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### **Academic Career**

- 2016- Royal Society Research Professor
- 2014- Sir Samuel Hall Chair of Chemistry, School of Chemistry, University of Manchester, UK.
- 2012-2013 Professor of Organic Chemistry, School of Chemistry, University of Manchester, UK.
- 2001-2012 Forbes Chair of Organic Chemistry, School of Chemistry, University of Edinburgh, UK
- 1998-2001 Chair of Synthetic Chemistry, Department of Chemistry, University of Warwick, UK
- 1989-1998 Lectureship and, from Jan 1996, Readership in Organic Chemistry in the Department of Chemistry, University of Manchester Institute of Science and Technology, Manchester, UK
- 1987-1989 Postdoctoral Fellow at the National Research Council of Canada, Biological Sciences Division, Ottawa, Canada. Supervisor: D R Bundle (now Lemieux Professor of Carbohydrate Chemistry at the University of Alberta, Canada)
- 1984-1987 PhD, University of Sheffield, UK. Supervisor: Sir J F Stoddart FRS (now Board of Trustees Professor of Chemistry, Northwestern University, USA)
- 1981-1984 BSc Special Honours in Chemistry, University of Sheffield, UK

#### **Awards & Prizes**

- 1998-2003 EPSRC Advanced Research Fellowship
- 2003 Royal Society of Chemistry Award for Supramolecular Chemistry
- 2004 Royal Society of Chemistry Award for Interdisciplinary Research
- 2005 Institute of Chemistry of Ireland Award for Chemistry
- 2005 Swiss Chemical Society Troisième Conferencier in Chemistry
- 2005-10 EPSRC Senior Research Fellowship
- 2005-10 Royal Society-Wolfson Research Merit Award
- 2005 Elected Fellow of the Royal Society of Edinburgh, Scotland's National Academy of Science & Letters
- 2005 Royal Society of Chemistry Award for Nanotechnology
- 2007 International Izatt-Christensen Award for Macrocyclic Chemistry
- 2007 Royal Society of Chemistry-Real Sociedad Española de Química (RSC-RSEQ) Prize for Chemistry
- 2007 HRH Prince Philip Chancellor's Award for Research
- 2007 Feynman Prize for Nanotechnology
- 2007 EU Descartes Prize for Research
- 2008 ERC Advanced Grant (inaugural call)
- 2009 Royal Society of Chemistry Merck Award for Organic Chemistry
- 2009 Elected Fellow of the Royal Society (London)
- 2010 Royal Society of Chemistry Tilden Prize
- 2013 Royal Society Bakerian Prize Lecture & Medal
- 2013 ERC Advanced Grant
- 2014 Royal Society of Chemistry Pedler Award
- 2015 Elected to the Academia Europaea, the European Academy of Science, Humanities & Letters
- 2016-26 Royal Society Research Professor

H-index: 69 (GooSch, 15 Dec 2016); Citations: 17,553 (GooSch, 15 Dec 2016).

Our research group's interests are broadly based on new approaches to functional molecule synthesis and the influence of non-covalent interactions on structure and function from biology to materials science. Over the past few years we have developed this chemistry to produce some of the first examples—all be they primitive by biological standards—of synthetic molecular level machines and motors [For examples see: *Nature* **406**, 608 (2000); *Science* **291**, 2124 (2001); *Nature* **424**, 174 (2003); *Science* **299**, 531 (2003); *Science* **306**, 1532 (2004); *Nature Mater* **4**, 704 (2005); *Nature* **445**, 523 (2007); *Nature* **458**, 314 (2009); *Nature Chem* **2**, 96 (2010); *Science* **328**, 1255 (2010); *Science* **339**, 189 (2013); *Nature Chem* **8**, 138 (2016); *Science* **352**, 1555 (2016); *Nature* **534**, 235 (2016)]. These molecules respond to light, chemical and electrical stimuli, inducing motion of interlocked components held together by hydrogen bonding. A noteworthy example is the first synthetic hydrogen bonded molecular rotor (*Nature* 2003; 'highlighted' in *Science* **301**, 438 (2003) and selected as one of the '*Chemical Highlights of* 2003' by the ACS). A significant advance on this system, a reversible synthetic rotary molecular motor, was reported a year later (*Science* 2004). The first example of using artificial molecular machines to do work in the macroscopic world (transporting a liquid droplet across a surface and up a gradient on a monolayer of synthetic molecular machines) was another significant breakthrough (*Nature Mater*. 2005) as was the non-adiabatic experimental realisation of James Clerk

Maxwell's 140 year old 'Demon' thought experiment as a fundamentally new motor-mechanism for synthetic nanomachines (*Nature* 2007; selected as one of the '*Chemical Highlights of* 2007' by the RSC). We reported the first hybrid organic-inorganic rotaxanes and molecular shuttles [*Nature* 2009; highlighted in *Angew Chem Int Ed* **48**, 6948 (2009)] and introduced the first artificial molecules that can 'walk' along molecular tracks, reminiscent of the dynamics and function of biological motor proteins such as kinesin (*Nature Chem.* 2010; selected as one of the '*Chemical Highlights of* 2010' by the RSC). In 2012 our group reported the one-pot self-assembly of a 160-atom loop pentafoil knot, the most complex non-DNA molecular knot prepared to date (*Nature Chem.* 2012; selected as one of the '*Chemical Highlights of* 2011' by the RSC). In 2013 we described a small-molecule machine capable of detaching and assembling a series of amino acid building blocks from a track into a peptide of specific sequence, a very primitive version of the task performed by the ribosome (*Science* 2013; featured in '*Breakthroughs of the* Year 2016; featured in '*Chemical Highlights of* 2016' by the RSC), a synthetic nanomotor that works through the same type of mechanism as motor proteins.

# Ten most significant publications (reverse chronological order)

1. "An autonomous chemically fuelled small-molecule motor" M R Wilson, J Solá, A Carlone, S M Goldup, N Lebrasseur and D A Leigh, Nature, **534**, 235-240 (2016).

Selected as one of the 'Chemical Highlights of 2016' by the RSC.

For highlights of this paper see: '*No turning back for motorized molecules*' (N&Vs), J Clayden, *Nature*, **534**, 187-188 (2016); '*Artificial molecular motors: Running on information*' (N&Vs), R D Astumian, *Nature Nanotech*, **11**, 582-583 (2016); '*Autonomous chemically fueled molecular motor revs up*' (news-of-the-week), *Chem & Eng News*, **94**(24), 4; '*Molecular motors start chemically-fuelled journey*' *Chem World*, 9 June 2016; etc.

2. "Allosteric initiation and regulation of catalysis with a molecular knot" V Marcos, A J Stephens, J Jaramillo-Garcia, A L Nussbaumer, S L Woltering, A Valero, J-F Lemonnier, I J Vitorica-Yrezabal, D A Leigh, *Science*, **352**, 1555-1559 (2016).

For highlights of this paper see: '*Molecular knot ties up anions to catalyse reactions*' Chem & Eng News, **94**(26), 8 (2016); '*Molecular knot inducing allosteric control of catalysis*' T M Swager, C-C A Voll, Synfacts, **12**, 911 (2016); etc.

3. "Sequence-Specific Peptide Synthesis by an Artificial Small-Molecule Machine" B Lewandowski, G De Bo, J W Ward, M Papmeyer, S Kuschel, M J Aldegunde, P M E Gramlich, D Heckmann, S M Goldup, D M D'Souza, A E Fernandes and D A Leigh, *Science*, **339**, 189-193 (2013). Cited 271 times as of 14.11.16 (*GooSch*).

Selected as one of the 'Breakthroughs of the Year 2013' in Science 342, 1441 (2013) and 'Top Chemistry Moments of 2013', C&EN, 10 Jan 2014.

For highlights of this paper see: 'Interlocked molecules: A molecular production line' (N&Vs) P R McGonigal, J F Stoddart, Nature Chem, **5**, 260-262 (2013); 'A supramolecular peptide synthesizer' J Bertran-Vicente, C P R Hackenberger, Angew Chem Int Ed, **52**, 6140-6142 (2013); 'Molecular robot mimics life's protein-builder' Nature, **493**, 274 (2013); 'Robot ribosome (News-of-the-Week)' Chem & Eng News, **91**(2), 5 (2013); etc.

4. "A Synthetic Molecular Pentafoil Knot" J-F Ayme, J E Beves, D A Leigh, R T McBurney, K Rissanen and D Schultz, Nature Chem 4, 15-20 (2012). Cited 174 times as of 14.11.16 (GooSch).

Selected as one of the 'Chemical Highlights of 2011' by the RSC.

For highlights of this paper see: 'One-pot pentaknot' (N&V's) M J Hardie, Nature Chem 4, 7-8 (2012); 'Molecule tied in pentafoil knot' Chem & Eng News 89(45), 25 (2011). 'Image of the Year 2011' Diamond Light Source.

5. "*Hybrid Organic-Inorganic Rotaxanes and Molecular Shuttles*" C-F Lee, D A Leigh, R G Pritchard, D Schultz, S J Teat, G A Timco and R E P Winpenny, *Nature* **458**, 314-318 (2009). Cited 186 times as of 14.11.16 (*GooSch*).

For highlights of this paper see 'The marriage of inorganic and organic building blocks for the assembly of rotaxanes', E K Brechin and L Cronin, Angew Chem Int Ed 48, 6948-6949 (2009); 'Rotaxanes go hybrid' Chem & Eng News, 87(12), 11 (2009).

6. "A Molecular Information Ratchet" V Serreli, C-F Lee, E R Kay and D A Leigh, Nature 445, 523-527 (2007). Cited 371 times as of 14.11.16 (GooSch).

Selected as one of the 'Chemical Highlights of 2007' by the RSC.

For highlights of this article see: 'Knowledge is power' (N&V) A P Davis, Nature Nanotech, 2, 135-136 (2007); 'Scientists build nanomachine envisaged 150 years ago' Scientific American, 31 Jan 2007; 'Tiny engine boosts nanotech hopes' BBC news, 1 Feb 2007; '1867 nanomachine now reality' CNN, 2 Feb 2007; 'Scientists build nanomachine envisaged 150 years ago' Washington Post, 31 Jan 2007; 'Reviving a 19th century nanomachine' The Australian, 1 Feb 2007; etc.

7. "*Macroscopic Transport by Synthetic Molecular Machines*" J Berná, D A Leigh, M Lubomska, S M Mendoza, E M Pérez, P Rudolf, G Teobaldi and F Zerbetto, *Nature Mater* **4**, 704-710 (2005). Cited 448 times as of 14.11.16 (*GooSch*).

For highlights of this article see: '*Drop by drop*' *Nature*, **437**, 4-5 (2005); '*Drop in attendance at motor show*' (N&V's), D Fitzmaurice *Nature Mater*, **4**, 657 (2005) etc. Editors' choice '*Top ten most influential* Nature Materials papers of 2005-2006'.

8. "A Reversible Synthetic Rotary Molecular Motor" J V Hernández, E R Kay and D A Leigh, Science **306**, 1532-1537 (2004). Cited 376 times as of 14.11.16 (GooSch).

9. "Unidirectional Rotation in a Mechanically Interlocked Molecular Rotor" D A Leigh, J K Y Wong, F Dehez and F Zerbetto, Nature **424**, 174-179 (2003). Cited 666 times as of 14.11.16 (*GooSch*).

Selected as one of the 'Chemical Highlights of 2003' by the ACS.

For highlights of this article see: '*Chemistry in motion – unidirectional rotating molecular motors*' C. P. Mandl and B. König, *Angew Chem Int Ed*, **35**, 1622-1624 (2004); '*Chemical Highlights of 2003*' *Chem & Eng News*, **81**(51), 39-50 (2003); '*Chemical turnstiles*' *Science*, **301**, 438-439 (2003); *etc.* 

10. "*Photoinduction of Fast, Reversible Translational Motion in a Hydrogen-Bonded Molecular Shuttle*" A M Brouwer, C Frochot, F G Gatti, D A Leigh, L Mottier, F Paolucci, S Roffia and G W H Wurpel, *Science* **291**, 2124-2128 (2001). Cited 583 times as of 14.11.16 (*GooSch*).

For a highlight of this article see: 'A Light-Driven Linear Motor at the Molecular Level' (N&V), J-P Sauvage, Science, **291**, 2105-2106 (2001).

# **Publications Impact**

Of the 190 papers produced by our group since 2000, more than 50% were published in *Nature* and *Science* (11), PNAS and Nature Chem/Mater/Nanotech (14) and Angew Chem and JACS (81). More than one-in-six (46 primary research papers) of our 251 publications have been cited more than 100 times each; two particularly highly-cited papers more than 500 times each. Over the last five years well over half of our publications have been highlighted in the scientific press or wider media. No fewer than eighteen of our papers have been the subject of independent published perspectives ('News & Views' articles) by other leading scientists, including: 'No turning back for motorized molecules' (N&Vs), J Clayden, Nature, 534, 187-188 (2016) • 'Artificial molecular motors: Running on information' (N&Vs), R D Astumian, Nature Nanotech, 11, 582-583 (2016) • 'A chiral catalyst with a ring to it' (N&Vs) S M Goldup, Nature Chem, 8, 404-406 (2016) • 'Molecules bearing robotic arms' (N&Vs), I Aprahamian, Nature Chem, 8, 97-99 (2016) • 'Molecular topology: Star-crossed self-assembly (N&Vs)' G H Clever, Nature Chem, 6, 950–952 (2014) • 'Interlocked molecules: A molecular production line' (N&V) P R McGonigal, J F Stoddart, Nature Chem, 5, 260-262 (2013) • 'Switchable catalysis' U Lüning, Angew Chem Int Ed, 51, 8163-8165 (2012) • 'One-pot pentaknot' (N&V) M J Hardie, Nature Chem, 4, 7-8 (2012) • 'Combining coordination chemistry and catalysis to tie a knot by an active-metal template strategy' (N&V) C Romuald and F Coutrot, Angew Chem Int Ed, 51, 2544-2545 (2012) • 'Attractive arrays' (N&V) A J Wilson, Nature Chem, 3, 193-194 (2011) • 'Synthetic molecular bipeds' (N&V) E M Pérez, Angew Chem Int Ed, 50, 3359-3361 (2011) •

Lectures and Presentations >300 Plenary/invited lectures at national/international conferences and university colloquia since 2005 including: • ETH 150th Anniversary Celebration Symposium, Zurich, 18 March 2005 • Institute of Chemistry of Ireland Award for Chemistry 2005 Lecture Tour, Ireland, May 2005 • Nobel Symposium on Controlled Nanoscale Motion in Artificial and Biological Systems, Gothenburg, Sweden, 13-17 June 2005 • 40 Year Celebration of Supramolecular Chemistry Meeting, Strasbourg, France, 27-30 July 2005 • BA Festival of Science, Dublin, 3-10 Sept 2005 • CUSO Conferencier 3eme cycle Lecture Tour, Switzerland, 23-29 Oct 2005 • 1st European Chemical Congress, Budapest, 27-31 Aug 2006 • British Association for the Advancement of Science Festival of Science, Norwich, 2-10 Sept 2006 • Alchemist Lecture, University of Glasgow, 25 Jan 2007 • RSC Annual Teachers Conference, Aston, 9-10 Feb 2007 • The Daniell Lecture, UCL, 17 Oct 2007 • 2007 Solvay Conference on Chemistry, Brussels, 28 Nov-1 Dec 2007 • RSC SW Schools Lectures, Exeter & Devon, 4-6 Feb 2008 • NEPA Lecture, Durham, 26 Feb 2008 • The Musher Lecture, Jerusalem, Israel, 30 Apr 2008 • YoungChem2008, Cracow, Poland, 15-19 Oct 2008 • E Gordon Young Memorial Lectureship, Montreal and Sherbrooke, Canada, 3-8 October, 2009 • 2009 Novartis Lecture, ETH, Zurich, Nov 16 2009 • Francqui Chair Lectures, Louvain-la-Neuve, Belgium, 15-18 March & 26-30 April 2010 • Edinburgh International Science Festival, Edinburgh, 3-17 April 2010 • 14<sup>th</sup> National Scottish Meeting for Teachers of Chemistry, St Andrews, 28 May 2010 • 2010 ICIQ Summer School, Tarragona, Spain, 19-23 July 2010 • Alex Hopkins Lecture (Cambridge Science Festival), Cambridge, 25 Mar 2011 • 15th H. Dudley Wright Colloquia, Geneva, Switzerland, 12-16 Nov 2012 • Sir Robert Robinson Distinguished Lectureship, Liverpool, 27 Nov 2012 • 1st EPS Christmas Lecture, Heriot-Watt, Edinburgh, 10 Dec 2012 • Bakerian Lecture, Royal Society, London, 11 Mar 2013 • 19th Robert W. Taft Memorial Lecture, UC-Irvine, USA, 9 Oct 2013 • Sir Gareth Roberts Memorial Lecture, Durham, 7 May 2014 • Institute of Creativity Distinguished Visitor Lectures, Hong Kong, 13-17 Nov, 2014 • TGH Jones Memorial Lecture, University of Queensland, Australia, 18 Dec 2014 • The Dewar Lecture, OMUL, London, 4 March 2015 • The Haworth Lecture, University of Birmingham, 25 Feb 2016 • The Robert Robinson Lectures, University of Oxford, 7-8 March 2016 • Hugh and Ethel Kelly Lecture, Virginia Tech, USA, 30 Sept 2016 • Anslyn-Iverson-Sessler Lecture, University of Texas at Austin, USA, 21 Oct 2016 • Dean's Podium

# Lecture, Ben Gurion University, Israel, 21 Nov 2016 • GDCh (German Chemical Society) 150<sup>th</sup> Anniversary Lecture, Berlin, 11 Sept 2017 • Tarrant Distinguished Professorship Lectures, University of Florida, USA, 15-29 Oct 2017 •

Research Support >£18M 1990-to date (research councils, EU, charities and industry) including:

July 2002 EU Future and Emerging Technologies IST 'Mechanised Molecules (MechMol)' (Coordinator D A Leigh) € 2.3M • Aug 2002 EU Research Training Network "Exploiting Mechanical Movement in Molecular Architectures (EMMMA)" (Coordinator D A Leigh) € 1.6M • Sep 2004 EU Future and Emerging Technologies STREP 'Hydrogen Bonded Molecular Motors and Machines' (Hy3M) € 2.5M • Oct 2004 EPSRC 'Approaches to Novel Synthetic Molecular Rotational Motors' £446K • Jan 2005 BBSRC 'Methodology for the Assembly of Interlocked Peptide & Protein Secondary Structures' £291K • Feb 2005 MoD/EPSRC Joint Research Grant 'Novel Synthetic Molecular Translational Motors and Machines' £519K • Jun 2005 EPSRC Senior Research Fellowship 'Synthetic Molecular Motors & Machines' £817K • Aug 2006 EU STREP "Smart Tag's" (STAG) € 2.5M • Sep 2007 EPSRC 'Mechanically Processive Motion in Synthetic Molecular-level Structures: Transition Metal Complexes that can Walk' £354K • Oct 2008 ERC Advanced Grant (inaugural call) 'Synthetic molecules that walk down tracks' € 2.25M • Jun 2009 EPSRC 'Quantitative analysis of extremely strong contiguous hydrogen bond arrays' £370K • Jan 2010 EPSRC 'Organic Supramolecular Chemistry: A Research Programme on Synthetic Molecular Motors and Machines' £3.09M • Jan 2012 EPSRC 'Hybrid rotaxanes as scaleable two qubit-gates for quantum information processing' £420K • Jan 2013 TSB/EPSRC 'Sustainable manufacturing of waterborne polymers for high performance decorative paints' £220K • Sep 2013 EU Marie Curie ITN 'SASSYPOL-Hierarchical self-assembly of polymeric soft systems' € 288K • Jan 2014 ERC Advanced Grant 'Machinery for molecular factories' € 2.15M • Jan 2015 EU Marie Curie ITN 'Eurosequences – sequence controlled polymers' € 546K • Oct 2016 Royal Society Research Professorship £1.8M •

# **Company Collaborations (1990-)**

Exxon Chemicals • GEC Marconi • Glaxo Group Research • British Gas • 3M's Minnesota • ICI • Scott Bader & Co • Nestlé (Switzerland) • Nippon Paint Co (Japan) • MoD/DRA • Zeneca Pharmaceuticals • Akzo Nobel (Netherlands) • DSM (Netherlands) • Philips (Netherlands) • Ciba Specialties (Switzerland) • Pfizer • Citala (Israel) • Syngenta •

### **Editorial boards**

2010- Associate Editor Chemical Science

2014- International editorial advisory board *Angewandte Chemie* 

2015- Editorial advisory board ACS Central Science

### Public research dissemination

The concept of 'molecular machines' is familiar to the general public because of the 'grey goo' fears of various high profile figures. Our work gives us a great opportunity to present the science facts rather than the science fiction in this field and promote the excitement of creative chemistry and the general benefits of science to society. Our work has featured in more than 1200 media articles in >80 countries in the last 5 years alone (32 different papers highlighted), and has featured on CNN, NBC, the BBC and in two TV documentaries. In addition to the >250 plenary/invited lectures I have given at national/international conferences and universities over the past 8 years, I typically give ~4-6 general public lectures on our work per year, including several for high school students, School Teacher conferences, Student Chemical Societies and general public lectures in both the UK and Europe. Specifically geared to young researchers, I gave the GDCh Christmas lectures in Düsseldorf in 2003, two public lectures at the ETH 150<sup>th</sup> anniversary in 2005, lectures to the Young Danish Chemistry Society (TOKS IX, 2007), the Young Dutch Organic Chemists Meeting in 2002, YoungChem2008 (Poland) and at Spanish, French, US, Danish and Dutch PhD Student Conferences and Summer Schools in Tarragona (2009), Urbana-Champaign (2010), Bordeaux (2011), Odense (2011) and Eindhoven (2011). I was a Swiss Science Foundation Conferencier 3eme Cycle in 2005, undertook a lecture tour as part of the Institute of Chemistry of Ireland Prize for Chemistry in 2005 and gave keynote public lectures at the British Association Festival of Science in both 2005 and 2006 and the Edinburgh International Science Festival in 2010 and Cambridge Science Festival in 2011. I took part in the celebrated public lectures of the 15th H. Dudley Wright Colloquia in Geneva, Switzerland, in Nov 2012, gave the Bakerian Prize Lecture at the Royal Society, London, in March 2013, and public lectures at the Institute of Creativity in Hong Kong (Nov 2013), Blacksburg, Virginia, USA (Sept 2016), Jerusalem (Nov 2016) and Christchurch, New Zealand (Feb 2017).