Introduction

Subsequent to RAE2001, and a new Dean for the School of Biosciences (**Jarvis,** start 2002), research within the School was substantially developed to build on previous strengths in biomedical science and biotechnology. Focussing on subjects allied to medicine and supported through QR capability funding, the University's research development fund and SRIF funding, five research clusters (Cell Communication, Cell Survival, Inflammation and Infection, Regenerative Medicine and Applied Biotechnology) have been formed with the aim of developing research excellence in these broad themes. Since 2001, eight staff have retired or left the University and as part of the University research strategy we have appointed twelve new members of staff (**Clements, Dwek, Farnaud, Getting, Harmer, Kang, Murray, Odell, Patel, Porakishvili, Renshaw, Smith**), ranging from early career lecturer to Reader. Newly appointed staff, collaborating with existing research active staff, have generated synergy through research clusters where internationally recognised biomedical research continues to be conducted. Since RAE2001, staff have attracted over £1.3 million in income (ten fold increase on previous submission in this UoA). A further £0.67 million in new awards has also been granted (not undergone significant expenditure in the period). Staff in this UoA have produced 180 peer reviewed publications (WestminsterResearch, http://westminsterresearch.wmin.ac.uk/view/subjects/UOW2.html) and have supported the completion of thirteen PhD students (excluding early career researchers, a three fold improvement per FTE on previous submission in this UoA).

Research Structure and Related UoAs

The School's Research Committee oversees research strategy, research student support and degree administration and coordination of staff research objectives. It is chaired by the School Research Director who reports directly to the Dean. Staff are associated with one or more research clusters where research activities pertinent to their interests are discussed and collaborative actions agreed.

Within the two biologically related units of assessment submitted in RAE2001, there were five research groups. With increased biomedical research, one of these groups (*Biomedical Science*) has been further developed and divided (to become three clusters: Cell Communication, Cell survival, Inflammation and Infection), the *Tissue Engineering Research group* has expanded to become the Regenerative Medicine Cluster and the *Fungal Biotechnology* group has expanded to become the Applied Biotechnology Cluster. *Food Nutrition and Public Health* is reported in UoA8 and the *Plant Science group* has disbanded and a new cluster entered into UoA17. One member of staff (**Hucklebridge**) is submitted to UoA44 (a longstanding Psychology/Physiology research collaboration).

To ensure effective translation and dissemination of research we are active in a number of ways. Regular meetings take place with WestmARC, the Technology Transfer Office of the University that informs our academic community of funding and commercial opportunities as well as fostering

interdisciplinary cross-School links to develop research. A comprehensive skills and expertise database of all research active members of staff and has been compiled and disseminated to the London Network Forums. We take a high profile role in London Networking Events including those run by the London Technology Network (**Dwek** was an LTN business fellow) and WestFocus consortia. Meetings and research presentations have led to the formation of new industry-academic partnerships, including links with companies such as Stem Cell Sciences (**Clements**), OnyVax (**Dwek**) and Pfizer (**Getting, Keshavarz**).

Research Clusters

Cell Communication

Within this cluster, aspects of cellular adaptation and differentiation in response to a complex range of physiological and patho-physiological stimuli are investigated. The following is illustrative of the work in the area.

Research undertaken by **Jarvis** via funding from the BBSRC has included the elucidation of mechanisms of vitamin C transport. Prior to 2000 little was known about the molecular properties of sodium-dependent vitamin C transporters. Two isoforms of human sodium-dependent vitamin C transports (SVCTs) were cloned and expressed in mammalian cells, and the mechanisms and regulation of transport investigated (**Jarvis, 1,3**). In collaboration with colleagues from the USA, mice were selectively engineered to over express hSVCT2 in the lens. This work implicates vitamin C in lens crystalline damage and will help in the search for drugs that inhibit damage by vitamin C oxidation products (**Jarvis, 2**).

Hypothalamic control of the reproductive axis has been the focus of **Murray's** research (in collaboration with St George's hospital, University of London). Leptin deficient mice are infertile and the role of leptin in regulating GnRH activity is well established. They were the first to demonstrate the importance of leptin in conception and/or implantation (**Murray, 1**). The *zona incerta*, appears to regulate the activity of GnRH neurones in the pre-optic area (in collaboration with Imperial College and King's College London). Orexin A can be either stimulatory or inhibitory on GnRH neuronal activity and hence LH release, depending on where in the hypothalamus it is administered (**Murray, 2**). **Murray** also demonstrated that orexin immunoreactive fibres form close associations with GnRH neurones in rats, as previously demonstrated in sheep. Utilising an agonist for MC5R and antagonists for both MCHR and MC5R, they have produced compelling evidence that MC5Rs are present in the hypothalamus and that both MCHR and MC5R are involved in central control of LH release by MCH (**Murray, 4**: same London collaborators and University of Florida).

Smith's research has focussed on aspects of the regulation of nitric oxide, an important cardiovascular signalling molecule. Nitric oxide synthase, the nitric oxide producing enzyme, is affected by oxidation of the cofactor, tetrahydrobiopterin, calcium signalling and inhibitors such as asymmetric dimethylarginine (ADMA); the latter of which is raised in numerous cardiovascular conditions. **Smith** examined the effects of altering ADMA on angiogenesis and performed microarray experiments to investigate the effects

of raised ADMA on endothelial cells. Future plans include investigating the effects of ADMA on NO signalling and stem cell differentiation as well as elucidating the role of ADMA on vascular calcification.

Farnaud focuses on iron metabolism in mammalian systems. Disorders of iron homeostasis are amongst the most common diseases of humans with iron deficiency leading to anaemia, and iron overload (haemochromatosis), now the most common genetic disorder in Caucasians. Since the identification of the anti-microbial peptide hepcidin and its possible role in iron regulation, major questions remain regarding its mode of action. **Farnaud** published the first results identifying iron-bound hepcidin, the presentation of these results in Barcelona in 2006 led to a conference award (**Farnaud, 1**). The structure-function study of hepcidin is still in progress in collaboration with King's College London, Innsbruck University, Austria and Rennes University, France.

Cell Survival

Cellular regulation of biochemistry and proliferation are important aspects of biomedical science. This cluster has concentrated on major research themes that include cancer studies, the elucidation of factors controlling stem cell differentiation and research into regulation of internal cellular organelle. The following is illustrative of the work in the area.

Clement's research focuses on understanding the regulation of mesenchymal stem cell (MSC) proliferation and differentiation. A series of novel retroviral based vectors were developed, permitting the generation of stable genetically altered cell lines of MSC. These tools were used to elucidate a previously unknown role for oxidative phosphorylation in the oncogenic transformation to MSC (**Clements, 4**). Recent work has shown, for the first time, a key role for γ-secretases in controlling the proliferation and lineage commitment during differentiation of MSC (**Clements, 3**). This work has implications for cartilage and bone development, as well as obesity.

Patel's research involves elucidating pathological mechanisms responsible for alcoholic liver disease (ALD), particularly examining mitochondrial function (**Patel, 1,3**), oxidative stress and cell death (**Patel, 2,4**). Initial work characterized the physiochemical properties of mitochondrial ribosomes using novel techniques (**Patel, 1**), which led to subsequent experiments demonstrating, for the first time, both functional and structural alterations to liver mitochondrial ribosomes following chronic alcohol exposure (**Patel, 2**). In collaboration with colleagues from Australia, USA and the UK he has recently assessed the formation of protein modification in cellular compartments of the liver using both an ELISA and proteomics approach. Modified proteins may be responsible for the immunogenic reaction that leads to cell death and thus contributes to the pathology of ALD (**Patel, 3,4**).

Porakishvili'sresearch was the first to demonstrate the expansion of CD4+ cytotoxic T lymphocytes in B cell chronic lymphocytic leukaemia (B-CLL) and to reveal their ability to kill leukaemic cells via bispecific anti-CD3/anti-CD19 antibodies (**Porakishvili, 1**). Together with French collaborators first demonstrated apoptosis of leukaemic cells *in vitro* through ligation of surface

CD5 (**Porakishvili, 3**) and the association between CD5-signalling pathways with B cell receptor (BCR) (**Porakishvili, 4**). Following collaboration with workers from the USA they were the first to show that BCR and toll-like receptor CD180 are differentially expressed by B-CLL clones and that the ligation of CD180 drives B-CLL cell activation (**Porakishvili, 2**). Future research is focussed on the apoptosis of B-CLL cells via BCR and associated molecules.

Dwek and others have reported a strong link between glycosylation changes and cancer metastasis (**Dwek, 1**). **Dwek** has shown that glycan mapping can be achieved reproducibly using formalin fixed paraffin-wax embedded (FFPE). Using this technology she showed, for the first time, glycan changes in FFPE tissues from patients with breast cancer and metastasis (**Dwek, 1**). Her work will continue to delineate glycosylation changes and resultant effects on cancer cell behaviour. To this end she developed proteomic tools which enabled identification of unique signatures in normal breast tissue, (**Dwek, 2)** and in cancer tissues (**Dwek, 3**). Further work has unravelled the molecular basis for HPA lectin recognition of metastatic cancer cells (**Dwek, 4**).

Odell's research is centred on the integration of biochemistry and structural biology to gain insight into protein function and to identify novel therapeutic agents. In collaboration with Sloan Kettering Institute, USA, they were the first group to propose a model for the recognition of nicked DNA by ATP-dependent DNA ligases (**Odell, 1)**. This model was further refined by solving additional crystal structures including the first structure of an ATP-dependent DNA ligase bound to a true nick in double-strand DNA (juxtaposed 3'OH and 5'P terminated nucleotides (**Odell, 4**). This structure reveals the role of a small flexible loop that mediates DNA binding in ligase enzymes that lack a dedicated DNA binding domain, a mechanism he first proposed in 1999. Using knowledge of the unique mechanism by which small eubacterial, ATP-dependent ligases recognize DNA; he has designed an inhibitor assay that is being used to screen a natural product library in collaboration with Hypha Discovery™ Ltd.

Inflammation and Infection

This cluster has investigated the inflammatory events that lead to activation and up-regulation of a multitude of systems including NADPH oxidase and nitric oxide synthase and the subsequent generation of reactive oxygen and nitrogen species.

Gordge's work has followed two themes, both related to effects of oxidative/nitrosative stress on cellular function and signalling events. One strand involves the role of uraemic toxins in inhibiting neutrophils and causing kidney stone formation (**Gordge, 1,2**). These previously poorly understood processes are clinically important in promoting infection (through neutrophil dysfunction) and progression of renal tubular injury (through stone formation) in patients with renal disease. The second strand of research focuses on the way nitric oxide (NO)-related signalling molecules achieve entry into platelets (**Gordge, 3,4**). **Gordge** has contributed to an emerging model that implicates

the enzyme protein disulphide isomerase (PDI) in this process, and was the first to show that PDI is required for entry of all redox derivatives of nitric oxide. These results will help to develop targeted NO replacement therapy in cardiovascular disease.

Getting has investigated the identification of the receptor(s) involved in modulating the anti-inflammatory effects of melanocortin and annexin peptides. Annexin 1 has long been recognised as a potential modulator of inflammation although little was known about the receptor it mediates. *In vitro* and *in vivo* analysis indicated, for the first time, that aspirin and dexamethasone induced lipoxins and annexin 1 act *via* the same lipoxin A4 receptor (**Getting, 1**). Melanocortins have long been known to modulate the host inflammatory response. MC3R was proposed by **Getting** and co-workers to mediate these effects and they were the first to identify that knee joint macrophages expressed this receptor. Intra-articular ACTH reduced inflammation elicited by urate crystals in a corticosterone-independent fashion indicating a local effect rather than *via* activation of the HPA axis (**Getting, 2**). In collaboration with colleagues from QMUL **Getting** has demonstrated, for the first time that melanocortins retain their anti-inflammatory effects in a model of gouty arthritis in mice with a non-functional MC1R (**Getting, 3**) but lose efficacy in MC3R-null mice (**Getting, 4**). All these studies highlight that, by identifying the molecular mechanism of naturally-occurring anti-inflammatory compounds, we maybe able to develop novel therapeutics that will act on these endogenous anti-inflammatory pathways.

Renshaw's research entails elucidating the local intra-adrenal mechanisms of the adrenal gland. Although central responses during stress for example, are well known, with activation of the HPA axis, the contribution of local factors such as neuropeptides have not been fully explored. Exploring local adrenal changes to physiological changes in sodium, ACTH (exogenous) and stress status (**Renshaw, 1**,**3)**, there is also evidence that systemic infection can effect cortisol secretion directly by releasing cortisol on cultured adrenal cells (**Renshaw, 2**), again demonstrating that the adrenal gland exerts a degree of autonomy from the brain and HPA axis. Changes in endothelial cell expression of the adrenomedullin receptor apparatus indicates that this adrenal peptide (globally expressed in endothelial cells) may be involved in endothelial cell signalling relating to angiogenesis in endothelial cells, including those of the adrenal gland (**Renshaw, 4**).

Regenerative Medicine

This cross-disciplinary cluster includes biomechanical engineers, cell biologists and a biotechnologist with expertise in designing and building bio-reactors and equipment to impart and detect biomechanical forces within cellular physiological force ranges. A major focus of this group is the regulation of tissue repair, scarring and fibrosis. Future work will concentrate on Biomedical research aimed at elucidating the cause of fibrosis in the connective tissue disease Scleroderma, investigations into the creation of 3 dimensional biodegradable scaffolds for tissue engineering and the development a computer model/simulation of tissue repair.

Research in this RAE period, funded by two EPSRC grants, included the fabrication of a collagenous scaffold for possible heart valve replacement (**Sarraf, 3**) and the measurement and calculation of cell proliferation rates in the fabric of such a prosthesis (**Sarraf, 1**). These pathology techniques are essential before any such graft could be performed for humans. The significance of this development is that in living tissue replacement, cell proliferation would need to be appropriate to avoid (a) expansion of the replacement's overall size, or (b) necrosis if cell proliferation were not sufficient. Current protocols developed at Westminster indicate that populating an inert matrix with stem cells greatly improves a tissue match between neighbouring host tissue and the regenerating part.

In collaboration with UCL and other major national and international research centres (Canadian Institute of Health Research Group in Skeletal Development and Remodelling, University of Western Ontario Canada; London Regional Genomics Centre; Cutaneous Biology Research Centre, Harvard Medical School, USA) the group has shown that addition of Endothelin-1 (ET-1) to normal lung fibroblasts induces expression of proteins that contribute to a contractile phenotype, including alpha-smooth muscle actin (alpha-SMA), ezrin, moesin and paxillin. They demonstrated that ET-1 enhances the ability of lung fibroblasts to contract extracellular matrix, a function essential for tissue repair, through induction of *de novo* protein synthesis. Therefore blocking ET-1 or the PI3-kinase/Akt cascades might be beneficial in reducing scar formation in pulmonary fibrosis (**Eastwood, 1**). Funded by the Raynaud's and Scleroderma Association and the Scleroderma Society they also demonstrated that some key profibrotic features of lesional SSc fibroblasts are dependent upon ALK-5 activity and influence Transforming Growth Factor (TGF) beta I. Thus, TGFbeta Receptor I kinase-mediated signalling may contribute to dermal fibrosis in the connective tissue disease, scleroderma (**Eastwood, 2,3,4**).

The behaviour of nerves around joints has been investigated by **Afoke**. Biomechanical tests demonstrate that nerve properties differ according to anatomic sites despite having similar microscopic appearances (**Afoke, 1**). When severed, nerves retract and retraction is dependent on the *in-vivo* state. Due to the composite nature of peripheral nerve tissue architecture, it behaves differently if *in-vivo* conditions are not preserved during specimen preparation before testing (**Afoke, 3**). Although the composite nature of the nerve is well documented, the way in which intraneural layers interact, move and respond to loading is poorly understood. **Afoke** (**2,4**) showed the interaction of the different layers during loading. Overall, these findings elucidate normal dynamic nerve physiology and provide insights as to why peripheral nerve repair outcomes are variable.

Roy's work, with EPSRC support, has included the production of polyhydroxyalkanoates, the biodegradable and biocompatible polymers from Gram-positive bacteria. *Bacillus cereus* SPV has been used, for the first time, to produce reasonably large quantities of good quality polymer using a large variety of carbon sources (**Roy, 3,4**). These polymers lack the endotoxins found in polymers isolated from Gram negative bacteria. In collaboration with

colleagues from Imperial College, London, these polymers have been combined with bioactive Bioglass® and carbon nanotubes, for the first time, to form composites suitable for hard tissue engineering (**Roy, 1,2**).

Applied Biotechnology

Within this cluster are two groups, one working on **microbial biotechnology** and the other on **antibody technology**. The microbial biotechnology group concentrates on the discovery of novel antibiotics, and enhancement of production of existing antimicrobials. The antibody technology group is focussed on accessing, engineering, and characterising recombinant human antibody fragments for a range of applied studies. Biotechnology within the School has a long record of applied research resulting in three spin-out companies (Klenzyme, Anglesey Natural Foods and Hypha Discovery™). The following are examples of current work being undertaken.

Elicitation in plant cell culture is well known, however, **Keshavarz** initiated research into elicitation in microbial cell cultures, for the first time, and, after establishing the existence of the process, first in fungal and subsequently in bacterial cultures (**Keshavarz, 2,3,4**), with support from Pfizer, has recently discovered a mechanism for elicitation in bacterial cultures (**Keshavarz, 1**). The impact of the finding is the delivery of a cheap method for enhancement of antimicrobial production at industrial scale. Another aspect of his research is quorum sensing in filamentous fungi. The hypothesis, first suggested by **Keshavarz** that quorum sensing also exists in filamentous fungi attracted support from researchers across Europe and the USA with funding from the European Commission and Pfizer. Quorum sensing molecules (gamma butyrolactone family) have been isolated and identified for the first time (internal EU reports). In the long term this finding will help in combating fungal infections in a clinical context and, in the industrial context, will have impact on improving mixing in viscous cultures helping in cheaper production of antimicrobial compounds.

Originally funded by BBSRC, and latterly by private finance, elicitation studies employing stimulatory fermentation techniques have been performed. This work has included extensive studies of the metabolomics of interacting fungal mycelia and has led to the discovery of natural products with unusual and novel structures including a previously unpublished structure for the antibiotic Fusidic acid (**Hedger, 4**). This work has been carried out in collaboration with the Universities of London and Manchester. The work has, in addition, led to the establishment of a University of Westminster 'Spinout'Hypha Discovery™ 2005 (see hyphadiscovery.co.uk), with current funding of £500K (including a SEEDA Research and development award and an external investor). The Company uses an innovative fermentation system to stimulate fungal cultures to produce biologically active secondary metabolites, with subsequent chemical and structural analysis. Current contracts include one with leading US/Canadian pharmaceutical company, Cubist, to explore their large culture collection base for possible antimicrobials. Hypha Discovery™ has also won a number of contracts with German and Japanese Agrochemical/Pharmaceutical companies for identification of active components in plant and microbial extracts.

Understanding the molecular basis of antibody-mediated protection in humans has been limited by the inability to readily generate monoclonal antibodies from immune or immunised donors against cognate targets. Two innovative approaches (a) antibody repertoire cloning combined with phage display (**Kang, 3**) and (b) hu/SCID mouse technology (**Kang, 4**) in two distinct infectious diseases, malaria and anthrax respectively, overcomes these difficulties. Malaria research was carried out in collaboration with UC Irvine CA, USA (**Kang, 1**) and the US Naval Medical Research Institute Rockville MD and funded by the US Department of Defence. The anthrax lead antibody was evaluated in collaboration with The University of Texas in a range of animal models and shown to protect rabbits against a lethal anthrax spore exposure (**Kang, 2**). This candidate antibody is being developed by Avanir Pharmaceuticals, CA USA and continues to be funded by the US National Institute of Health. Both of these and future projects will guide the development of next generation vaccines against currently intractable human diseases.

The common theme of **Harmer's** research is antibody genes and antibody engineering (**Harmer, 1,2,3**) with particular emphasis on Phase I/II clinical trials of DNA vaccination as a treatment for follicular lymphoma. The research so far demonstrates the use of DNA vaccines to produce the required type of response (anti-idiotypic) (collaboration between the Universities of Cambridge, Manchester, Southampton and the National Blood Service). The outcome is presently being evaluated and is not yet published. Thirty patient specific clinical grade vaccines were produced based on a plasmid constructed for the trial. This was one of the first trials of this type using DNA vaccination. Future studies will investigate the specificity of the patients' lymphoma antibodies targeted in the clinical trial with a view to increasing knowledge of the role of antigen drive in follicular lymphoma.

Research Infrastructure and Facilities

Research is conducted in dedicated laboratories at the Cavendish Campus of the University that have been completely refurbished using investment from the University and SRIF (Biosciences Laboratories, £4 million). New research facilities have been developed, particularly in the area of molecular biology, analyticalinstrumentation, fermentation and cell culture facilities and biomechanical testing of cells and tissues. A dedicated imaging suite houses a three-laser, dual-microscope confocal system, fluorescent imaging facilities including a cell sorter and a Power PC analysis system. PhD students have been provided with new office facilities considerably improving their ability to focus on private study and offering opportunities for peer support.

There is a wide range of analytical equipment for: LC, FPLC, HPLC, GLC, TLC, CE (Capillary Electrophoresis), Flow Cytometer Cyan (DAKO Cytomation), GC-MS (Gas chromatography-mass spectrometer), FTIR (Fourier transform infra red spectrometer), UV/VIS, atomic absorption and fluorescence spectrometers. Most of this equipment is housed in a dedicated instrumentation suite. Furthermore, there is a radiation suite with a beta-scintillation and gamma counters, molecular biology laboratories equipped with sequencers quantitative-PCR cyclers and apparatus for both solution and *in situ* hybridisation, an imaging suite with upright and inverted fluorescence

microscopes, high resolution digital camera, image analysis hardware and software, and a microbiology suite with a media kitchen and autoclaves, cell culture facilities, free standing incubators, a centrifuge laboratory and central general stores. The fermentation suite has capability for computer-controlled fermentations at all scales from 2 to 72 litres. A proteomic facility has been established based on 2-dimensional electrophoresis, dual laser fluorescence scanning and state-of-the-art data analysis stations. Specialist laboratories are maintained by dedicated technical staff who contribute to research.

Knowledge transfer and innovation

Dwek and **Kang** have been successful in gaining patents. **Dwek** has patented an assay method, GB 2379444, to diagnose prostate cancer with greater accuracy. Patients with symptoms indicative of prostate cancer are routinely assessed for the level of a serum biomarker - prostate specific antigen (PSA) (>1 million PSA tests are run in the NHS alone per annum); 30% of all PSA tests suffer from false positive readings. **Dwek** recognised an opportunity to refine the PSA test to render it more specific for prostate cancer. The patent describes the use of a carbohydrate binding protein (UEA-1) for profiling the glycosylation of PSA. The invention is currently being developed as a diagnostic test for prostate cancer.

Kang has been issued with 7 US Patents (6,476,198 Multispecific and multivalent antigen-binding polypeptide molecules; 7,118,866 Heterodimeric receptor libraries using phagemids; 6,586,236 Modulation of polypeptide display on modified filamentous phage use; 6,468,738 Heterodimeric receptor libraries using phagemids; 6,323,004 Modulation of polypeptide display on modified filamentous phage; 6,235,469 Heterodimeric receptor libraries using phagemids and 6,190,908 Modulation of polypeptide display on modified filamentous phage). The patent portfolio covers three areas: (a) the creation of novel recombinant receptor assemblies, (b) the display of these receptor assemblies on the phage surface, permitting the selection of novel receptors, such as antibodies, TCR, MHC molecules and (c) the modulation of receptor polypeptides displayed on phage since it is the only phage system that displays single or multiple copies of the receptors permitting high affinity or low avidity selection respectively. The combined technologies permit the facile selection and engineering of recombinant antibodies for a range of applications.

Eastwood has been engaged by Moorfield's Eye Hospital to produce a specialised form of the tensioning-Culture Force Monitor that has been miniaturised to enable it to operate on a confocal microscope. These specialised pieces of equipment are now being used in Universities across Europe and in the USA.

Staffing Policy

Of 22 new members of staff appointed in the School since RAE2001, 13 are included in this submission, strengthening and developing medically related areas of biotechnology and cellular and molecular biology. Research areas for new staff are identified in the School's plan bearing in mind the existing research strengths and expertise and teaching needs. Therefore an established research track record is a key criterion for the appointment of staff. It is our intention to continue this policy and to further develop our research potential in subjects allied to medical professions.

Since RAE2001 four previously submitted members of staff (**Adlard, Bucke, Evans and Veness**) have retired. **Bucke** continues to support PhD students within the School and mentor staff and is submitted as Category B staff. A further 4 previously submitted staff have left the School (**Leveritt, Saunders, Sumar and Trevan**). Nine further members of staff who were included in RAE2001 (**Biggs, Chowdrey, Cunliffe, Curley, Greenwell, Lewis, Locke, Madgwick and Thompson)** are still research active but have either been submitted to other UoAs or have focussed their work on other responsibilities within the School.

Staff support and development

Research active staff receive annual teaching relief concomitant with their research commitments set against measurable outputs (e.g. grant applications, journal papers). Success in this strategy is indicated by increase in outputs (380 vs. 111) and over ten times increase in income (£1.35 vs. 0.13 million) (RAE2008 vs. RAE2001). The School has introduced a sabbatical policy that allows staff with five years service to dedicate a semester to research, free from teaching or administrative responsibilities.

Staff undertake annual appraisal where development needs are identified and staff are encouraged to attend conferences, supervisors and grant application workshops. The University's Masters in HE has a module (Supervising Research Students) available as CPD provision.

Support for new staff

Start-up funding (internal bursary of at least £2,000 and up to £15,000) for newly appointed staff is provided against agreed research plans and progress is monitored against agreed targets. All new staff have mentors to guide them through their first two years when teaching loads are deliberately light. New staff are encouraged to join PhD supervisory teams and are recruited to be assessors for the PhD programme to prepare them for supervising students of their own. The School's Research Scholarships programme provides fully funded PhD scholarships that are preferentially allocated to collaborative research programmes of new staff.

Sustainability and succession planning

In the coming five years around one quarter of the staff in the School will be of retiring age. Through staff review, staff within this time frame for leaving have been identified and a planned distribution of their roles and responsibilities

between existing staff (often as development opportunities) and new appointees is being made. As indicated above the appointment of new academic staff will be based on their research potential and their affinity with one or more of our research areas that are congruent with our teaching needs.

Research Strategy
The research strategy of the past five years has been to establish state-of-the-art research facilities, to appoint new staff, to promote and increase coordination of research activities by formation of research clusters and to increase the quality and number of research students. In the next five years the overarching aims are to:

- Develop younger research active staff and extend their research output through the interdisciplinary research clusters with focus on mechanisms of cell function and survival through identification, amelioration and treatment of medical conditions.
- Reinforce and strengthen the existing clusters by the appointment of new staff as current staff retire.
- Foster further collaborative research by the application of our discoveries in basic research to applied output through links with companies and NHS trusts.
- Increase research income generated by staff by application of the current strategy of setting clear and measurable targets for research inputs and outputs.
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The above strategic aims build on current areas of international excellence, whilst at the same time extending them to tackle developing areas so as to ensure that our research remains cutting edge in both basic and applied fields.

Esteem Indicators
*ECR

Staff in School are active in journal editorship:

Sarraf, editor, *Cell Proliferation*, and **Getting,** editor, *Scientific World Journal* and are on editorial and advisory boards: **Bucke,** *Molecular Biotechnology, Enzyme & Microbial Technology* and *World Journal of Microbiology and Biotechnology;* **Dwek,** *Molecular Biotechnology*, *The Open Cancer Journal* and *Recent Patents in Anti-Cancer Drug Discovery;***Eastwood,** *Cell Proliferation;* **Jarvis** *Biochemical Journal* and *Molecular Membrane Biology;* **Kang,** *Human Antibodies* and *Journal of Immune Based Therapies and Vaccines and Proteome Science;* **Keshavarz,** *Journal of Biotechnology and Applied Biochemistry;* **Roy,** *Journal of Chemical Technology and Biotechnology*; **Murray,** *Reproduction.*

Invited presentations:

Clements,* Symposium on Stem cell repair and regeneration (Imperial College, London. October 2006); **Dwek,** 2nd International Caribbean Cancer Research Congress 2007; **Eastwood**, 16th Annual Cardiothoracic College of Surgeons, Queensland, Australia 2001; Invited lecture University of Michigan, USA, 2004; **Farnaud*,** Annual Meeting, European Iron Club (EIC) 2006, Barcelona, EIC 2007, London (member of scientific and organising committees), London Iron Metabolism Group meeting 2006, 6th International Conference on Lactoferrin, structure, function and applications, Capri Italy 2003; Site-Directed Mutagenesis at The Molecular Biology Techniques course of INETI (Instituto Nacional de Engenharia, Tecnologia e Inovação, ucar) in Lisbon (Portugal) 01/2003 and 10/2003; **Getting,** Invited speaker, Serono Pharmaceutical Research Institute, Geneva, 2005; Pfizer Global Research, Kent, 2004; Novartis, Sussex, 2003; 2nd University of Naples, 2003; University of Windsor, Ontario, Canada 2007; **Jarvis,** Chilean Societies of Biology, Pharmacology, and Physiological Sciences, Chile 2001; **Kang,** Cambridge Health Institute, Recombinant Antibodies, Cambridge MA, USA 2003; International Congress of Insect Biotechnology and Industry 2007, Daegu, South Korea; **Patel*,** Society of Alcoholism International Society for Biomedical Research on Alcoholism. San Francisco, USA, 2002; **Porakishvili,** DAKO, biomedical Sciences 2006; Euroscience Society 2007; **Roy,** International Symposium on Biological Polyesters, Minneapolis, USA, 2006; **Sarraf,** Stem Cell Biology, 2006; Stem Cell and Tissue Engineering, 15th annual meeting, Society of Cytometry 2006; **Smith*,** European Sciences Conference 2007.

Examples of memberships of advisory groups, society councils and research council assessment panels:

Bucke, Biologicals and Vaccines Expert Advisory Group of the Medicines and Healthcare Products Regulatory Agency; **Eastwood** BBSRC/EPSRC Assessment panel membership (October 2005), Stem Cell Science and Engineering Initiative; **Hedger,** Council, British Mycological Society 2002-2006; Judge, Chairman of Judges, SET for Britain Young Scientist Competition House of Commons 2003, 2004, 2006, 2007; **Jarvis,** Past Chair of the Southern Sector Region Section and member of the Professional and Education Committee of The Biochemical Society 1996-2002; **Keshavarz,** UK representative and member of the management committee of two COST Actions (European concerted research Action): COST 868: Biotechnical functionalisation of renewable polymeric materials; COST FP0602: Biotechnology for Lignocellulose Biorefineries, Chair, Biotechnology Group, SCI; Committee member (SOPHIED), White Biotechnology Platform of EU Suschem; Reviewer for Italian Research Council; **Kang,** NIH/NIAID Grant Reviewing member 07/2004, 11/2004, 06/2005, 08/2005, 07/2006; **Murray,** Council, Society of Reproduction and Fertility; **Eastwood**, Chair London Matrix Group.

Other indicators of esteem:

Bucke, Jubilee Visiting Professor of Microbiology at Kasetsart University, Bangkok, Thailand; **Dwek,** New Independent Investigator Award, International

Council for Electrophoresis Society, 2003; **Getting,** Willoughby Investigator award, 5th World Congress on inflammation 2001; **Hedger,** consultant for BBC Natural History Unit; **Patel*,** Symposium organiser for European Society for Biomedical research on Alcoholism and International Society for Biomedical Research on Alcoholism; **Porakishvili** Order of Esteem, Georgian Government; **Sarraf,** Fellow, of the Royal College of Pathologists; **Smith*,** Servier Young Investigator Award, 2002.