden. “Fungi know how to make molecules that embed themselves into cell membranes, because that’s one way they can wipe out competing bacteria. So we have stolen that idea – making molecules out of a structure known as Aib – to make our own membrane-active molecules.”

Whatever next?
Nature is a constant source of inspiration for Professor Clayden and his team: “Biological molecules have been perfectly tuned to specific purposes by evolution. We want to make molecules that have more general potential – controlling the function of artificial vesicles, which are like miniature synthetic cells.

“Biological systems store genetic information in what is chemically quite a simple way – the directionality of pairs or triplets of bonds. The way that information is turned into biochemical function is marvellously elaborate, and involves the most remarkable molecular structure in the known universe, the ribosome. But we are working on an idea for short-circuiting this route, converting this sort of bond-directional information into a chemical signal much, much more simply.”

“BIOLOGY USES SHAPE CHANGES TO COMMUNICATE INFORMATION IN ALL SORTS OF MOLECULES, FROM HAEMOGLOBIN IN THE BLOOD TO RETINAL IN THE EYE”

Professor Jonathan Clayden

Record-breaker
Professor Jonathan Clayden’s group is a world record holder in molecular communication. In 2004, his team showed that it was possible to use molecular shape to control the selectivity of a reaction through a chain of 23 bonds. That record beat the previous record of 14 bonds set in 1997, and it stood until 2014, when the group shattered its own record with a reaction controlled through 61 bonds. The team are now building polymers that could extend this range to hundreds or maybe thousands of bonds.
“The beauty of a living thing is not the atoms that go into it, but the way those atoms are put together.” So said the legendary astrophysicist Carl Sagan. The challenge that transfixed Sagan and countless scientists since is how to figure out the mechanics underlying atomic structures, and how to observe molecular formations.

It’s a particularly staggering challenge considering that the reactive encounters between molecules, as generated during chemical synthesis experiments, last for a mere trillionth of a second. That’s the time it generally takes to break an existing chemical bond and form a new one.

The challenge is even more complex given the dynamic environment in which molecules exist, tumbling and colliding in ways that continually alter the reaction mechanism. This is especially true where the chemical synthesis is taking place in a liquid solvent, because the solute and solvent molecules undergo similarly rapid collisions with their neighbours.

“Because chemical reactions occur on extremely fast timescales, it’s a real challenge to develop intuitive pictures of how they happen,” says Dr David Glowacki, who, along with Professor Andrew Orr-Ewing, has developed experiments and simulations that provide the clearest picture to date of how a chemical reaction happens in a liquid.

Making moves
Dr Glowacki, from Bristol’s Centre for Computational Chemistry, and Professor Orr-Ewing of the Laser Spectroscopy and Dynamics Group, have been jointly exploring how to capture snapshots of chemical reactions in solution and connecting them to make movies of reaction pathways.

Their approach – hailed as a “World Changing Idea” by the leading popular science magazine Scientific American – involves combining ultrafast laser spectroscopy and computer simulation to track chemical reactions and make accurate movies of the reactive events.

Professor Orr-Ewing and former Bristol PhD student Greg Dunning used lasers to observe the picosecond-timescale details of reactions in liquids. Dr Glowacki and Professor Jeremy Harvey then wrote simulation software that could predict the
results of these spectroscopy experiments with extraordinary accuracy.

The team were specifically interested in understanding how the reaction of a fluorine (F) atom removed a deuterium (D) atom from an organic solvent molecule to make deuterium fluoride (DF).

They were able to identify a series of important fundamental steps of the chemical reaction, including the flow of the energy released by the reaction into stretching of the DF bond; the formation of hydrogen bonds between the DF product and the solvent within one picosecond of reaction; the subsequent dissipation of energy into the surrounding solvent as heat; and reorientation of the solvent molecules around the DF to accommodate this polar reaction product. This whole series of chemical steps is over in about 50 picoseconds.

**Chain reaction**
Bristol researchers are now investigating how biologically important molecules interact with ultraviolet light and resist photochemical damage, or how electrons and holes separate in new photoactive media intended for use in solar cells.

These methods are now being incorporated into computer simulations for academic and industrial use which could benefit researchers who use computer simulations to model biochemical processes in living organisms such as enzyme catalysis or mechanisms of drug action.
Back to School

Chemistry Explored talks to Dr Karen Parrish, who joined the School last year as a Teaching Laboratory Fellow...
On her new job...

“I have responsibility for the second year practical teaching in the School of Chemistry. I work four days a week during term time. My job involves a range of different things – including organising the practical teaching, coursework and assessment, overseeing the labs (where experiments are taught by a team of postgraduate demonstrators), designing new experiments and improving old ones, training demonstrators and helping to run a summer school for GSK (GlaxoSmithKline) placement students. I’ve only been here since November so I haven’t done all of these yet!”

On her typical day...

“Generally I supervise labs which start at 11am and go on until 5pm. There are about 100 students each day, with seven postgraduate demonstrators at a time who teach the experiments, and there are a couple of experiments that I teach as well. The students work on about 25 or so different experiments in groups of four, so they rotate around the lab and do a different one each week. The demonstrators stay with the same experiments each week, and I oversee them. The technical staff keep the lab running smoothly.”

On the biggest challenge of the new job...

“The biggest change is from doing chemistry in the lab to teaching it. I’ve also had to get used to explaining things at a slightly different level that can be understood by people who are not so far on in their careers. In my old job I worked quite a bit with third year placement students, so it has not been too difficult to adjust. I work with a much greater number of people than I used to and that brings its own challenges.”

On returning to the School...

“I think Bristol’s a very vibrant city and in a really lovely part of the country. I did my PhD here in the department many years ago and I’ve lived in the city ever since. I particularly enjoyed working with and training new graduates in my previous job, so when I saw this job advertised it looked perfect. It was strange coming back here. There are not many of the people I knew well still around – there’s no one left from my own research group, but every now and again I’ll walk down the corridor and I’ll see a face that I do recognise but haven’t seen for 16 years. It’s very nostalgic being here again.”

On her old job...

“I used to be a medicinal chemist, working for Evotec doing drug discovery – I was involved in designing new medicines and synthesising prototypes. These would undergo testing and the results would help us design better drug molecules.”

On her favourite restaurant...

“My Bristol

Favourite restaurant:
Aquila on Baldwin Street – really tasty Italian food and great service. It can get a bit pricey though, so it’s better if someone else is paying!

Favourite shop:
I’m not fussy – anywhere that sells chocolate!

Favourite landmark:
The Clifton Observatory. On a sunny day you can go up the tower and into the Camera Obscura at the top, where you can watch tiny people and tiny cars moving around on a white table. It’s weirdly fascinating.

Favourite café:
Boston Tea Party on Park Street – it was quite new when I was a student, but I’m glad to find it’s still here.

“NOW THAT I’M HERE I’M FINDING IT A FUN PLACE TO WORK, AND IT’S GREAT TO BE WORKING WITH THE NEXT GENERATION OF CHEMISTS.”

Dr Karen Parrish
Chemistry camps

Bristol ChemLabS, a UK Centre for Excellence in Teaching and Learning, organises several Chemistry Camps (‘summer schools’) each year for both home and international school students and undergraduates and has done so for nearly a decade. Students can stay in halls of residence (if available) or local hotels and enjoy several sessions of practical work, lectures and lecture demonstrations and take tours of analytical laboratories and, if requested, can have a presentation on the university application process.

27–29 June 2016:
THREE-DAY CHEMISTRY CAMPS FOR INTERNATIONAL SCHOOL
Fifty places will be made available for a three-day programme of practical workshops, lectures, talks and demonstration lectures.

07–08 July 2016:
TWO-DAY CHEMISTRY CAMP FOR SCHOOLS, BRISTOL CHEMLABS
Up to 20 places are available for a school group from anywhere in the UK to join the two schools already scheduled.

19–20 July 2016:
TWO-DAY RESIDENTIAL CHEMISTRY CAMP FOR INDIVIDUAL STUDENTS
Two-day residential camp designed for Year 11 and 12 students who are thinking of pursuing a career in chemistry to experience what it is like to be an undergraduate.

05–06 January 2017:
WINTER CHEMISTRY CAMP, BRISTOL CHEMLABS
The annual winter camp for school groups of students in Year 10–13. Maximum 50 students in total can attend.

Additional sessions will be available in late June and July 2017 including a joint visit between Bristol and Trinity College Dublin. For more information please contact t.g.harrison@bristol.ac.uk.