Welcome to this most recent report highlighting the considerable achievements of the Centre and our hard-working students.

The ever-increasing outputs of the Centre are testament to the skill and creativity of our students and validation of the CDT approach to postgraduate education. The much admired publication output has been commented upon very favourably by many: over 160 publications to date in national and international journals such as Science, Nature, Angewandte and JACS.

Students have continued to win a string of presentation and poster prizes at conferences, as well as prestigious fellowships such as JSPS (Japan) and Damon Runyon (USA). CDT students have also been very active in Outreach and Public Engagement activities such as STEM and SET for Britain in the Houses of Parliament, the online ‘I’m a Scientist Get Me Out of Here’ [won] and the Chem Dine With Me exhibit at the Bristol Bright Night festival. Participation in these types of events is crucial for promoting the CDT message to a wider audience.

We are very proud of our students, both past and present, and it has been a privilege to lead the Centre over the years and to observe their successes and watch their careers develop. None of this would have been possible without the support and input from the staff at Bristol.

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Professor Kevin Booker-Milburn
Director
**Timeline of success**

**2015**
- **Alex Henderson** (2011 Cohort) awarded a Royal Society of Chemistry (RSC) Travel grant to present his work at Pacificchem 2015.
- **Matt Burns** (2009 Cohort) selected as finalist for the Reaxys PhD prize.
- **Niall McCreanor** (2011 Cohort) selected by RSC to present his research at J-NOST-11.
- **Professor Melanie Sanford** (University of Michigan, USA) selected as the recipient of the 2016 BCS CD- Syngenta Award.
- **Jo Sampson** (2011 Cohort) selected as finalist for the Reaxys PhD prize.
- A delegation of 12 BCS CDT students visited universities in China representing the Centre.
- **Tim Shuttleworth** (2012 Cohort) was part of the Chem Dine With Me exhibit at the Bristol Bright Night festival.

**2016**
- **Several BCS students attended a Green and Sustainability Workshop organised by colleagues at the CDT in Sustainable Chemistry, University of Nottingham.**
- **Steven Street** (2012 Cohort) presented his work at the House of Commons as part of the SET for BRITAIN.
- **Dr Antony Burton** (2011 Cohort) awarded Damon Runyon Fellowship for cancer research.
- **Jo Sampson** (2011 Cohort) won prestigious Leverhulme Trust Studentship.
- **Isabel Perez-Powell** (2012 Cohort) and **Sam Timson** (2011 Cohort) awarded RSC Chemistry Teacher Training Scholarship.
- **Megan Shaw** (2010 Cohort) selected as finalist for the Reaxys PhD prize.
- **Katy Pellow** (2013 Cohort) presented her research to Parliament as part of STEM for BRITAIN.
- **Isabel Perez-Powell** (2012 Cohort) awarded by RSC to present work at J-NOST-12.
- **Giaccomo Crisenza** (2012 Cohort) selected by the RSC to present work at J-NOST-12.

**2017**
- **Charlotte Boott** (2012 Cohort) selected as finalist for the Reaxys PhD prize.
- **Paul Walker** (2014 Cohort) invited to develop a character (a chemical scientist) to feature in the latest SurgeonX comic to raise awareness of antimicrobial resistance.
- **Antony Burton** (2011 Cohort) receives a Faculty of Science Commendation for his doctoral thesis, which was singled out by examiners as an outstanding piece of work.
Dr Elliot Murphy
Elliott graduated in 2014, after completing his PhD project on the synthesis and properties of the so-called ‘ultimate sigma donor’ carbene ligands. He is currently working for St Austell Brewery in Cornwall.

He says...
“There is an immense amount of chemistry, general science and engineering involved in properly understanding brewing. Practically speaking, the processes are similar to lab work: transferring solutions, heating, reacting, cooling and filtering the resulting products through celite, whilst trying to exclude air. We even have a giant column to de-gas water.

Having a strong organic chemistry background has proved invaluable, particularly for hop compounds and their isomerisation/oxidation reactions. I definitely wouldn’t be as interested in brewing if it wasn’t pretty much entirely science.

The CDT training benefited my PhD research by exposing me to a wider range of knowledge and techniques that I would have come across if I had come straight from undergraduate into my PhD project. It also gave me a network of fellow PhD students, with knowledge covering a wide range of areas within synthetic chemistry, which was very valuable for problem solving.”

Dr Megan Shaw
Meg graduated in 2015 after completing her PhD project in the area of C-C bond activation with focus on the development of Rh-catalyzed ring expansion methodologies for the synthesis of N-heterocycles. She is currently working with Professor MacMillan at Princeton University (USA) as a postdoctoral research associate.

She says...
“The training program undertaken at the beginning of my PhD was extremely valuable. It had a massive impact on my postgraduate experience and it allowed me to join a research area that I found extremely interesting. Furthermore, it also prepared me for my postgraduate studies by providing training in scientific writing, promoting critical analysis of journal articles and brainstorming ideas for new research projects.

The CDT has provided me with many skills that have proven vital for postdoctoral studies in an academic lab. Firstly, the development of my oral presentation skills through involvement in departmental poster sessions, CDT summer conferences and attendance at external scientific meetings. In addition, the CDT encouraged discussion between postgraduates working in distinct areas of chemistry and provided the cohort with opportunities to discuss our research once separated into different research groups. These interactions are important as discussions with researchers in other scientific areas can initiate collaborations and new research directions.

I am aiming to pursue an academic career and in the near future, I would hope to be running a successful research group and supervising a group of postgraduate and postdoctoral researchers.”

Dr Emma Blackham
Emma graduated in 2017 after completing her PhD project in the area of palladium catalysed annulation reactions of tricyclic vinyl aziridines. After graduating, she joined Sygnature Discovery, a leading centre for integrated drug discovery in Nottingham.

She says...
"Looking back, it is clear how the different elements of the CDT training benefited my PhD research. I was able to refresh my practical skills, as well as learning new ones, which allowed me to hit the ground running. The time spent in the different lab rotations allowed me to forge a network of contacts from whom to seek technical advice during the duration of my PhD. Other elements like Director’s Cut and brainstorming sessions expanded my knowledge of certain chemistry areas previously not well known to me.

With regards to my professional career, the CDT training has been invaluable. Amongst other things, it has given me the confidence to develop my own ideas and communicate them effectively; the ability to rapidly integrate into a new team; the capacity of writing reports in a short space of time and the skills to give a clear, concise presentation to both a small group and a large department.

As for the future, I intend to remain in the field of drug discovery, taking on a leadership role.”

Alumni profiles
We spoke to three of our alumni to ask them how they feel the Centre training benefited their PhD research and helped develop their career.

100% of CDT graduates are currently employed
Year 1

PhD students following the CDT route will have a different experience than students on the conventional route. They start year 1 with an 8-month training period referred to as PACT, which is short for ‘Postgraduate Advanced Chemical Techniques’.

The over-arching goal of PACT is to equip our students with the tools required to make an informed PhD project choice. Students also benefit from learning and developing a wide range of transferable skills including presentation, team work and problem solving.

The six elements of PACT are:
- Brainstorming of PhD proposals
- 8-week lab rotations (known as RBS)
- Director’s Cut Problem sessions
- Journal Club (literature review)
- Lecture courses (assessment by exam)
- Postgraduate DLM (lab experiments in a virtual environment).

Years 2 to 4

During this time, student focus on their research. Importantly, their training does not end with PACT, as they attend a series of development courses throughout their PhD. The graphic shows some of the courses that are an integral part of our CDT experience.

Year 1
- PACT
- Scientific Writing

Year 2
- Introduction to Public Engagement
- Innovation and Enterprise
- STEM Ambassador Training
- Outreach Day

Year 3
- Process Chemistry
- Agrochemicals
- IP and Patent Law
- Business Pitch (Dragon’s Den)

Year 4
- Employability
- Communicating your Science
- CV writing and interview technique

Postgraduate Advanced Chemical Techniques

PACT

Postgraduate Dynamic Laboratory Manual

PgDLM

The DLM contains e-learning tools designed to enable mastery of important synthesis techniques.

A range of interactive tools are used to allow students to experience experiments in a virtual environment prior to attempting them in the laboratory. These include virtual instrumentation and equipment, tutorials, guides, quizzes and video modules. This is especially useful if students have not had experience with a particular technique or experiment.

- X-ray single crystal diffraction
- 1D and 2D NMR techniques
- Chemistry in a glovebox
- Protein purification
- Retrosynthetic analysis
- Design of experiments
- Physical organic chemistry
- Medicinal chemistry
- Process chemistry

“I feel much more prepared to start a real research project now, than I did seven months ago.”

The PgDLM is a growing resource which supports students by covering a number of advanced synthetic and analytical techniques such as:
Training

What are the highlights of postgraduate study in the CDT?

Paul Walker

Looking back, what I most enjoyed about the training element of the course was the opportunity to work in a number of different labs during my RSS rotations, through which I learnt a range of useful skills and techniques. The facilities in the School - NMR, Mass Spec, X-ray crystallography and microanalytical lab to name but a few - are excellent. Furthermore, the administrative and academic staff are always available and willing to help with any questions or problems. I think I am more suited to academia than industry, so ideally, I would look to work in Higher Education after completing my PhD.

Krisha Mistry

I decided to apply for this programme because during my undergraduate research I had only experienced one area of synthetic chemistry and I wasn’t sure I wanted to specialise in that. A PhD in the Chemical Synthesis CDT gave me the chance to explore different areas of chemistry, so I could make an informed decision. I also gained more practical experience before starting my PhD, which was a plus! What I would say to prospective PhD students is that if you enjoy synthesis but are not sure in what particular area you want to work, this programme is a good choice for you. I am still undecided on what I want to do once completing my studies but I would like to stay in chemistry. I am considering undertaking a post-doctoral position or looking for a lab-based job in industry.

Dan O’Flynn

I was extremely aware of the main advantage of the CDT programme before joining. For me, this was getting to work on three very different projects in three very different research groups. Also, the chance to get to know potential supervisors and brainstorm PhD proposals before choosing the project I would work on for the next 3.5 years sounded like a sensible idea. The staff in the CDT are very approachable and you can get as much support as you need. When I graduate, I would like to pursue a career in industry, ideally in medicinal chemistry or agrochemical research.

Research

Research projects

Synthesis encompasses a wide range of chemistry, and projects within the Centre are varied. We asked a small selection of our students to explain how their research targets a current global challenge.

Ailis Chadwick

Exploiting radioactivity to image and treat cancer

According to the World Health Organisation, cancer is a leading cause of death worldwide, with over 23 million cases expected to be reported each year globally by 2030. Survival rates are drastically improved by early detection and management; therefore, the development of novel detection and treatment procedures is more important than ever.

“Lab rotations have resulted in me choosing a PhD project far from what I had originally envisaged, but one I’m confident I’ll enjoy.”

Nuclear medicine uses small amounts of radioactive material to diagnose and treat a variety of diseases, including cancer. This is done by administering a radiopharmaceutical (a drug that incorporates a radioactive metal e.g. $^{99m}$Tc) to the patient, which localises at the diseased tissue using small molecules called ligands.

Cancerous cells often overexpress receptors on the surface of the cell. My project, in collaboration with King’s College London, focuses on the synthesis of new ligands that can be attached to small proteins that fit into these receptors. Once attached, they will form new radiopharmaceuticals that will target cancer specifically and will be tested for their efficacy as imaging agents. Furthermore, rhenium-188 ($^{188}$Re) is a structurally similar metal to $^{99m}$Tc used in radiotherapy. By attaching our ligands to $^{188}$Re, we can create new targeted radiopharmaceuticals for treating cancer too.

David Heard

Natural products for crop protection

The rise of antimicrobial resistance and its challenges is now widely recognised. In contrast, the related issue of increasing resistance to herbicides and fungicides in agriculture is less well documented but will have a significant impact on our ability to meet the global demand for food in the future. Thus, the development of new herbicides and fungicides is of utmost importance.

In order to survive, many bacteria and fungi have evolved to produce bioactive compounds that are detrimental to the growth of competitors. These natural products provide a rich resource for the development of agrochemicals.

One such example inspired my PhD project. It was observed that the growth of a particular fungus on Douglas Fir trees in Canada appeared to confer to the tree a measure of resistance against several strains of pathogenic fungus, but did not affect the tree itself. This selectivity is of particular value in agrochemicals.

I began my project by growing this fungus in the laboratory and isolating the key compounds. Next I aim to synthesise these molecules (and analogues) in order to investigate how these structures are related to the fungicidal activity they present.
Chemistry is out there solving some of the world’s most pressing problems.”

Paul Walker
How to make new antibiotics

Bacteria make antibiotics to kill other types of bacteria as a defensive mechanism. These properties have been harnessed by modern medicine to produce antibiotics in the lab. However, the number of bacteria resistant to antibiotics is on the rise, leaving the human population vulnerable to common bacterial infections.

As bacteria constantly evolve, it is important to identify new antibiotics, but also to modify existing ones to overcome resistance. The focus of my research is to understand the pathways used by bacteria to generate compounds able to defeat attacking microorganisms, with the aim of engineering new ones that are more potent, selective or can overcome resistance mechanisms.

To do this, I isolate compounds and test their activity against a range of bacteria, including some “superbugs” such as MRSA and VRE. Chemical synthesis is used to determine the structure of the isolated compounds and to make derivatives starting from the naturally produced compound. Finally, structural biology and enzymology are used to isolate the enzymes that catalyse interesting steps in the pathway and then recreate them in a test tube. Overall, the aim is to overcome the challenges presented by resistant bacteria to currently available antibiotics.

Sarah Michel
Mimicking skin for in utero repair of Spina bifida

Spina bifida is the most common birth defect worldwide. It is due to a foetus’ spine failing to close during pregnancy, resulting in the exposure of nerves to the amniotic fluid. To date no treatment exists and the damage to the nerves is irreversible. In utero surgery can be performed during the first months of pregnancy but the operation remains very invasive and life-threatening.

The aim of my project is to develop a safer, less invasive approach to prevent the nerves from being damaged. A possible solution could lie in covering the opening in the spinal cord with a material non-permeable to the amniotic fluid, which would protect the nerves and therefore prevent the induced life-long complications.

I am working with polysaccharides, which are highly attractive materials due to their biocompatibility, non-toxicity and their ability to favour wound healing. The material would be injected in utero with a simple needle and then adhered to the spina bifida opening to form a tough and highly flexible protective wound dressing that seals the nerves from the amniotic fluid. These materials would also find applications in the management of chronic or internal wounds.

Mike O’Hagan
A new treatment for cancer

Cancer represents a significant and growing global health problem, with the number of new cases projected to rise by 70% over the next two decades. Fortunately, international scientific research has led to the development of powerful treatments, and survival rates have increased dramatically over the last 40 years. Many of the leading chemotherapy drugs work by causing damage to the DNA inside cancer cells. Unfortunately, they also affect healthy cells, which leads to the adverse side effects often associated with cancer treatment.

I’m working on an alternative method of targeting DNA to reduce these side effects. It is based on the discovery that particular DNA sequences associated with cancers, can fold into a special type of structure known as a quadruplex. This is an interesting fact, because certain biological pathways that lead to cancer are disrupted when the DNA is in ‘quadruplex mode’. I’m working on an alternative method of targeting DNA to reduce these side effects.

My project aims to make new molecules that encourage these quadruplex structures to form. A key benefit of this approach is that these molecules would target quadruplexes very selectively, with no effect on healthy cells. Therefore, they may provide starting points for the development of a new generation of anti-cancer medicines that display reduced side-effects.

David Morris
Hydrogen-bonding machines for communication with cells

Hydrogen-bonding is one of the most predominant and powerful non-covalent interactions found in nature. It is responsible for countless natural phenomena, including the binding of drug molecules in proteins and the folding of proteins into their highly specific structures, which are vital to their function. Furthermore, a hydrogen-bond has an inherent directionality associated with it that can lend itself to more exotic functions. It is this directionality which is responsible for the storage, communication and processing of information in biological systems.

Taking inspiration from nature, organic chemists have created many molecular machines that use hydrogen-bonding to perform useful biomimetic functions. However, there are few examples that exploit their inherent directionality to perform function despite its prominence in nature.

The aims of my project are to simplify this natural phenomenon into a molecular machine that can take binary information from DNA, communicate it through space and have it perform function remote from the informational source. This machine could find use in a wide range of medicinal applications as it has the capacity to communicate with cells through their membranes and to use its hydrogen-bonding properties to replace/mimic cellular functions that would otherwise give rise to disease.
null
Public engagement

Bristol Bright Night event
by Synthesis CDT Researcher Tim Shuttleworth

Harbourside venues @Bristol, the Green Capital Lab Space and the Watershed played host to Bristol Bright Night, a free event designed to excite and engage the public about all areas of Science. @Bristol was the venue for a range of entertaining demonstrations and hands-on activities, all devised and led by researchers from the University of Bristol and UWE. Together with my colleagues from the Pringle group, I was part of the “Chem Dine With Me” exhibit.

“Chem Dine With Me” aimed to introduce the public to the apparatus that we use every day in the lab, through the medium of a cooking demonstration. To start, meat was cooked and the juices filtered off. These juices were then separated into the watery (aqueous) juices and the fatty (organic) juices using a separating funnel, just like an aqueous extraction performed in the lab. The meat was then combined with a tomato sauce. This was served on a bed of rice, which had been cooked using a heating mantle in a very large round bottomed flask was equipped with a reflux condenser, showing how we can heat reactions without allowing them to boil dry.

Taster portions of the dish was then served to the audience. In addition, we had a few separating funnels on tables around the exhibit. These were filled with a mixture of oil and water, which meant that anyone could attempt an aqueous extraction for themselves.

Can sugars cure cancer?
by Synthesis CDT Researcher Steven T. G. Street

The Science Society at Redmaids School in Westbury-on-Trym is run entirely by students, who regularly organise seminars featuring guest speakers from outside the school. I was invited to give a talk on a science topic of my choice and seeing as I often give outreach lectures at the School of Chemistry, I was happy to accept.

My audience ranged from Year 7 to Sixth Form students and included science teachers too, so it was a challenge to include something for everyone to take away! The title of my talk was “Can Sugars Cure Cancer? A tale of what it’s like to be a chemist”. My intention was firstly, to inspire people to further pursue a career in science, and secondly to inform them of exactly what that life is like. The first part of my talk described the decisions that had led me to where I am today and what life as a chemist is like. Most importantly, it delved into why you might want to study chemistry at university level. The second part of my talk focused on my PhD project. My research centres on developing new sugar inspired anti-cancer drugs, which work by targeting a specific DNA sequence.

After the talk there was an opportunity for questions, which centred on what life as a chemist and PhD student is like, and also some very pertinent questions relating to the future challenges my research area faces. Overall it was a very pleasant day speaking to some very bright students.

Science visits

Outreach is an important part of the EPSRC Centre for Doctoral Training in Chemical Synthesis. We ensure that all our PhD students go through the STEM ambassador programme, which is designed to encourage and inspire young people to pursue science, technology, engineering and maths subjects at school.

Each year the Centre sponsors at least one event for invited schools at the Bristol ChemLabs. On 11 November 2015, the 2014 Cohort hosted 62 Year 12 pupils from five schools from the South West of England. They spent the day involved in laboratory work and lectures.

Our visitors started their day by extracting caffeine from tea leaves and analysing the product by infra-red spectroscopy. In the afternoon there were science talks given by Synthesis CDT researchers Kristina Mistry (‘Frustrated Lewis Pairs used as Catalysts’) and Horatio He (‘My PhD Story and My PhD Project’) before Tim Harrison performed the lecture demonstration ‘Glasses in the Air’.

The schools attending were: Queen Elizabeth Hospital (GBH) School (Bristol), Richard Huish College (Somerset) and UTC Plymouth (Devon).

On 16 November 2016, the Centre hosted 43 Year 11, 12 and 13 pupils from three schools (Redland High School for Girls and Bradley Stoke Community School in Bristol and Gloucester Cathedral School, an independent school in Gloucester).

Synthesis CDT researcher Sarah Michel gave a talk based on Spina Bifida treatment and Michael O’Hagan on sugar-based anti-cancer. Tim Harrison and Emma Liddle completed the afternoon with a lecture demonstration ‘A Pollutant’s Tale’.

The schools attending were: Queen Elizabeth Hospital (GBH) School (Bristol), Redland High School (Bristol), St Brendon’s Sixth from College (Bristol), Richard Huish College (Somerset) and UTC Plymouth (Devon).

“Wanted to say thank you so much for yesterday. The girls had a really great time – really informative and useful as well as being thoroughly enjoyable.” Teacher

“All enjoyed the practical and the level of responsibility they felt at using unfamiliar equipment. They all thought the PhD student helpers were brilliant and very approachable, pitched their explanations at the right level. They really enjoyed the exciting demo lecture, and one of the other lectures. It has made at least two of our year 11’s reconsider their A level options to include chemistry!” Chemistry Teacher

“I saw pupils yesterday and they were buzzing with it – really enjoyed every bit, except having to leave early!” Deputy Head, King’s Gloucester
Collaboration

Partnerships

Key to our success in the Centre are the partnerships and associations with industry and universities. This high impact collaboration allows for the BCS CDT students to be trained in a diverse environment, with access to the expertise required to make them world-class synthetic chemists.

Many of our students have second supervisors from other Universities. These students have regular contact with their academic partners and have the opportunity to visit their laboratories for a period of time. Students benefit from the additional specific expertise their secondary supervisor can provide, as well as the specialist equipment they have available. These academic partners are based throughout the UK and around the world.

Management structure

Good management and effective governance is the heart of the efficient running of the Centre and we ensure this through three committees.

The Planning Group

The Director, Course Manager and Centre Administrator meet once per week to discuss all aspects of the day to day running of the Centre, including PACT, recruitment, student issues, finances etc.

- Professor Kevin Booker-Milburn, Director
- Dr Emma Rose, Course Manager
- Ms Mar Ruiz, Administration Manager
- Professor Kevin Booker-Milburn (BCS CDT – Director)
- Varinder Aggarwal (BCS CDT – Industry Chair)
- Jonathan Clayden (BCS CDT Management)
- Matthew Davidson (CDT in Sustainable Chemical Technologies)
- David Fox (Vulpine Science & Learning)
- Talat Ghaffar (EPSRC)
- Stanislaw Golunski (CDT in Catalysis)
- Shou Hachou (Syngenta)
- Nelly Harvey (RSC)
- Zoe Henley (GSK)
- Gregory Hollingworth (Novartis)
- John Knight (Jkonsult)
- John Leonard (former AZ)
- Martin Lowe (UCB)
- Chris Moody (CDT in Sustainable Chemistry)
- Jonathan Mosesy (CatSci)
- Paul Murray (Catalysis Consulting)
- Nick Norman (BCS CDT Management)
- Mark Purdie (AZ)
- Jeff Richardson (Lilly)
- Emma Rose (BCS CDT Course Manager)
- Peter Scott (Warwick University)
- Anneisa Seddon (BCFN)
- Martin Smith (CDT in Synthesis for Biology & Medicine)
- Tony Swain (AWE)
- Karl Swift (Bio-techne)

The Steering Group

Meets annually, and is chaired by an external member. Membership consists of industrialists, EPSRC, Directors of other CDTs, consultants and external academics. The group is presented an annual report from the Director and they discuss industrial funding, as well as offer advice on the running and future of the Centre. This is our main opportunity for quality control from external parties, as they see first-hand what the CDT has achieved in the previous year.

- Varinder Aggarwal (BCS CDT – Industry Chair)
- Kevin Booker-Milburn (BCS CDT – Director)
- Jonathan Clayden (BCS CDT Management)
- Matthew Davidson (CDT in Sustainable Chemical Technologies)
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- Tony Swain (AWE)
- Karl Swift (Bio-techne)
Research themes

Our research is organised into eight themes, though there is much overlap and many academics work in more than one area.

New Scaffolds for Medicines and Agrochemicals
- Synthetic chemistry
- Medicinal chemistry
- Heterocyclic chemistry
- Synthetic analogues
- Iron-based catalysis
- Upgrading of alcohols for fuel

Design & Synthesis of New Bioactive & Functional Molecules
- Supramolecular chemistry for recognition and transport
- Design of new peptide and protein structures

Development of Expedient New Synthetic Methodologies
- Glycosylation methods
- Organo-boron and organo-sulfur chemistry
- Oligosaccharide chemistry
- Heteroatomic chemistry

Metal Catalysed Transformations
- Synthesis of new heterocyclic chemistry
- Iron-based catalysis
- Gold catalysis
- Upgrading of alcohols for fuel

Cleaner Synthesis Chemistry
- Compound extraction and characterisation
- Bioinspired synthetic pathways
- Total synthesis
- Isotopic labelling

Natural Product Chemistry
- Compound extraction and characterisation
- Bioinspired synthetic pathways
- Total synthesis
- Isotopic labelling

EPSRC Centre for Doctoral Training in Chemical Synthesis
- Synthesis of new heterocyclic chemistry
- Iron-based catalysis
- Gold catalysis
- Upgrading of alcohols for fuel

Designers Ligands for Catalysis
- Synthesis of phosphorus-containing ligands
- Carbohydrate-base ligands
- Polyamide and protein based ligand design

Natural Product Synthesis
- Cyclization of equilibrating enamines
- Cyclization of 1,2,3,4-tetrahydroisoquinolines
- Cyclization of 4-hydroxyquinolines

Development of Novel New Initiations for Directed Carbon-Carbon Bond Activation
- Rhodium-Catalyzed (3+1+2) Cycloadditions of N-Aminomethylcyclopropanes (DOI: 10.1021/acs.lett.6b00365)
- Maleimide Diimide Ligands Display High Proton Transfer Activity in a Fluorescently Labeled Oligomer (DOI: 10.1002/jacs.201605714)
- Three-minute synthesis of sp3 nanocrystalline carbon dots as non-toxic fluorescent platforms for intracellular delivery (DOI: 10.1039/C6NR07336K)
- New Initiation Modes for Directed Carbon-carbon Bond Activation: Rhodium-Catalyzed (3+1+2) Cycloadditions of N-Aminomethylcyclopropanes (DOI: 10.1021/acs.lett.6b00365)

EPSRC Centre for Doctoral Training in Chemical Synthesis
- Synthetic analogues
- Heterocyclic chemistry
- Photochemistry
- Biocatalysis
- Flow chemistry
- C-H activation
- Catalysis
- Supramolecular chemistry for recognition and transport
- Hetereocyclic chemistry
- Glycolsilation methods
- Organo-boron and organo-sulfur chemistry
- Oligosaccharide chemistry
- Heteroatomic chemistry
- Transition Metal Catalysed Transformation

Cleaner Synthesis Transformation
- Synthesis of new heterocyclic chemistry
- Iron-based catalysis
- Gold catalysis
- Upgrading of alcohols for fuel

Development of Expedient New Synthetic Methodologies
- Glycosylation methods
- Organo-boron and organo-sulfur chemistry
- Oligosaccharide chemistry
- Heteroatomic chemistry

Natural Product Chemistry
- Compound extraction and characterisation
- Bioinspired synthetic pathways
- Total synthesis
- Isotopic labelling

EPSRC Centre for Doctoral Training in Chemical Synthesis
- Synthesis of new heterocyclic chemistry
- Iron-based catalysis
- Gold catalysis
- Upgrading of alcohols for fuel

Designers Ligands for Catalysis
- Synthesis of phosphorus-containing ligands
- Carbohydrate-base ligands
- Polyamide and protein based ligand design

Natural Product Synthesis
- Cyclization of equilibrating enamines
- Cyclization of 1,2,3,4-tetrahydroisoquinolines
- Cyclization of 4-hydroxyquinolines

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