

Institution: University of South Wales

Unit of Assessment: B10 Mathematical Sciences

**1. Unit context and structure, research and impact strategy****Unit context and structure**

The Unit of Assessment (UoA) comprises ten staff from the Mathematical Sciences Research Group (MSRG) (<https://maths.research.southwales.ac.uk/>), which sits within the University of South Wales (USW) Faculty of Computing, Engineering and Sciences (FCES). The MSRG is divided into three key themes of roughly equal size – (i) **Algebra and Combinatorics**, (ii) **Data Science and Industrial Mathematics**, and (iii) **Computational Modelling** – and the ten UoA researchers work within one or more of these themes. This structure, including the above sustainable and cohesive themes, naturally evolved from the one outlined in the REF 2014. This evolution was in response to a small number of staff changes and a strategic decision to develop our existing staff skills in Data Science. The MSRG also includes research students and a small number of other staff (2.8 FTE) who are not returned in this UoA submission – because they are not independent researchers, for example – but do contribute to the UoA's research culture.

**Research and Impact Strategy**

During the assessment period, the UoA had a Research Strategy and an Impact Strategy, which complemented and reinforced one another. The **Research Aims** of the UoA, as laid out in the REF 2014, were to:

- R1. Increase the number of active researchers.
- R2. Continue to expand the research culture, focussing on the three keys themes (listed above).
- R3. Improve research quality and income generation within the Mathematical Sciences Research Group, including through collaboration with industrial partners.

These **Research Aims** have been achieved, as evidenced below:

- R1. While 9.2 FTE researchers were returned in REF 2014, 10.3 FTE researchers have been active during most of the current REF period, including six early- to mid-career researchers. However, due to the departure of one staff member (Kent) in July 2020, only 9.3 FTE researchers are included in this submission.
- R2. The UoA's research culture has been enhanced during the current REF period. In 2014, mathematical research was divided between two separate research units. During the current assessment period, however, these were merged into the single MSRG described above and an overarching website developed (<https://maths.research.southwales.ac.uk/>). This amalgamation has facilitated the establishment of a regular, fortnightly seminar series at which invited external speakers share work that mirrors or relates to the UoA's key research themes (a list of past speakers is available on the MRSG's website). Another example of the expanded research culture was a London Mathematical Society (LMS) supported event in 2015 that introduced newly appointed staff to the UoA through talks given by the appointees and other invited researchers.
- R3. Research income has increased to approximately £4K per FTE per annum – more than doubling the equivalent figure from REF2014. This has come from a variety of funding sources, uniformly spread across the submission period and across the three research themes. Examples of funding diversification through new partnerships include projects with Cardiff and Vale University Health Board Mental Health team (funded via the Health Foundation), the NHS Wales Informatics Service, and Talent Intuition, a strategy consultancy firm.

### Contribution to research strategies

The UoA has helped to shape USW's overall Research Strategy, particularly the formation of the University's Accelerated Development Areas (ADAs) – see REF5a. The University's 'Sustainable Environment' ADA, for example, was established partly as a response to work by **Roach** and **Holborn**. Their work strengthened the UoA's existing industrial links through collaborations with Tata Steel. This involved a series of projects investigating efficiency in blast furnaces and predictive maintenance using data analytics techniques. These projects included several PhD studentships. **Roach** also worked during the current assessment period with industrial partners VDEh-Betriebsforschungsinstitut (BFI), Swerea MEFOS AB (MEFOS) and AMM Steel in collaboration with Faculty colleagues in Mechanical Engineering. Previous intra-Faculty collaboration between the UoA and Mechanical Engineering also led to the REF 2021 impact case study – 'Developing statistical tools for energy management services – RUMM Ltd' presented in REF 3. Furthermore, work by **Holborn** with NHS organisations (e.g. NHS Wales Informatics Services, Cwm Taff Morgannwg University Health Board and Aneurin Bevan University Health Board) and others (e.g. Central South Consortium Joint Education Service) helped inform the University's 'Health & Wellbeing' ADA. The UoA has also helped to develop University-wide procedures and opportunities for all of USW's research students feeding into the establishment of the University's Graduate School, which is led by **Roach**.

As well as contributing to the University's overall Research Strategy, the UoA is actively responding to it. For example, in early 2020, **Pachon** received FCES seed funding to work with Visa UK to develop improved data analytical techniques to detect cyber-crime. This work aligns with the University's 'Crime, Security & Justice' ADA.

The UoA's research is not confined to the University's ADAs, as evidenced by the unit's many collaborations with a variety of industrial partners. During the assessment period, for example, **Roach** and **Wyburn** continued collaborations with HPC Wales (a Welsh research facility, now Supercomputing Wales), OSTC Ltd (an investment company) and Fujitsu, to better predict financial market behaviours and improve the training of traders. In particular, collaborations with HPC Wales and Fujitsu built on partnerships established prior to the REF 2014. Indeed, the UoA was involved with the setting up and testing of HPC Wales (which formed a case study in the REF 2014 from this UoA). Further international collaborations between the UoA and numerous partners, including the Deutscher Wetterdienst (the German Meteorological Service) and NASA, developed and implemented accurate and efficient numerical schemes applied to solve equations related to weather and climate forecasting. More locally, **Wyburn** has engaged with social scientists through the Wales Institute of Social & Economic Research, Data & Methods to model the maintenance and spread of the Welsh language.

In addition to the Research Strategy detailed above, the UoA also had an Impact Strategy. Developed prior to the REF 2014, and implemented since, this Impact Strategy had the following **Impact Aims**:

- I1. Identify and respond to new opportunities, utilising agile working approaches.
- I2. Develop and expand existing successful research teams to widen impact.
- I3. Engage in collaborative projects, working especially with end-users.

This strategy has yielded considerable success. Examples of **Impact Aims** I1 and I3 being realised include the naturally collaborative nature of **Holborn's** work with NHS Wales Informatics Service and the UoA's REF 2021 impact case study – 'Enhancing computational models for weather and climate forecasting' – presented in REF3. To illustrate the success of **Impact Aim** I2, at the start of the current assessment period only **Roach** had a project with Tata Steel; this has now expanded through two further research studentships (supported via the European Social Fund) under the direction of **Holborn**.

## Unit-level environment template (REF5b)

The UoA's strategy over the next ten years is to merge the successful, but previously independent, Research and Impact Strategies detailed above so that future research is, where appropriate, conducted to generate the maximum impact. This revamped and naturally evolved UoA strategy has three objectives. These are consistent with the career stages and trajectories of current staff and the University's Research Strategy, as detailed in the institution-level statement (REF5a) and ['USW 2030 vision'](#):

- (A) Focus on staff development – especially early-career researchers – to support them to become internationally-recognised.
- (B) Align more closely the UoA's academic research with the goals and timescales of its industrial and Third Sector partners. This will deliver greater and more immediate impact and build more sustainable partnerships.
- (C) Engage in collaborative projects, working (where possible) alongside end-users, and making use (where appropriate) of University-wide expertise in the identified ADAs to deepen the knowledge base of the wider scientific communities.

These objectives will be achieved as follows:

- (A) All recent and newly-appointed academic staff are assigned by the Academic Subject Manager (**Perkins**) an experienced, research-active mentor from within the Mathematical Sciences Research Group (MSRG). This bolsters the strategy to integrate newly-appointed staff with established researchers and further enhance the research culture within the MSRG. The UoA also plans to increase the number of collaborations between active researchers within and outwith the MSRG through suitable projects (e.g. those requiring statistical input) and the continued joint supervision of research students. Staff will continue to be supported to join appropriate early career networks, such as Welsh Crucible (see Section 2 for further details).
- (B) Existing partnerships will be developed, and new ones sought by better understanding the needs of different industries and third parties. For example, the traditional academic-industrial partnership typically revolves around a three-year PhD project. Industrial partners, however, may need solutions over significantly shorter timescales, perhaps weeks or months. The UoA will use its expertise in mathematical and statistical modelling to address this by utilising more flexible approaches to staffing projects. An example of this approach is the aforementioned project between **Pachon** and Visa UK where **Pachon** will be embedded within the company to best apply her theoretical expertise in random graph theory to analyse the behaviour of financial networks with a view to identify the systemic risk associated with the structure of control chains in financial systems. Much of the UoA's recent growth in partnerships builds on the development of the taught programmes, particularly its Masters programmes in Data Science. Industrial partner involvement in student projects initiates knowledge transfer and an understanding of the businesses' needs. This frequently then leads to a succession of collaborations between the UoA and partners, while simultaneously ensuring a pipeline of research talent for these projects. The approach has led to a flexible mix of personnel involvement, from student internships to PhD studentships funded through Knowledge Economy Skills Scholarships ([KESS](#)), a major pan-Wales operation supported by the European Social Fund through the Welsh Government – for example, with Tata Steel.
- (C) The UoA will continue to establish joint projects with other research groups from the University and other Higher Education Institutions (HEIs). This builds on many existing and successful activities, such as the internationally-focussed Dynamical Core Modeling Intercomparison Project workshops (see REF3 Impact case study: "Enhancing computational models for weather and climate forecasting"), and more locally via the dedicated Mathematical Biology Day in 2019 which brought together members of the UoA and the University's Biological Sciences Group to showcase each other's skills. The

recently created Data Science and Artificial Intelligence pan-University Network is another example of this kind of collaboration. The recently formed, LMS funded South Wales Applied Mathematics for Biomedical Advances (SWAMBA) network also links mathematical biology researchers from across the region.

## 2. People

### Staffing strategy and staff development

The UoA has maintained the growth in active research staff numbers reported in the REF 2014. Recent appointees – including **Pachon, Brown, Gill, Holborn** and **Choudhury** – have strengthened the UoA's interest in applied mathematics, data science and mathematical biology, and extended its research base in pure mathematics, especially group theory and the probabilistic analysis of networks. High-calibre research students from the Mathematical Sciences Research Group (MSRG) have also been appointed to part-time lecturing positions in algebra, mathematical biology and data science. These strategic appointments have increased the number and proportion of research-active staff in the UoA who complement and expand on its established research themes. This builds on the staffing strategy outlined in the UoA's REF 2014 submission and aligns with the University's priority to support applied research. The UoA will continue with its policy of recruiting established or high-potential research-active staff who complement and strengthen existing research themes within the MSRG. This will ensure the continuity of its successful research agenda over the medium and long terms.

The USW Academic Workload Model makes a time allocation of 20% for staff with Significant Responsibility for Research (SRR), with professors allocated 30% from 2018-19. Within the context of USW as a post-92 institution, the team in MSRG have varying levels of teaching and other duties. The UoA leaders (**Boswell** and **Roach**) are allocated additional time within the Workload Model for research leadership. Research is a key element of USW's Development and Performance Review Scheme which includes a 12-month review in June-September and a mid-point review in January-February. In addition, the UoA leaders meet regularly with Unit members and offer individual mentoring as and where appropriate. Newly appointed researchers initially work alongside an experienced mentor and the Academic Subject Manager (**Perkins**) to better integrate into the MSRG. Staff career development is fully supported by the UoA and the University, as set out in the key principles of the Concordat and outlined in the institution-level statement (REF5a). Courses on funding and grant writing have been attended by over half of UoA members within the last three years, while impact training courses have been attended by around a third of UoA members within the last 12 months alone. Staff involved in research student supervision undergo continuous training on good practice via a combination of multi-day workshops and drop-in sessions. As well as the internal development courses detailed above, the University works closely with a network of other HEIs to provide researchers with access to further opportunities to develop their skills. The Effective Researcher, Welsh Crucible and Leadership In Action are examples of such collaborative provision utilised by researchers.

Within the MSRG, all research students are supervised by a team comprising a minimum of two staff members, who collectively have successfully overseen at least two completions. Approximately half of the UoA's ten current research students have supervisory teams that include recently appointed researchers, and it is anticipated that the majority of its early- to mid-career researchers will have supervised a successful PhD completion within the next five years. This builds the UoA's supervision capacity and demonstrates its commitment to the ongoing career development of its researchers.

Promotions to Professor and Associate Professor are made by the University's Higher Academic Awards Committee in response to research excellence and the University's strategic direction, which is driven by local and national initiatives. **Gill** was promoted to Associate Professor in 2019. Both **Gill** and **Roach** are members of USW's HR Excellence in Research committee; **Roach** and **Boswell** sit on the Faculty Research Committee, and **Brown** is a member of the



Faculty Research Degrees Committee. These appointments ensure that the UoA's researchers are represented across the University and shape its research agenda.

Early- to mid-career researchers across USW are encouraged to apply for membership of the pan-Wales Welsh Crucible program (<http://www.welshcrucible.org.uk/>), which is designed to develop future research leaders and encourage cross-disciplinary research. Kent (2015), **Brown** (2018) and **Holborn** (2020) were among the 30 successful candidates selected from across Wales. They attended numerous residential workshops where training was provided to help establish collaborations and grow the skills needed to forge international research profiles.

### Research Students

Ten research students, at various stages of their studies, are currently supervised by members of the UoA, and approximately 20 (including a small number based outside of the UoA) have been supervised by UoA members during the current assessment period. These students were recruited from both the UK and overseas. Funding for these students has been obtained from an extensive range of sources, including EPSRC Case awards, Knowledge Economy Skills Scholarships (KESS) (with funding from the European Social Fund and an industrial partner, such as NHS Wales and Tata Steel), and other industrial collaborations, such as with Fujitsu. All research students are provided with high-quality office space, comprising individual desks equipped with a computer running standard mathematical software (e.g. Matlab, SAS) and any project-specific specialist software (e.g. Comsol, Stella). Remote log-in facilities enable agile working approaches – an advantage during the current COVID-19 pandemic, for example. Students typically meet with their supervisory team on at least a weekly basis.

A number of forums enable the postgraduate research community to share its views, and there are student representatives on Faculty and University research committees. In the 2018 Postgraduate Research Experience Survey (PRES), 93% of the University's research students said their research skills had developed during their studies – 4% above the national average and a 3% improvement on the comparable 2013 statistic. Since 2011, the University's Postgraduate Research Centre has provided a multi-disciplinary learning space for University research students who use it for collaborative discussions across subject disciplines. The University-wide Graduate School was launched in 2018, administering the postgraduate journey from admission to award, supporting students and their supervisors, and providing pathways for growing experience in external engagement. Research student progress is formally monitored by the University's Research Degrees Committee / Graduate School board, chaired by **Roach**, which supports the research team, appoints examiners, and disseminates good practice in the delivery of research degrees to current and future supervisors. Within the MSRG, postgraduate research students have attended many of the research workshops provided to newly appointed staff, such as workshops on grant writing and developing successful Knowledge Transfer Partnerships (KTPs).

Students in the MSRG typically take on a low level of undergraduate teaching to develop further essential professional skills. They are also encouraged to attend and present at suitable conferences, such as annual Faculty and University research workshops, regional events (e.g. Wales Mathematics Colloquia), major national and international conferences aligned to the student's area of expertise (e.g. British Applied Mathematics Colloquia, British Combinatorial Conferences, SGAI International Conferences on Artificial Intelligence) and specialist postgraduate conferences (e.g. Postgraduate Combinatorial Conferences). Research students also attend internal and external training sessions relevant to their individual needs.

### Equality and diversity

The University and UoA are fully committed to supporting Equality and Diversity (E&D), as demonstrated by the implementation of the Athena SWAN charter and the in-house Women's Development Programme. More detail on the University's E&D policy is included in the institution-level statement (REF5a).

The University won the 2019 Guardian Advancing Equality award and was shortlisted for the 2019 Womenspire Diversity Employer of the Year award, with significant contributions from members of the UoA. The MSRG comprises 13 academic staff (12.1 FTE) of whom five are women. This is consistent with the sector average for mathematical sciences. Of the ten members of staff returned in the UoA's submission, four are women – a considerably more balanced ratio than the sector norm. This is also a significant increase compared with the REF 2014, when the UoA returned one woman staff member. Consistent with the sector average, approximately 15% of staff within the MSRG are BAME. Half of the staff in this category are included in the UoA's submission, while the other half are currently not classed as independent researchers for REF purposes as they are completing their PhDs (and are in receipt of equivalent workload allowances to do so).

The UoA is actively involved in promoting and ensuring equality across the University and the wider subject discipline. **Holborn** chaired and **Brown** was a member of the School of Computing & Mathematics Athena SWAN self-assessment team at USW. **Holborn** and **Brown** were members of USW's Women in Academia Network and are now part of the Wales Women in STEM Network; the former programme facilitates supportive relationships between women academics, and the latter, founded at USW, addresses barriers to women's progression in STEM. **Holborn** was a member of USW's gender equality sub-group, and in 2019 was an invited speaker at the annual ITWales International Women's Day Celebration.

The University and the UoA celebrate diversity. In 2020, the University was rated 24th in the Stonewall Top 100 Employer index (compiled from the Stonewall Workplace Equality Index), up from 43rd in 2019 and 104th in 2018. The UoA plays an active role in promoting diversity: **Gill** is a Fairplay30 (the University's E&D network) champion and **Brown** is currently a USW Trans Ally. In addition to the individual contributions of staff within the UoA, the MSRG hosts an annual seminar as part of the International Day for LGBT+ People in STEM – with recent talks from Princep (2018) and, in association with [Spectrum](#) and Fairplay30, Davies (2019).

### 3. Income, infrastructure and facilities

#### Income

During the assessment period, nearly £300,000 of funding has been secured, a significant increase on the previous REF period. This income has been generated from a wide variety of sources and across the three research themes within the Mathematical Sciences Research Group (MSRG). Just over half of this income has come from Research Councils while the remainder has been obtained from other sources, principally industrial partners and UK-based charities. The increase in total income aligns with the diversification of income sources, further enhancing the MSRG's research sustainability.

**Gill** has received two EPSRC grants, covering 2016-2018 and 2019-2021, and contributing to the development of the product decomposition conjecture and a complete proof of Cherlin's conjecture respectively. The London Mathematical Society (LMS) awarded funds to support the Wales Mathematics Colloquia, which was organised by group members; a conference celebrating new USW mathematics appointments (**Holborn**, & **Gill**); and for mentoring African Research Mathematicians (**Gill**). The LMS also awarded funds, along with the European Mathematics Society, for hosting a Kenyan PhD visitor (**Gill**). The Welsh Crucible awarded funds in kind for the training and research skills development of Kent. **Holborn** received KESS awards (see above) to support research students, has buyout funding from Smart Cymru and Smart Partnerships awards, and funding from local NHS Health Boards (see above). Contributions from a €1.4M grant from the European Commission Research Fund for Coal and Steel were used to buy out 12.5% of **Roach**'s time during 2015. To continue the upward income trajectory, members of the group are collaborating with a range of industrial and Third Sector partners – many of which are involved in our taught degree programmes (e.g. MSc in Data Science) – to expand these partnerships (into formal KTPs, for example).

**Infrastructure and facilities**

The MSRG is based in a single building on the University's largest campus, Treforest. All staff and research students have high-quality workspace with their own networked desktop PCs installed with standard and specialist mathematical and statistical software (e.g. Matlab, Maple, Comsol, SAS) where appropriate. They receive full professional IT support. All desktop computers are configured for remote access, ensuring that agile working approaches can be adopted by all staff. Various mobile devices and tablets are also provided to staff to further enable remote working. Physical copies of books and journals are held in the University's libraries while subscriptions to electronic research journals are available online. Consequently, members of the UoA – and its postgraduate research students – were well-placed to cope with the transition to home-based working during the COVID-19 pandemic. Research supervision and liaison with external partners continued during the lockdown restrictions with only minimal interruption.

Access to high-performance computing facilities were made available through HPC Wales, a £44 million pan-Wales project providing world-class supercomputing performance to researchers and businesses. It was established in 2010 in partnership with Glamorgan (which became part of USW in 2013), Aberystwyth, Bangor, Cardiff and Swansea Universities, the University of Wales, the Welsh Government and Fujitsu. UoA researchers have been involved with HPC Wales from the outset (this was an impact case study in the REF 2014) and have continued to use its facilities during the assessment period (e.g. **Roach & Wyburn**).

**4. Collaboration and contribution to the research base, economy and society**

USW is a member of the University Alliance, ensuring it is well-placed to make national and international contributions to society. The UoA also has close collaborative links with other HEIs across Wales – via the Wales Mathematics Colloquia, for example – while individual researchers utilise wider national and international networks related to their areas of expertise. The networks used by the UoA include the Wales Institute for Mathematical and Computational Sciences (WIMCS), which supported and promoted events, seminars, conferences and workshops that enabled researchers to create and maintain a thriving research culture, and the newly formed SWAMBA. The UoA's contributions to specific research areas are described below in line with the unit's three key research themes:

**Research theme: Computational Modelling**

Building on the REF 2014, the UoA has maintained a wide-ranging interest in applied and computational mathematics with research in fluids (**Trevelyan**), mathematical biology (**Boswell, Brown, Trevelyan, Choudhury**), the industrial applications of mathematics (**Boswell, Roach**), and the applications of system dynamics (**Roach, Wyburn, Boswell**).

Research in fluids has focussed on both analytical results and the construction of numerical routines. **Trevelyan** has focused primarily on reactions in immiscible systems of the form  $nA+mB \rightarrow C$ , where  $n$  and  $m$  are integers, and has obtained small- and large-time asymptotic solutions in collaboration with Professor Anne De Wit (University Libre de Brussels, Belgium) and co-workers. A key achievement has been the complete classification of the 62 types of density profiles that occur in buoyancy-driven instabilities around miscible  $A+B \rightarrow C$  reaction fronts. This work has been significantly expanded through investigations of more physically realistic geometries with Dr Alan Walker (University of the West of Scotland).

In mathematical biology, the focus has been on mycological applications and infectious disease modelling. **Boswell, Trevelyan & Choudhury** have published several papers on fungal interactions. In particular, the rates of displacement between two rival fungi have been quantified as a function of resource, and the first mathematical model of iron uptake by fungi has been formulated and algebraic solutions obtained. **Boswell** is continuing with his expertise in mycology through planned collaboration with mycologist Dr Kathryn Morris and physicist Dr Jonathan Morris (Xavier University, USA) on the redistribution of allelochemicals in mycorrhizae. **Brown**, with collaborators including Dr Melody Walker and Dr Lauren Childs (Virginia Tech,

USA), Dr Julie Blackwood (Williams College, USA), Dr John Drake, Dr Heather Barton, Dr David Stallknecht, Dr Pejman Rohani and Dr Justin Brown (University of Georgia, USA), has developed new insights into Allee effects in mosquitoes with implications for disease control, and modelled disease dynamics in avian influenza viruses.

Research in industrial mathematics has been continued by **Roach** and **Boswell**. Through collaboration with Dr A Walker, the first mathematical model detailing the structure of smectic-A liquid crystals in non-uniform domains has been derived and solved numerically and has so far resulted in one PhD completion and one publication. Work on the effectiveness of fractal structures for theoretical piezo-electric transducer designs (also with Walker) has also yielded a PhD completion and several publications. **Roach** has continued activities described in the REF 2014, namely efficiency and design of blast furnaces through industry-funded collaborative projects via the EC Research Fund for Coal and Steel with mechanical engineers (Dr CK Tan, USW and Dr Yukun Hu, UCL) and VDEh-Betriebsforschungsinstitut (BFI), Swerea MEFOS AB, AMM Steel and TATA Steel UK.

**Boswell** has performed new work in system dynamics (with Dr John Hayward; retired USW), constructing new techniques to quantify feedback loops. Ongoing work with **Roach** is further expanding the loop quantification method. In a series of papers, this novel approach applies the method to concepts of mechanics adding rigour to the analysis of system dynamics models to broader ordinary differential equation models. **Wyburn**'s research has also utilised a system dynamics methodology but focused on social issues. Two publications relate to bilingual population models and assess strategies for expanding bilingualism, building on work returned in the REF 2014. An additional publication, with co-authors including **Roach**, has used system dynamics methods to investigate changes in party political activism.

#### **Research theme: Data Science and Industrial Mathematics**

Much of the work in data science, particularly by **Holborn**, has been in collaboration with industrial partners, generating a significant number of research studentships. Additionally, **Pachon** who joined the group in 2018, has broadened this work by developing theoretical techniques that utilise a graph theoretical approach.

**Holborn** has used her expertise in applied statistics and operational research to investigate a myriad of problems. One publication with Dr Rhyd Lewis (University of Cardiff) focused on developing and implementing an algorithm for a packing problem. A number of other publications, with practitioners from the Aneurin Bevan University Health Board, focused on caseload management and improvements in mental health care through the construction of scoring-based systems. **Holborn** is currently supervising five research students on joint projects with NHS Wales Informatics Service and Tata Steel UK.

**Pachon** has continued to investigate random graphs and scenery reconstruction. This has resulted in six publications during the assessment period with collaborators including Dr Elena Agliara (Sapienza Università di Roma, Italy), Prof Mihyun Kang (Graz University of Technology, Austria), Prof Heinrich Matzinger (Georgia Institute of Technology, USA), Prof Federico Polito and Prof Laura Sacerdote (University of Torino, Italy), Prof Serguei Popov (University of Campinas, Brazil) and Dr Pablo Rodrigues (Universidade Federal de Pernambuco, Brazil). New results have been obtained on phase transitions and connectivity in random graphs, establishing connections between the Barabási-Albert, the Simon and the Yule models.

Existing collaborations will continue with Cardiff & Vale University Health Board, and new projects on assessing mental health patient pathways are underway (**Holborn & Roach**). **Pachon** has recently started working alongside Visa UK to develop and implement models of risk within financial sectors. The MSRSG will also look to capitalize on the newly formed (December 2020) Wales Institute of Digital Information, which will use methods of Data Science to advance research in health and care, and is a joint initiative between USW, the University of Wales Trinity Saint David and the NHS Wales Informatics Service.



**Research theme: Algebra and Combinatorics**

Building on the REF 2014, research in combinatorics, coding theory and its applications has continued with **Gill**, **Perkins** and **Roach**. Research in group theory has been significantly strengthened – for example, through the formation of reading groups of active researchers, research students and undergraduate students, which resulted in a publication on Cherlin's conjecture.

**Gill's** work on group theory has resulted in 16 publications through collaborations with national and international co-authors, including Prof Harald Helfgott (University of Gottingen, Germany), Dr John Britnell and Prof Martin Liebeck (Imperial College London), Prof Pablo Spiga and Dr Francesca Dalla Volta (University of Milano-Bicocca, Italy), Dr Jeremias Ramirez (Universidad de Costa Rica), Dr Neil Gillespie (University of Bristol), Dr Jason Semararo (University of Leicester), Mr Sam Hughes (University of Southampton), Prof Laszlo Pyber and Dr Endre Szabo (Rényi Institute, Hungary) and Dr Kimeu Arphaxad Ngwava (Moi University, Kenya). Funding for this work was obtained through various sources, including EPSRC and LMS. **Gill** is currently supervising several research students, including two at USW, one through the Open University and two overseas students in Kenya as part of the LMS's Mentoring African Mathematicians programme (one more has just completed). **Gill's** main interest is proving Cherlin's conjecture for binary primitive permutation groups. When work started in this area, the conjecture was open for almost simple groups. But due to the work of **Gill** and his collaborators, this is now proved for groups with alternating socle, sporadic socle, and socle a group of Lie type of rank 1. This has resulted in three papers. The remaining case, for finite almost simple groups of Lie type of rank at least 2, is the subject of **Gill's** recent EPSRC grant and will result in a final monograph (with Liebeck and Spiga) that will complete the proof. **Perkins** has continued to research the application of coding theory to DNA storage, which has resulted in the publication of two papers with Prof Derek Smith (Professor Emeritus, USW). In addition to this work, **Perkins** has published papers (with **Roach**) on combinatorics and popular mathematical puzzles, an area of work that has resulted in two PhD studentships. Current research is continuing into mathematical puzzles focusing on special forms of magic squares.

**Exemplars on leadership and involvement in the academic community:**

Conference / workshop organisation: **Boswell:** Scientific Committee Member, British Applied Mathematics Colloquium (BMAC) & minisymposia organiser (2014). **Gill:** Organiser, Wales Mathematics Colloquium (WMC) (2018). **Holborn:** UK OR Society Annual Conference (2018). **Brown:** Organiser of SWAMBA meeting (2020).

Advisory board membership: **Holborn, Roach:** NHS Wales Modelling Collaborative Health Foundation Programme Board (2019-present).

Leadership roles in industry, commerce, Research Councils, learned societies: **Boswell:** Research Committee Member, Wales Institute of Mathematics and Computational Sciences (2011-2015). **Gill:** European Maths Society Committee for Developing Countries. **Holborn:** General Council of the UK OR Society (2016-2019), Treasurer of South Wales Operational Research Discussion Society (2018-present), UK OR Events Committee (2016-2019).

Conference program chairs: **Boswell:** BAMC (2014), WMC (2018). **Gill:** WMC (2018, 2019). **Trevelyan:** WMC (2018).

Invited keynote lectures, lecture series and seminars: **Gill:** two-week course on Galois Theory at Tribhuvan University, Nepal as part of a seven-year 'Nepal Algebra Project' through funding by the LMS (2017); one-week course on 'Growth in Groups' at the University of Costa Rica (2017); one-week course on 'Crecimiento en Estructuras Algebraicas' as part of the 4th summer school of mathematics at the University of Leon, Nicaragua (2017); Banff International Research Station, Canada (2015 & 2019); seminars at University of Western Australia (2017), University of Southampton (2016 & 2019), Université catholique de Louvain, Belgium (2017), Swansea University (2017), University of Lincoln (2018), University of London (2019), University of

**Unit-level environment template (REF5b)**

Cambridge (2015), University of Bristol (2015 & 2018, as part of London Maths Society Triangle), University of Costa Rica (2014). **Pachon**: seminars at National University Columbia (2017), Tomsk State University, Russia (2014), Saarland University, Germany (2014), Technical University of München, Germany (2014); workshops at TU Berlin, Germany (2017), Utrecht University, Netherlands (2017), Radboud University, Netherlands (2015). **Brown**: Cardiff University (2018). **Holborn**: Cardiff University (2019).

Conference presentations: **Trevelyan**: BAMC (2014), WMC (2014). **Choudhury**: BAMC (2016). **Wyburn**: Wales Institute of Social and Economic Research, Data & Methods (2015). **Boswell**: BAMC (2014), WMC (2018). **Holborn**: SAS Global Forum, USA (2017), UK OR Society Annual Conference (2018), Data Confex – AI & Big Data (2019). **Pachon**: International Symposium of Statistics, Columbia (2016). **Gill**: International Conference on Algebraic Combinatorics and Group Actions (2016), Open University Winter Combinatorics Meeting (2016), WMC (2016 & 2017), Dame Kathleen Ollerenshaw Combinatorics Day in Manchester (2017).

Journal Editorships: **Holborn**: Journal of Child Health Care (Associate Editor, Statistics 2017-2018). **Boswell**: Network Biology (2009-present).

Grant and journal reviews: **Boswell**: UKRI Future Research Leaders, Journal of Theoretical Biology, Fungal Ecology, Journal of Sports Science, Journal of the Royal Society Interface, Journal of Physics A; Mathematical and Theoretical. **Wyburn**: Journal of Mathematical Sociology. **Gill**: American Journal of Mathematics, Journal of Group Theory, Journal of the London Mathematical Society, Bulletin of the London Mathematical Society, Archiv der Mathematik, Journal of Algebra, Mathematische Annalen as well as the EPSRC. **Trevelyan**: Fluids, Physical Review Fluids. **Holborn**: Journal of the Operational Research Society, Health Systems. **Roach**: Journal of the Operational Research Society, Computers and Operations Research, Journal of Cultural Economics. **Pachon**: Random Structures and Algorithms, Discrete Mathematics, Revista Colombiana de Estadística. **Wyburn**: Journal of the Operational Research Society, European Journal of Operational Research, Journal of Mathematical Sociology. **Brown**: Bulletin of Mathematical Biology.