**Institution: University of Aberdeen**

**Unit of Assessment: 8 (Chemistry)**

## a. Overview

Research in Chemistry at the University of Aberdeen focuses on three main areas; *Energy and Environment, Biomolecular Chemistry* and *Materials Chemistry*. Each of these areas contains multiple staff with high international profiles. Integration across the three areas is reflected by the involvement of a number of staff in more than one. There is strong overlap between the three areas, with facilities and expertise being shared across all three. This complementarity provides an excellent basis for research collaborations with other disciplines; interdisciplinary research is a major facet of the Department's research strategy.

*Energy and Environment*: **(Anderson** (group lead), **Cheng, Cuesta, Feldmann, Glasser, Howe, Imrie, Krupp, Law, Macphee, Raab, Wells; (**associate members Dionisi, Kiefer and Vega Maza – submitted to UoA 15 General Engineering**)** studies the development and application of processes for energy production and environmental control, and the analysis and speciation of environmentally hazardous elements.
*Biomolecular Chemistry*: **(Jaspars** (group lead), **Beattie, Deng, Ebel, Feldmann, Krupp, Raab, Storey, Trembleau)** researches the discovery, analysis, metabolic profiling and synthesis of molecules of biological and medical significance.
*Materials Chemistry*: **(Howe** (group lead), **Cheng, Cuesta, Gibson, Glasser, Harrison, Imrie, Macphee, Mclaughlin, Skakle)** investigates the synthesis, characterisation and properties of novel materials and their applications.

The Unit has grown significantly in extent, vitality and international profile since RAE2008. This is evidenced by the increased size of our submission (20.2 FTE compared with 12 in RAE 2008), the step change increase in research spend (from £3.9M for 2001-2007 to £10M for 2008-2013) and a 65% increase in annual citations per staff member submitted from 141 in 2007 to 232 in 2012 (*Web of Knowledge*). The increase in staff numbers includes 5 new appointments in the period 2008-2013. The University has recognised the upturn in performance of Chemistry since 2008 with strategic new appointments and major funding for refurbishment, research facilities, and the recent announcement of a new science building that will accommodate chemistry research as part of a core investment (scheduled for completion in 2018).

Our challenge as a relatively small unit in the post RAE period has been to maximise use of resources in order to compete at an international level. To achieve this, we have mapped our research activities onto the University's institutional research themes: Energy, Environment & Food Security, Pathways to Healthy Living and The North. Chemistry in Aberdeen is now well-placed as a central, enabling science involved in significant research collaborations both across the University, and with partner institutions across Scotland, the UK, and internationally.

## b. Research strategy

At the heart of our research strategy, common to all three research groups, is the promotion and encouragement of multidisciplinary research with a strong Chemistry base, aiming to diversify and maximise research funding streams and enhance the quality of outputs. Recruitment of staff specifically to augment existing expertise and expand collaborative opportunities, and strategic investment by the University in research facilities are key components of the strategy.

The research strategy of the *Energy and Environment* group is based on applying the expertise in surface chemistry, catalysis, electrochemistry and environmental speciation to challenges in energy futures, implementation of green chemistry, and food and water security. In *Biomolecular Chemistry* the strategy is to strengthen the link between discovery, synthesis and biosynthesis in order to create chemical diversity with potent and selective biological and pharmacological activity, and to apply newly developed analytical techniques to problems in human, animal and plant health. The strategy of the *Materials Chemistry* group is to bring expertise in materials synthesis and characterisation to bear on challenges in biomaterials, electronic, magnetic and construction

materials, and to underpin surface and materials chemistry issues arising in the other themes. Each of the research groups contains individuals who link between the different areas, and who have specific expertise essential to collaborators from other units. For example, thermal analysis (**Imrie**) and X-ray diffraction (**Skakle**) in Materials Chemistry are extensively used in Energy and Environment. A key element of our approach is an open access policy to facilities.

Exemplars of the multidisciplinary strategy within *Energy and Environment* include **Feldmann's** collaborations with Plant and Soil Science and Geology, (BBSRC, EU FP7 and the Food Standards Agency) and **Glasser's** major funding from the Gulf Organisation for Research and Development for a green concrete project together with Engineering. **Anderson** has collaborations with several new appointees in Chemical Engineering (EPSRC funding with Kiefer, PhD studentships with Dionisi and Vega Maza). The recent appointment of **Cuesta** brings an established European reputation in electrochemistry, electrocatalysis and corrosion that will link into Engineering, as well as with existing expertise in catalysis and surface chemistry.

In *Biomolecular Chemistry***, Beattie** has funded collaborations with microbiologists and biochemists in the Rowett Institute, the Institute of Medical Sciences and the James Hutton Institute (formed in 2011 by merger of the Macaulay Land Use Research Institute and the Scottish Crop Research Institute). Establishment of the Marine Biodiscovery Centre (MBC) in 2010, led by **Jaspars** and **Feldmann,** has opened up opportunities for collaborations with microbiologists, molecular geneticists and structural biologists, resulting in a portfolio of funding (EU FP7, BBSRC, TSB, Leverhulme Trust, Institut des Recherches Servier).

In *Materials Chemistry***,** the biomaterials and regenerative medicine research of **Gibson** involves funding, joint studentships and publications with colleagues from the School of Medical Sciences and the School of Medicine and Dentistry (*Gibson 1).* **Skakle's** expertise in X-ray diffraction and solid-state synthesis has likewise resulted in funded collaborations with Medicine and Dentistry, while **Mclaughlin**, together with **Trembleau** from the Biomolecular Chemistry theme, has enjoyed a funded collaboration with Medical Sciences in the area of nanoparticles for cancer detection.

At a local level this strategy has involved the development of individual collaborations across the University, active participation in Scottish Funding Council (SFC) pooling initiatives ScotChem, Scottish Universities Life Sciences Alliance (SULSA), Scottish Universities Physics Alliance (SUPA), Northern Research Partnership (NRP) and the Energy Technology Partnership (ETP), and in activities promoted by the University research themes.

At a national level, our strategy is to facilitate staff contributions to national and international conferences, and to visit potential collaborators. The various pooling initiatives we are involved with also provide opportunities for projects jointly supervised by two different Universities. Examples of national collaborations include the participation of **Anderson** in the EPSRC-funded Catalysis at Harwell and UK Catalysis Hub programmes; the collaboration of **Jaspars and Deng** with St Andrews University on biosynthesis (*Jaspars 2,4, Deng 2,,4*); and the collaborations of **Mclaughlin** with groups in Edinburgh and Heriot Watt on novel magnetic materials (*Mclaughlin 1)*. **Mclaughlin's** work in this area has been rewarded by the recent (08/13) award of an EPSRC large grant (Exploration of Novel Transition Metal Oxyarsenides, £302k). **Howe**'s participation in the UK and Ireland Semiconductor Photochemistry Network led directly to major EPSRC funding for a consortium led by Aberdeen studying photocatalysis for organic synthesis (*Howe 3).* The new analytical facilities funded by the University and BBSRC in the MBC, supported by the appointment of **Raab** in 2010**,** underpin the funded collaborations of **Feldmann** with Universities of Liverpool and St Andrews (EPSRC), and the European Association of National Metrology institutes (EURAMET) for metrology of metalloproteins.

At a European level, we successfully participate in European funding bids, and **Feldmann, Glasser, Jaspars** and **Macphee** have all secured FP7 funding in the REF period. Further European links have been established through our strategy of placing final year undergraduate MChem students with European partners for research projects, and through our reciprocal acceptance of Erasmus students for research placements with us (*Gibson 2,3).*

Other international links result from individual staff research profiles in particular areas. For example **Feldmann** and **Raab**'s collaboration with US colleagues on microbial infection and trace element sequestration was based on Aberdeen's expertise and facilities for trace element speciation, and led to a *Science* paper (*Feldmann 2*). **Jaspars** and **Ebel's** collaboration with IBM Zurich on natural products characterisation resulted in a *Nature Chemistry* paper (*Ebel 1)*.

The oil & gas industry is of key strategic importance both locally, and in the wider UK and international context. We have fostered strong links with the industry through the collaborative development of an advanced MSc in Oil & Gas Chemistry that began in 2010 (now 15 students per annum). All students in this course undertake an extended research placement in industry. These links have also led recently to the development of research projects with companies such as MI-Swaco (**Howe**), Statoil (**Howe**), Chevron (**Imrie**, **Krupp**), as well as funding international collaborations with other significant oil & gas research centres including NTNU (Trondheim). It is our strategic objective to grow these collaborations in the coming years. Two new staff appointments made in 2013 (**Cheng, Cuesta**) will enhance Chemistry's contributions to the oil & gas industry, especially through the modelling of interfaces and electrochemistry related to corrosion. The Oil and Gas Academy of Scotland (OGAS), in which Aberdeen is a founding partner, will provide professional development programmes enabling further pathways towards industry collaboration. Key to the success of the industrial collaborations is the expertise and research infrastructure in Chemistry. The Department's vision for the future of collaborative research involves extending and improving that expertise and infrastructure, building on the existing links and aiming to further diversify funding streams for research.

The final element of our research strategy is the encouragement of academic staff to form spin-out companies or otherwise commercialise research, supported by the University through its Research and Innovation office. **Gibson** and **Skakle** founded a spin out company in 2010 (Sirakoss Ltd), commercialising research developed in *Materials Chemistry* on bone implant materials with Scottish Enterprise Proof of Concept (PoC) funding. Sirakoss Ltd was nominated for the UK Genesis 2011 Med-Tech Innovation award, based on new classes of calcium phosphate materials. **MacPhee,** in *Energy and Environment,* founded a spin out company, Enocell Ltd (in 2011), working on improved electrocatalysts for hydrogen fuel cells following PoC and industrial funding. In *Biomolecular Chemistry* the Tau Rx project was developed through a spin-out company in 2003 to develop new drugs for the treatment of Alzheimer's disease. This project has continued to grow dramatically since 2008, and now employs 18 research assistants and research fellows in the Chemistry Department, led by **Storey.**

**c. People, including:**

**i. Staffing strategy and staff development**

Vital contributions to the enhanced performance of Chemistry following RAE2008 have come from the strategic appointments of new staff. The creation of the Marine Biodiscovery Centre in 2010 was accompanied by the appointment of **Deng**, a biosynthetic chemist, and **Raab**, as an instrumentation specialist, to augment expertise already available in *Biomolecular Chemistry*. The University's "Shaping the Future" recruitment campaign has resulted in the appointment of **Cheng** and **Cuesta** in 2013. **Cheng** is a computational chemist, coming from a Research Fellowship at the University of Cambridge. His expertise in applying ab-initio methods to solids and solid-liquid interfaces will see him contributing to *Energy and Environment* and to *Materials Chemistry*. **Cuesta** is an electrochemist from the Spanish National Research Agency who was recruited specifically to contribute to *Energy and Environment***.** His international reputation in spectro-electrochemistry, electrocatalysis and corrosion augments existing expertise in surface chemistry and heterogeneous catalysis and will result in further links with the oil and gas industry in particular. **Idriss** was appointed to an Energy Futures chair in 2009. He strengthened the surface science and catalysis component of the *Energy and Environment* theme, and although he left the University of Aberdeen in 2011 to move to a senior industrial research position (SABIC) his research collaboration with **Howe** in the area of photocatalytic hydrogen production (*Howe 2*) continues in Aberdeen with US government funding (Idriss retains an Honorary Professor position).

The international profile of *Biomolecular Chemistry* has been further strengthened by the 2013 appointment of Albert **Sickmann** (Chair of the Leibniz Institute for Analytical Sciences (ISAS) in Germany) as an Honorary Professor in Chemistry. **Sickmann** is an expert in bioanalytics and proteomics, which enables the group to interact more intensively with the Medical Sciences.

Staff originally appointed to the University with external funding (**Mclaughlin,** Royal Society of Edinburgh Research Fellow and Leverhulme Early Career Fellow; **Gibson,** EPSRC Advanced Research Fellow) have transferred to permanent academic posts during the REF period, and are supported by the University with studentships and laboratory refurbishment. Both have subsequently achieved major EPSRC (Mclaughlin) and TSB (Gibson) funding.

The involvement of **Gibson** in the *Materials Chemistry* theme reinforces links with the School of Medical Sciences. Collaboration with the recently formed Chemical Engineering unit has been strengthened by the conversion of **Anderson** to a joint appointment with Chemical Engineering in 2012, and staff appointed to Chemical Engineering (Dionisi, Kiefer and Vega Maza – submitted to UoA 15) who have substantive chemistry research are now associate members of the *Energy and Environment* theme.

Early career researchers in Chemistry (**Cheng**, and previously **Deng, Krupp, Raab** and **Trembleau**) are supported through a probation scheme in which they are mentored by an experienced researcher. A high priority is given to pump-priming the research activities of ECRs; in particular they are given priority in PhD studentship awards funded by the University. Senior research leaders encourage new researchers to integrate into the research environment both locally and across the university.

The vitality and achievements of the research groups over the assessment period are also reflected in promotions: (**Gibson** to a Chair; **Skakle** to Reader then Chair, **Wells** to Chair, **McLaughlin**, **Ebel**, and **Krupp** to Senior Lecturer).

At the institutional level, University has a dedicated Researcher Development Unit (RDU) providing programme of career development opportunities for researchers (irrespective of level or discipline). Several Chemistry staff have benefited from Principal Investigator training courses operated through the RDU (**Deng**, **Ebel**, **Krupp**, **Law**, **Trembleau**). All activities are aligned with the Researcher Development Statement and Framework (www.vitae.ac.uk/rdf). The RDU also supports staff development through a Researcher-Led Initiatives Fund. In Chemistry, flexible working hours have been implemented for staff with child-care requirements. All staff are given Equality and Diversity training providing fundamental awareness in the legislative framework and its practical implementation. This training is mandatory for all staff with supervisory and recruitment responsibilities. As a result of these types of activity, the University holds an HR Excellence in Research Award that recognises alignment and implementation with the Concordat to support career development of researchers 2008 (www.vitae.ac.uk/concordat), and an Investors in People Award (institutional bronze). The University has also been awarded a bronze Athena Swan Award for its' provision of a supportive environment for female researchers.

Since 2012 **Anderson** has served as lead for the University's Energy Research theme. **Imrie** (2003-2010) and **Skakle** (2012-present) have served as Head of the School of Natural and Computing Sciences, and **Wells** since 2011 as Director of Teaching and Learning for the College of Physical Sciences. **Gibson, Skakle** and **Wells** have completed an award-winning (Times Higher 2007) institutional International Leadership Development Programme, which aims to enhance the operational and strategic leadership skills of senior researchers and to enable the implementation of institutional strategic goals.

Teaching relief for research active staff has been provided through the appointment of 4 full time teaching fellows during the REF period. Our postdoctoral research fellows (numbering 23 in July 2013) are encouraged to gain teaching experience with us (delivering lectures, tutorials and laboratory class supervision) to progress their career development.

### ii. Research students

The Table below shows a snapshot of annual PhD student population within the Chemistry Unit during the REF period.

| | |
|---|---|
| 31 July 2008 | 26.89 FTE |
| 31 July 2009 | 30.04 FTE |
| 31 July 2010 | 32.79 FTE |
| 31 July 2011 | 34.55 FTE |
| 31 July 2012 | 35.48 FTE |
| 31 July 2013 | 32.87 FTE |

All staff are active in recruiting and supervising research students. The fractional FTE figures reflect the fact that students engaged in collaborative research projects with other units are attributed fractionally to the co-supervisor(s). The recruitment of PhD students is achieved via several means, including selection of our best undergraduates, Erasmus exchange students, worldwide advertisements, and personal national and international networks.

An important aspect of PhD student recruitment in Aberdeen is the range of options available for student support. Full studentships are offered by the College of Physical Sciences to retain outstanding undergraduates. The College also encourages industrial collaborations by offering matching funds for studentships when industrial funding is secured for the balance. The University research themes offer PhD studentships for projects jointly supervised between two different Departments. Chemistry has benefitted from all three of these options. PhD students in Chemistry are also supported through the various Scottish Funding Council (SFC) research pooling initiatives, where funding is provided from the SFC, the University, and in some cases industry. These include the Energy Technology Partnership (ETP), the Northern Research Partnership (NRP), the ScotChem SPIRIT scheme, the Scottish Universities Life Science Alliance (SULSA) and the Scottish Universities Physics Alliance (SUPA). More traditional modes of studentship funding (Industrial CASE awards, DTA studentships) are also common, as well as examples of full industrial funding of studentships and European students supported through Marie Curie ITN. Our high international profile has resulted in increasing numbers of overseas PhD students with government funding from their home countries including, for example, the Brazilian Government *Science Without Borders* programme, the Nigerian Petroleum Development Fund, and the Indonesian Directorate of Higher Education.

All PhD students participate in weekly research colloquia delivered by external speakers. Examples of international visitors who have contributed to the research colloquium series include A. Corma (catalysis), D. Bahnemann (photocatalysis), H. Freund (surface science and catalysis), D. Gunther (analytical chemistry). A diverse Seminar Programme run by the different research themes also provides an excellent opportunity for PhD students and staff to learn about and become engaged in multi-disciplinary topics. Many PhD students have also presented posters and talks at national and international meetings. The University provides travel assistance for PhD student participation in conferences through the Principal's Excellence Fund.

Progression of PhD students is monitored through a system of progress oral examinations conducted by two independent members of staff not associated with the research project after 9 months and 21 months. Records of these and of regular meetings between students and supervisors are maintained by the College of Physical Sciences Graduate School. Training for postgraduate research students is provided by the Graduate School following the Research Councils' Joint Statement on generic skills training, combining courses from the University's generic skills programme (designed for postgraduate students at the University of Aberdeen) with discipline-specific courses. All PhD students use a personal development plan (PDP) and are required to present their work at research group seminars at least once per year. Once a year, a poster is presented by all level 1 and 2 students while final year PhD students give a departmental seminar. Other pan Scotland activities allow students supported through the SPIRIT scheme (joint SFC/industry funded) the catalysis groups (SURCAT Ecosse) and The Energy Technology Partnership (ETP) to present their work to a wider group of peers. The Graduate School supports

training of new and experienced supervisors, with refresher training undertaken every 5 years.

**d. Income, infrastructure and facilities**

The success of our strategy of diversifying research income is illustrated by comparing research spend figures for 2008-2013 with 2001-2007. UK and Scottish Government spend has increased from £218K to £1.48M, industry spend from £705K to £4.8M, and EU spend from £58K to £894K. 8 staff have recorded a research spend of more than £500K in the REF period. Total grant awards to date exceed these figures; a noteworthy feature is the participation of our staff in successful large collaborative bids to Research Councils and EU with other institutions. For example, **Anderson** is the Aberdeen link to a UCL led EPSRC funded project (£1.75M) involving 9 universities entitled "*Catalytic Science in the Harwell Research Centre*", with access to neutron and synchrotron sources. **Anderson** also is part of the UK wide Catalysis HUB recently funded by EPSRC (£13M). **Feldmann** was involved in a BBSRC-DFID project (£650K) on genetic approaches to lower the inorganic level of arsenic in rice, which involved collaboration from colleagues in Plant & Soil Science as well as researchers from Rothamsted Research Institute (UK) and partners in China, India and Bangladesh. **Feldmann** also participated in the NERC-funded (>£10M) Lake Ellsworth Project to sample the water of an ancient subglacial lake in Antarctica, and in an EPSRC-funded project (£656K), led by Liverpool on development and use of microelectrodes for arsenic speciation in soils. **Howe** leads an EPSRC-funded consortium of 4 Universities (Aberdeen, St Andrews, Robert Gordon and Queens University Belfast) investigating photocatalysis for organic synthesis (£673K). **Jaspars** has BBSRC, Leverhulme Trust, TSB and industrial funding (£575K) for a collaborative project with Naismith at St Andrews on the biosynthesis of modified ribosomal cyclic peptides.

At a European level**, Jaspars** is the scientific lead for the FP7 "Pharmasea" project (€9.5M total funding, €760K to Aberdeen). This is a consortium with 24 partners in the EU and ICPC (International Co-operation Partner Countries). The project is focused on discovery of anti-infectives and treatments for diseases of the central nervous system. **Macphee** has FP7 funding (£228K) as part of the "Light2CAT" consortium investigating photocatalytic cements. **Feldmann** and his collaborators in Plant and Soil Science were awarded an FP7 Marie Curie training grant for study of arsenic loss from paddy fields through biovolatilisation (£148K). **Raab** and **Feldmann** hold a research excellent grant ( REG, €260K) from EURAMET (European Association of Metrology Institutes) and are member of the consortium from four EU countries to investigate the metrology of metalloproteins (€4.3M).

Major industrial funding continues with the Tau project led by **Storey** (£7.5M income for the period 2009-2014), with the most recent work mainly in the development phase of Alzheimer's therapies, currently undergoing phase III international clinical evaluation trials. In addition, Bayer-Schering has funded the discovery of new imaging agents for the early diagnosis of Alzheimer's disease (£900K). The Gulf Organisation for Research and Development has funded a 4-year project on "Green Concrete" (£3.3M jointly held with the School of Engineering), and in collaboration with the University of Dundee (**Glasser** and **Macphee).** This project aims to develop low carbon concretes with processes which reduce carbon dioxide emissions during cement production, and which sequester carbon dioxide into building materials. **Macphee's** research on photocatalytic cements has also benefited from funding through the "Nanocem" consortium of European cement companies and research laboratories (£133K to Aberdeen). Other major industrial funding includes £300K from SABIC (**Anderson)** for development of catalysts for selective acetylene hydrogenation**,** £100K from Statoil for a project on scale inhibition (**Howe),** and £178K to **Jaspars** from the French pharmaceutical company Servier for work on natural products derived from extremophile actinobacteria.

Funding from government agencies includes £700K to **Beattie** and his collaborators in the Rowett Institute from the UK Department of Health (formerly the Food Standards Agency) on human biomarkers of zinc status. The Food Standards Agency has also funded work by **Feldmann** and **Krupp** on arsenic in food, and bioimaging of metals in fruits, cereals and vegetables (£300K). **Beattie** and **Feldmann** with their collaborators in the Institute of Medical Sciences received funding of £435K from the National Research Foundation of Korea for an investigation of the role

of zinc in vascular health and disease. The TSB has funded **Gibson's** collaborations with two commercial partners and colleagues in the School of Medical Sciences on cell therapy (£560K).

*Facilities and Infrastructure*
Since 2008 there has been a significant increase in investment in buildings and facilities by the University which has seen refurbishment of the catalysis and environmental analytical laboratories in 2012; refurbishment of laboratories for biomaterials and tissue engineering in 2008 (Royal Society Wolfson grant of £193K); and the opening of the Marine Biodiscovery Centre in 2010 (with University investment of £1.4M). This Centre contains facilities for chemistry, chromatography, spectroscopy (Varian 600/400 MHz NMR, high resolution Thermo Scientific Orbitrap LC-MS, Element high resolution ICP-MS), molecular genetics and microbiology. The Centre already has a number of successful funded collaborative links with biological and medical sciences. Further significant improvements in instrumentation in the Department since 2008, all based on external funding sources, include Laser ablation (UV 213 nm); a high resolution ICP-MS to accomplish HPLC-ES-QTOFMS (BBSRC £162K,); installation of a JEOL FA200 EPR spectrometer equipped with liquid helium cryostat; and a hydrocarbon free high vacuum system for ultra-pure sample preparation (EPSRC £285K), further enhancing our reputation as a centre with particular expertise in application of spectroscopy to materials. The 2013 appointment of **Cuesta** saw the establishment of a laboratory for scanning probe microscopy (AFM and STM) and spectro-electrochemistry measurements. Also in 2013, joint funding from the University and from a private endowment fund has resulted in installation of two new powder X-ray diffraction instruments and a new triple quadrupole ICP-MS instrument to a total value of £500K. The endowment funding is also being used to upgrade spectroscopy and analytical facilities used in upper level undergraduate and postgraduate research, including FTIR, GC-MS, HPLC, IC and MIP-AES instruments to a total value of £220k. Facilities in the Tau group have been augmented by establishing a new GMP laboratory, making combination of cGMP, GCP and GLP accredited facilities that is unique in a UK Chemistry Department. **Beattie's** research has benefitted from the installation in 2012 of an ICP-MS instrument funded by the Scottish Government Rural and Environment Science and Analytical Services. The Green Concrete project initiated by **Glasser** resulted in the installation of specialised facilities for automated synthesis of materials, high temperature reactions of $SO_2$ and thermal conductivity measurements. The Maxwell High Performance Computing Cluster, recently established by the University, will be used for large-scale first principles calculations of gas phase molecular dynamics **(Law**) and (electro-)chemical processes on surfaces (**Cheng**).

The University's commitment to the long-term future of Chemistry as an enabling component of its research portfolio is reflected also in a new Science building planned for opening in 2018 (a £50M investment) that will feature flexible, multipurpose laboratories and support for research instrumentation.

**e. Collaboration or contribution to the discipline or research base**
*Collaborations:*
High levels of national and international collaboration, a feature of the unit's RAE2008 submission, have been further expanded. Many of our submitted outputs have resulted from such collaborations, for example those with St Andrews University on microporous materials (*Howe 4);* on molecular structure calculations *(Law 3)* ,biosynthesis (*Jaspars 2)* and fluorinated natural products *(Deng 3);* with Edinburgh and Heriot Watt Universities on magnetic materials *(Mclaughlin 1);* with Valencia, TU Delft and University of Bordeaux on liquid crystals *(Imrie 1,3);* with the University of Turin and the University of Kyushu on biomaterials (*Gibson 2,3,4);* with Korean Andong University on arteriosclerosis and zinc status (*Beattie 1);* with Bangladesh Agricultural University, Calcutta University, and the Chinese Academy of Science Xiamen on arsenic in rice (*Raab 3,4);* with Cambridge University and the ETH Zurich on computational chemistry (*Cheng 1,2,4);* with Argonne National Laboratory and the Catalysis Research Institute Hokkaido on electrocatalysis *(Cuesta 1,2,4);* with the University of Tromsø on marine natural products (*Jaspars 3); and* with IBM Zurich on structure determination of organic molecules by STM (*Ebel 1).*

*Contributions to the Discipline:*
Six of our staff are members of the EPSRC Peer Review College. **Howe** and **Imrie** have served on

EPSRC panels. **Howe** has served on 5 panels for the Norwegian Research Council, and **Wells** on EU FP7 panels and the Advisory Committee for European Networks of Excellence. **Imrie** is Editor of the journal Liquid Crystals, and **Jaspars** chaired the Editorial Board of the journal Natural Product Reports (2007-2010). Chemistry staff serve on Editorial Boards of 15 major journals.

*Visiting International Professorships*: **Anderson**- University of Witswatersrand (2005-2011) **Jaspars** – University of Tromsø (2007-2014). Chinese Academy of Sciences (2012-13).

*Contributions to the research base:*
During the REF period **Jaspars** held a BBSRC Research Development Fellowship, **Gibson** an EPSRC Advanced Fellowship, and **Mclaughlin** a Leverhulme Early Career Fellowship. **Imrie** was awarded the Cyril Hilsum Medal by the British Liquid Crystal Society in 2011 "*for overall independent contributions to liquid crystal science and technology*" and in 2012 the LG Display Award by the International Liquid Crystal Society "*for outstanding and influential work in liquid crystal chemistry, including pioneering work on LC dimers and oligomers, and LC block copolymers*". **Glasser** received the Jose Calleja prize for "*professional excellence in the area of cement and its applications*" in 2011 and the Hume-Rothery prize from the Institute of Materials and Mining in 2012 for "*achievements in advancing the application of thermodynamics to the study of metals and substances of interest to metallurgists*". He has also been elected a Distinguished Life Member of the American Ceramic Society (2010).

*Membership of Advisory and Professional Bodies and Conference Organisation:*
**Anderson** is Chair of SURCAT (RSC Surface and Reactivity group, 2009- ), served as Secretary of EFCATS (2007-2011) and on the RSC Faraday Council (2008-2013). **Harrison** served on ISIS (Rutherford-Appleton Lab STFC neutron source) diffraction panel (2006 to 2009) and **Mclaughlin** has been an ISIS Crystallography Facility access panel member since 2012. **Imrie** was elected Chair (2007/09), Vice-Chair (2009/10) of British Liquid Crystal Society, UK representative on the Board of the International Liquid Crystal Society (2006-2012), member of the International Advisory Boards for the 23rd International Liquid Crystal Conference (Krakow 2010) and 24th International Liquid Crystal Conference (Mainz 2012). **Macphee** was Co-ordinator of Functional Surfaces for the European Nanocem Consortium (2006-2010). **Jaspars** served on the ESF-Marine Board Working Group on Marine Biotechnology which prepared the position paper on the future of marine biotechnology in Europe (2009-10), on the Biosciences KTN Industrial Biotechnology Sector Group (2009-current) and on the Scientific Advisory Board of MabCent SFI, Tromsø, Norway (2007-2014). **Krupp** was a, co-organiser of ICMGP: International *Conference* on *Mercury* as a *Global* Pollutant (Edinburgh, 2013)**. Feldmann** served on scientific committees for Metallomics 2011 (Munster, Germany), European Winter Conference on Plasma Spectrochemistry 2009 (Graz, Austria) 2013 (Krakov, Poland), TraceSpec, Mainz, Sept 2009, Metallomics Symposium (Analytica, Munich 2012), 1st and 2nd Georgian Bay Conference for Bioinorganic Chemistry (2007, 2009), 34th Colloquium Spectroscopicum Internationale (CSI), Buzios, Brazil (Sept 2011). **Feldmann** and **Krupp** are members of EVISA (European Virtual Institute for Speciation Analysis, www.speciation.net) **Anderson** and **Wells** served on organising committee of Europacat X, Glasgow 2011. **Feldmann** organised the UNEP Workshop on Mercury in Waste and Waste Management, King's College, Aberdeen, (2011). **Feldmann** (organizer) and **Beattie** (co-organiser) organized the IUPAC 4th International Symposium on Trace Element in Food (TEF-4), King's College, Aberdeen (2011).

Many of our staff have also been invited to deliver keynote and plenary lectures, including **Anderson** (5), **Feldmann** (15), **Glasser** (2), **Imrie** (6), **Jaspars** (2), **Macphee** (4), **McLaughlin** (1), **Krupp** (8).