**Institution: UNIVERSITY OF BIRMINGHAM**

**Unit of Assessment:** 3

## a. Overview

Dentistry is one of five Schools within the College of Medical & Dental Sciences (MDS). The college strategically focuses on cross-cutting research domains of significant strength and expertise including Dentistry; Cancer; Immunity & Infection; Health & Population Sciences; Genetics & Development; Respiratory & Neurological Sciences; Cardiovascular, Endocrinology & Metabolism. Each domain is driven by important clinical specialties and basic research is translated to clinical endpoints, facilitated by interactions with the local NHS environment. MDS employs >800 researchers, attracts >£60M competitively-awarded research funding per year, and represents a world-leading international centre for biomedical research.

In Dentistry our overriding research objective is to develop and promote excellence in basic and clinical science with the goal of translating this to improve human oral and general health. Our research spans the three inter-linking theme areas of Tissue Injury & Regeneration, Biomaterials and Public Health & Clinical Epidemiology, which have strong translational focus and are underpinned by significant basic-clinical scientist partnerships. Our theme areas each encompass several related research groupings providing significant strength and enabling a critical mass of activity, concentration of research facilities and sharing of expertise. This interlinked structure facilitates collaborative interactions with areas of cognate strength across themes and in broader research areas of biology and medicine (see section **b**). This dynamic platform enables us to respond rapidly to new research opportunities arising from healthcare and funding initiatives and priorities as well as changes in personnel.

Research within the School draws on an extremely large, and socially and ethnically diverse, patient population (Birmingham Dental Hospital serves a population of ~5.5 million with treatment provided for ~115,000 p.a.), with basic science studies being undertaken in recently refurbished (at a cost of £1-million) state-of-the-art laboratories which will be replicated in our new Dental Hospital (due 2015).

## b. Research strategy

Our vision is to optimise and maximise the development, and use, of our resources and expertise to enable us to continue to be world-leading in original and distinctive research areas where we can have significant impact upon the mechanistic understanding, prevention and treatment of oral diseases. Our ultimate goal is to improve oral health and general health within the population. To achieve this we strive to provide a vibrant and dynamic research environment which will attract, retain and develop the very best researchers for whom we provide world-class infrastructure, resources and training (also see **c**).

Our research strategy builds on that developed over the last 10+ years in which we have focussed our activity in key areas of strength. Enhanced by our intra- and inter-university collaborations and collegiate structure and strategy, our research demonstrates increasing emphasis on interdisciplinary translational research facilitated through well developed and strong basic-clinical scientist partnerships. Our **three theme areas** (below) have evolved with recruitment of new staff (eg *Grant* - expansion of 'omics' research; *Dietrich*, *Ravaghi*, *Albuquerque* - greater emphasis on public health/clinical epidemiology; *Wiench* - development of oral cancer research). Over the REF period, in line with plans outlined at RAE2008, we have continued to grow and extend the international standing and awareness of our research through high-quality publications within high-ranking international peer-reviewed journals and strong international research collaborations. This growth is further evidenced by our international and national markers of esteem (see **e**).

We have continued to develop collaborative links with several research groups within MDS including: the MRC Centre for Immune Regulation and Musculoskeletal Ageing and the Medawar Centre for Healthy Ageing Research (exploring the links between oral, chronic & systemic inflammation & the ageing immune system); the Birmingham University Stem Cell Centre (BUSCC; development of new cell therapies) and Cancer Research UK Centre (oral cancer research). These

links are evidenced by membership of our staff on joint committees (eg BUSCC), co-supervision of several doctoral studentships (eg stem cell research and periodontitis with systemic inflammatory diseases), joint staff appointments (eg *Wiench* with Cancer Sciences) and joint publications (eg periodontal disease with rheumatoid arthritis / renal disease). Collaborations have been enhanced by the 2008 University reorganisation which has provided a new College/School-based structure.

Outside the College, the inter-disciplinarity of our research is evidenced by collaborations with researchers from Biosciences (proteomics and systems biology studies), Chemical Engineering and Metallurgy & Materials (for biomaterials and implant studies). Our intra- and inter-university collaborations (demonstrated by publications, grant income, Honorary Professors and PhD co-supervision) have considerably enhanced our research activity and enabled increased success in: i) targeting research sponsors where we have been previously under-represented (eg EU and NIHR programmes, ~£2-million awarded recently), and ii) attracting joint high-quality appointments (*Wiench* with Cancer Sciences) and doctoral research students (with several Schools across the University). Broader institutional strategies for collaborative research programmes, internationally involving China and Brazil, complement our existing international collaborations (eg with *He* - Fourth Military Medical University, Xi'an, China; *Rodrigues* - UNIBAN, Brazil and *Santos-Filho* - Universidade do Estado do Rio de Janeiro, Brazil) and are already resulting in attraction of research personnel (eg *PhD students* and *Visiting Researchers*). Our collaborative initiatives and evolution of research directions are essential in continuing the delivery of our high level of research activity and in enhancing our national and international reputation.

Described below are our **three broad research theme areas** which encompass our research groupings. These themes and groupings are aligned along disciplinary boundaries however this does not restrict cross-disciplinary interactions.

**1) TISSUE INJURY & REGENERATION.** This theme area seeks to understand molecular and cellular processes underlying tissue injury and health (periodontitis, endodontics & caries and oral cancer) to develop novel and improved approaches to diagnosis, prevention and therapy.

In the ***Periodontal disease*** area *(Chapple, Matthews, Grant, Dietrich, Milward, Cooper, Ling, Sharma)*, a major strand of research is focussed on unravelling the complex stress response pathways which occur during periodontal inflammation at the molecular, cellular and clinical levels. Identifying the mechanisms underpinning disease pathogenesis and the inter-relationships between periodontal inflammation and other chronic inflammatory diseases (such as rheumatoid arthritis) and the ageing immune system are key goals. Translation is a priority through clinical trials to provide novel diagnostics and host-modulating therapies. Indeed we have completed the first ever randomised phase 3 controlled trial of a phytonutrient supplement, designed for periodontitis treatment and developed over the last 6 years in collaboration with Unilever (Micronutrient approaches - Impact Case; Chapple et al. J Clin Perio 2012). We now lead a large European multicentre trial (ClinicalTrials.gov:NCT01229631), to test the clinical significance of these findings in an “un-treated” population. Characterisation of the saliva and crevicular fluid proteome for the first time in health, gingivitis, mild and severe periodontitis, is being undertaken in a project designed at novel biomarker discovery (with Philips Oral Healthcare & MARS Petcare UK – see Predictive Technologies - Impact Case study).

In the ***Pulp biology and regenerative endodontics*** research area (*Cooper, Smith, Shelton, Lumley, Tomson, Scheven)*, our long-standing programme on dental tissue regeneration is exploring the dentinogenic potentiality of stem/progenitor cells, their recruitment, tissue niches and matrix-mediated cell signalling, to provide a strong mechanistic foundation for clinical translation. Several staff are active members of BUSCC and national/international stem cell societies (eg *Cooper* – founding member of European Society of Dental & Craniofacial Stem Cells), which keeps us at the leading edge of developments within the field. This focus is complemented by our pioneering work on engineering of a physiological-like vital pulp tissue and is based on our mechanistic studies in pulp regeneration, identification of novel signalling pathways, matrix biology, and inflammation-regeneration interaction, which is central to clinical translation. Aspects of this work are in collaboration with world-leading scientists (eg *Nor* – University of Michigan, *Ferracane* -

Oregon Health and Science University, Portland, USA, *Simon* – University of Paris, *He* - Fourth Military Medical University, Xi'an, China). Other novel developing areas for translation include the biomodulatory application of ultrasound and photonics (NIHR funding – *Palin, Cooper, Milward*), and the exploitation of dental pulp stem cells for neurological repair (*Scheven*).

In the area of ***developing dental technologies***, our research on ultrasound (US) (*Walmsley, Scheven, Cooper, Sammons*) has characterised its use in the cutting and cleaning of dental hard-tissues. Studies bridge both periodontal and endodontic research programmes and also underpin our biological studies into the use of US for stimulating tooth regeneration (*Scheven, Walmsley*). The physical sciences aspect of our US research has resulted in the establishment of significant research collaboration with the University's EPSCR-funded Physical Sciences of Imaging in the Biomedical Sciences Doctoral Training Centre (*Walmsley, Cooper*). Through these links this work has evolved to include novel imaging of nanoflow under US (*Walmsley, Sammons*) and has recently attracted significant EPSRC funding. The dental cleaning aspect of US is further complemented by our research on the abrasive properties of dentifrices (*Smith, Cooper*) which has informed the development of novel toothpaste compositions in collaborative research funded by GSK for >25 years. These novel formulations minimise tooth wear whilst optimising cleaning and stain removal.

We are growing our research programme in ***Oral Cancer*** (*Landini, Wiench*), which draws upon interdisciplinary research in cell biology, biomedical imaging and the computational modelling of patho-physiological processes. This programme aims to identify and develop novel evidence-based diagnostic tools, novel biomarkers and therapeutic targets for oral cancer. The recent timely recruitment of *Wiench* from NIH, USA, who has significant cancer epigenetics expertise, fits well with the increased focus on head & neck cancer by MDS and recent high-level clinical scientist appointments (eg Professor Hisham Mehanna, Chair, Head and Neck Surgery). This area is anticipated to have significant sustainable growth and also complements our epigenetic studies in pulp biology (*Cooper, Smith*).

**2) BIOMATERIALS.** This theme area seeks to develop novel biomaterials and tissue engineering approaches for application in dental and broader body organ contexts and to relate their clinical performance to studies of their mechanical and biological properties.

In the area of ***Resin materials development***, key activities include studies optimising the setting reactions of photoactive resins and resin-based composites using innovative techniques to analyse the change in optical properties (*Palin, Shortall, Shelton, Cooper* - NIHR funded), curing light characteristics (*Palin, Shortall*), mechanical response of nanoparticulate resin composites and resin-modified 'sandwich' restorations (*Palin, Addison, Shortall*).

In ***Cement development***, our focus is on the generation and characterisation of high-strength bioresorbable calcium phosphate bone cements (*Hofmann*) and their functionalisation as drug release carriers. Other dental and orthopaedic related research, in collaboration with Orthos Ltd, is developing durable, rapid-setting, injectable cements for minimally-invasive surgery (*Hofmann, Shelton*). Cement-based endodontic sealing materials are also being developed and optimised (*Hofmann, Shelton, Coomaraswamy, Lumley*), including the development of methods for the accelerated setting of mineral trioxide cement aggregates for use in root canal therapy.

The area of ***Materials-cell/-tissue interactions and tissue engineering*** spans a range of activities aimed at clinical translation. Our implant integration work has recently been supported by a NIHR Clinician Scientist Award (*Addison*, £~1M) to explore implant driven tissue inflammation in collaboration with the periodontal research group. This work is complemented by studies on osteoblast responses to micro- and nano-structures (*Sammons*) and overall this area aims to identify novel diagnostic markers of implant failure and develop implant materials with enhanced biocompatibility. In the bone biology area, studies are investigating the effects of altering the proton density on nanophase hydroxyapatite (HA) surfaces to enhance bone formation and reduce resorption and to determine how HA-based bone substitute graft materials are resorbed in the body (*Sammons*). Collaborative industrial research (funded by Orthopaedic Research UK) is also

aimed at developing spring reinforced tissue engineered 'bone-to-bone' ligament replacements (*Sammons*). Strategies for promoting osteogenic differentiation of bone marrow stem cells using different materials/processing, eg octacalcium phosphate scaffolds, are also being investigated along with utilising hydrogel tissue technologies and rapid prototyping for the development of next generation bone replacement materials (*Shelton*). Hydrogel-based approaches for oral mucosa tissue engineering are also being examined to identify novel clinical delivery methodologies and provide disease relevant models (*Landini, Shelton, Cooper*).

**3) PUBLIC HEALTH & CLINICAL EPIDEMIOLOGY.** This theme area in Birmingham has a long-standing track-record and focuses on: i) building the evidence-base to underpin policy developments on access to, provision of, and delivery of, oral healthcare at the primary care interface; ii) assessment of the effectiveness of treatment modes within this setting; and iii) broader public health implications of our epidemiological evidence-base. In this research area (*Dietrich, White, Hill, Ravaghi, Chapple*), there is a strong focus on epidemiological oral health surveys of UK (Dental Health Surveys - Impact Case study) and international patient populations. This has helped identify disease trends and healthcare needs and thus strongly impacts upon healthcare policy and delivery. Importantly, our novel analyses have now identified significant relationships between oral and systemic diseases, including associations between periodontal diseases and cardiovascular disease and rheumatoid arthritis. As this theme is of strategic priority to the School we have recruited several NIHR-funded ACFs/ACLs to support and grow this area.

**Performance of new technologies and dental materials** within the real-world environment of dental practices *(Burke, Stewardson)* is assessed by way of two well-established Practice-Based Research Networks (PBRNs), which are pioneering in this increasingly recognised field. This approach facilitates translational research and helps identify needs for future development of targeted dental technologies. Interrogation of large datasets on dental restorations placed within the NHS has also characterised restoration longevity and survival as well as determining the factors influencing their performance and resulted in recommendations for optimal future treatment approaches (*Burke*).

**FUTURE RESEARCH PLANS AND SUSTAINABILITY**

We aim to build on our excellent research progress and sustain our standing as a leading international centre for our three well-developed research themes. Future research programmes will be carefully selected in response to identified national priorities and/or innovative ideas and will take into account plans for disseminating research to achieve the greatest impact (detailed in Impact Template). Many of our research areas have already secured funding well into the next REF period. Future research capacity and capability building will be ensured as detailed below:

***Development of our own researchers***

- "Growing our own" research leaders has been central to our success and has facilitated a strong team-working ethos. We will build further on this with development of early career researchers from pre-doctoral (eg ACFs) through to new lecturers and recruiting through a broad profile of appointments including NIHR ACFs/ACLs, doctoral researchers (national, European and international) and research fellows (with focus on high potential researchers including through the Marie-Curie & other European schemes, eg *Hofmann*). Development of these researchers, through our institutional graduate and postdoctoral schools, will reinforce our research culture and sustain our high-level research. We also have a strong policy of supporting staff in engaging with other researchers, organisations and learned societies at local, national and international levels.

***Targeted appointment of key researchers***

- Our changing staff profile due to retirement of several senior staff has also enabled us to recruit young researchers on rapid career trajectories. This approach has facilitated evolution of our research directions and enabled us to exploit new opportunities for growth which is also frequently in collaboration, including new research programmes in: oral cancer with Cancer Sciences, cleft lip and palate with Birmingham Children's Hospital, and periodontal disease with systemic chronic disease areas. These areas are being further supported and developed by recruitment of key personnel in clinical trials coordination and biostatistics.

***Collaborative research initiatives***

- We aim to continue to develop our existing, and initiate new, local, national and international collaborations with world-leading scientists wherever these strengthen and enhance our research. Our philosophy of nurturing basic-clinician science partnerships has also long been embedded in our research strategy and positions us well for our focus on translational research. We aim to maximise these strengths in our goal for research innovation for patient healthcare and well-being by continuing to target translational funding streams (eg Technology Strategy Board, NIHR) and growing our portfolio of clinical studies.

***Research infrastructure and environment development***

- We aim to maintain a diverse and international portfolio of funding, with further growth in our share of competitively awarded NIHR and EU grants whilst sustaining our excellent portfolio of research council, charity and industrial funding. This approach will enable capacity building and further strengthen our critical mass of research activity. Our proposed new Dental School & Hospital, at a cost of £50-million, is targeted for completion within ~2 years and world-class laboratories and clinics are planned to sustain our research programmes. The location of the new School, adjacent to the University campus, will further facilitate our access to equipment and expertise, reinforce research links and provide significant opportunity to develop new areas of research.

**c. People, including:**

**i. Staffing strategy, staff development, equality and diversity**

Our staffing profile reflects **strategic recruitment** to strengthen and develop key research areas whilst maintaining personnel across dental specialities for educational need. Recruitment and promotion are entirely on merit and support of equality and diversity are reflected in both our staffing profile and promotions record. **Integration of clinical academics and NHS-active researchers** is central to our translational research and clinical staff undertaking PhDs are routinely jointly supervised by basic scientists and clinical staff. Regular supervisory meetings along with cross-College seminars further enhance cross-disciplinary discussions and debate. Staff are encouraged to participate in a broad range of symposia and conferences nationally and internationally and this is supported by School Research Travel Funds. All research active staff (~40 in total) are encouraged to engage in active membership of the International Association of Dental Research as well as participation in other relevant organisations, societies and learned bodies. We are cognisant of the **differing career pathways and development needs of non-clinical and clinical staff** and through regular individual research reviews and mentoring by senior academic staff, we aim to develop all staff to maximise their potential (see section **e**). The School is committed to the principles of the Athena Swan Charter, as illustrated by the recent recruitment of four female lecturers (*Grant, Wiench, Batt, Gorecki*) over the past 3-years (7 available lecturer positions). Significant female representation in senior management positions and on School Committees and promotions panels also provides important role models for junior staff.

We are fully committed to develop our research staff, through the principles of the **Concordat to Support the Career Development of Researchers**. Staff draw upon a comprehensive range of support from the University's Professional Services units for training and development in areas such as grant writing, research leadership & supervision, project management, and enterprise & entrepreneurship. At College-level, the Research & Knowledge Transfer (R&KT) Office provide strategic input and comprehensive one-to-one support for research development, business engagement and technology transfer, as well as running College-wide workshops/training events. At School-level, a dedicated Research Administrator supports individuals and teams with identifying and submitting funding applications. We are also benefiting from MDS initiatives such as senior mentorship and internal peer review for all RCUK and NIHR research grants and tutorial-style support is embraced by early career researchers in Dentistry and is positively contributing to researcher development (*Addison, Wiench, Grant*). More recently, in order to strengthen staff engagement with strategic priorities, School- and College-level champions have been identified from our leading academics to support staff in identifying partnerships and funding opportunities in European networking, engagement with industry and international relations (*Walmsley, Dietrich, Chapple*). Our **Early career researchers** are further developed through the MDS Postdoctoral/Early Researcher Career Development and Training (PERCAT) programme.

Masterclasses, scientific writing workshops, mentoring, careers advice and access to Research Development Funds, equip staff with the necessary skills to become future leaders. Our vital and vibrant research culture combined with career development support, to increase the likelihood that promotions, rewards and progression are equitable and transparent, is aimed to ensure the retention of staff key to our future research aspirations.

**ii. Research students**

**Doctoral research students** represent key members of our research teams and their effective training and development is critical to realising their potential and equipping them for their future careers. Their importance is recognised with competitive college-based scholarship schemes, as well as institutional initiatives focussed on specific geographical areas (eg China and Brazil). Scholarship schemes also form an important part of our doctoral student-funding portfolio, with the School hosting a number of studentships co-funded by the University with the MRC, BBSRC, CAPES (Brazil), China Scholarship Council, along with several CASE awards from the BBSRC (GSK) and EPSRC (Implantium Ltd; Orthos Ltd). Our experiences with CASE awards has highlighted its merit in providing students with exposure to industry and commercial influences on R&D as well as opportunities for generating new technologies as evidenced by patent filing (eg, EPSRC with Orthos Ltd and *Hofmann, Shelton*). Doctoral students are assigned a minimum of two supervisors providing cross-disciplinary and basic-scientist-clinical expertise as well as an independent mentor for pastoral support. An appropriate mix of earlier and later career supervisory staff is encouraged to allow effective supervisor development. Progress is monitored through supervisory meetings at least monthly and by an annual review process, to enable on-going review and support. The University and MDS Graduate Schools provide fora for doctoral students to interact with the postgraduate research community on a broad cross-disciplinary basis as well as providing a broad skill base training through a range of courses and workshops. Our research students participate in annual University and MDS Graduate Research Festivals.

In Dentistry we encourage a strong community spirit for our doctoral students with provision of dedicated group study rooms and IT facilities, doctoral student representation on the School's Graduate School Committee and a range of social/team/network building activities which are inclusive of both staff and students. A regular seminar programme facilitates presentation skills training and discussion of student research with exposure to other research areas. The School also provides training sessions on 'statistics', 'public engagement with science and research', 'scientific writing', 'how to publish', 'open-access publishing' and 'Intellectual property', delivered by internal senior academics and external speakers (eg Resident Scientist at ThinkTank Science museum, BDJ Editor-in-chief, University statistical advisory service, collaborators from industry). Students are encouraged to join professional societies and we support them with, and applying for, funding for conference travel, collaborative visits, prizes, and fellowships. During the REF period, our students' research excellence is reflected in winning international prizes (eg, 2009 Paffenbarger Award, Academy of Dental Materials, 2010 IADR Heraeus Kulzer Award for innovation in materials testing, the 2010 and 2011 IADR Periodontal Research Group Past President's Award, 2012 John Zamet Memorial Prize in periodontal research, 2012 IADR John Gray Fellowship, the 2008 Sir Wilfred Fish Research Prize, British Society of Periodontology); securing grants (American Board of Forensic Odontologists, Oral & Dental Research Trust, European Society of Endodontology, British Society of Periodontology, British Orthodontic Society, RCS Eng Faculty of Dental Surgery, Funds for Women Graduates); as well as invited presentations (Royal Society of Medicine Clinical Forensic & Legal Section conference, University of Pennsylvania Gordon Conference in Periodontal Research, Br Assoc for Biol Anthropology & Osteoarchaeology Conference, International Symposium on Advances in Legal Medicine, Br Assoc. for Forensic Odontology). The majority of our students go on to pursue careers in science.

**d. Income, infrastructure and facilities**

Our **attraction of research funding** reflects the need to ensure our research is strongly supported to produce the highest quality outputs and is also a marker of our excellent research standing amongst funders. We have significantly increased our research awards during the REF period with a 325% increase in 2010/11 and 385% increase in 2011/12 both relative to 2009/10. Despite the challenging funding environment, our research income over the REF period has increased year-on-

year (aside from a slight fall in 2010/11), with a 40% increase in 2012/13 relative to 2008/09. This income is provided by a broad portfolio of funders including medical charities, RCUK, NIHR, EU and industry and demonstrates our strategic responsiveness to opportunities and initiatives. At RAE2008 we identified that we were under-represented in NIHR and EU funding and specifically targeted these areas with subsequent success (**EU-** RAPID ITN, Gums&Joints, TRIGGER Collaborative; **NIHR-** Clinician Scientist, RfPB & i4i awards).

The **quality of our infrastructure and facilities** is central to the delivery of internationally-leading research. Our strategy is to ensure we have in-house facilities that receive extensive and on-going use. We share or collaboratively access facilities/equipment used less frequently or which are of high cost (eg mass spectrometry). This fits well with our research strategy in building strong collaborations which extend scope, multi-disciplinarity and reach for our research programmes. We continue to actively develop state-of-the-art clinical and laboratory research facilities and our projected new Dental School & Hospital (due 2015) is designed with purpose-built facilities for research and clinical programmes with a translational focus. Recent strategic investment in capital equipment (eg Wellcome Trust – microCT; £0.8M BCHC Trust Grant) keeps us at the cutting-edge of research capabilities, with recent new equipment acquisitions supporting imaging (environmental SEM, confocal microscopy) and cell/molecular biology (Illumina DNA sequencer, real-time PCR, FTIR). Our team of research technicians (HEFCE, NHS & industry funded) oversee the smooth running of our facilities, provide training and support and contribute significantly to delivery of high quality research. These facilities are complemented institutionally by the MDS Technology Hub with its extensive range of large 'state-of-the-art' medical research equipment, other University central service facilities (eg mass spectrometry), the development of cutting-edge bioinformatics, the Human Biomaterials Resource Centre and a central asset register for facilities/equipment available within the University. We also benefit from access to equipment at other institutions – eg Synchrotron beam time (Oxford, Grenoble, Chicago – *Addison*), equipment access through the EPSRC (*Addison, Palin*) and the EPSRC equipment loan scheme (*Walmsley*).

Our **clinical research** benefits from our co-location in Birmingham Dental Hospital and access to a mixed and diverse population (see **a**), excellent clinical facilities, research nurses and hygienists, which underpin our clinical trials. We are also embedded within the £10-million Inflammation Research Facility (IRF) within the Centre for Translational Medicine (CTM) at Birmingham's new Queen Elizabeth Hospital, for research exploring links between periodontal and systemic diseases (underpinning our NIHR ACF/ACL research). The IRF houses 6 clinics where patient cohorts from 5 different specialties are collaboratively studied, and provides resources for disease specific assessment. Excellent infrastructure for the conduct of clinical trials exists with Birmingham's Clinical Trials Unit (CTU) which brings together expertise from across the University and three large, well-established, UKCRC fully-registered CTUs. We are able to further develop our capacity for clinical trials by accessing their expertise, and through the regional Research Design Service.

The School, through its Strategic Research Committee, the University's central Research Governance team and University's Clinical Trials Quality Management System, works closely with the local Birmingham Community Health Care Trust Research & Development office on all matters of **research governance** to ensure compliance with local, national and international standards and effective management of our activities, including assignment of research sponsorship, ethical approval and audit of these activities. The School holds a Human Tissue Authority (HTA) license (no. 12313) for storage of relevant materials for research and has a Designated Individual (*Chapple*) on the University's HTA Steering Group. The School has tissue bank ethical approval specifically covering the use of extracted teeth for use in research (REC ref. 09/H0405/33).

**e. Collaboration or contribution to the discipline or research base**

Collaboration is embedded within our research programmes, and has significantly extended the scope and inter-disciplinarity of our research. Joint authorships on manuscripts and co-applications on grants with collaborators highlight the success of our approach. Collaborations include **local, national and international partners**, eg work with a consortium of UK Dental Schools and the ONS on UK dental health surveys (*White, Hill*), EU-funded RAPID, TRIGGER and Gums&Joints (*Dietrich, Cooper, Chapple*), China (*Smith/ Cooper*), Brazil (*Addison, Palin, Chapple, Hofmann*),

US (*Smith, Landini, Chapple*). This is complemented by a number of industrial research collaborations (eg *Chapple/Milward/Grant* – Unilever, Philips, Mars, J&J, NSA) some of which are long-standing (GSK, 25+ yrs - *Smith/Cooper*; Unilever & Philips, 15+ yrs - *Chapple*) and have generated new technologies (eg Impact Case studies; patented new biomaterial-*Hofmann/Shelton*; new abrasive toothpaste formulations-*Smith/Cooper*). Locally, the CTM is an exciting collaboration between Dentistry (*Chapple, Dietrich*) and: Rheumatology; Renal Medicine; Pulmonary Medicine; and Diabetes, providing well-characterised cohorts with chronic inflammatory diseases to explore cardiovascular, bone and periodontal co-morbidity.

The importance of **interdisciplinary research** (eg utilising biological, chemical & physical sciences) is illustrated by our studies on implants (*Addison, Chapple*), dental/orthopaedic materials (*Palin, Hofmann*), and automated microscopy (*Landini*) amongst a number of other activities. The level and diversity of these collaborations has been central to much of our research strategy and establishment of a collegiate structure in Birmingham has greatly facilitated this. Our collaborative working has also been promoted through appointment of **international honorary visiting Professors** (*Ferracane* and *Nor* – Oregon and Michigan, US, respectively). We also regularly **host visiting international researchers** (eg Brazil - *Rodrigues* with *Addison/Palin* and *Santos-Filho* with *Chapple*: Japan - *Takahashi* with *Cooper/Smith*: China - *He* with *Smith/Cooper*: Germany - *Krifka* with *Smith/Cooper*).

Our researchers undertake **national and international leadership roles in Dentistry** with their involvement being at various levels often reflecting career stage. Staff in more senior leadership roles, include: British Dental Association Scientific Adviser (*Walmsley*), BSODR Management Committee member (*Walmsley*), President of BSPPD (*Walmsley* – 2010/11), President BSODR Dental Materials research group (*Addison* – 2011/13); IADR and AADR Board/Council member (*Smith* to 2010), President Elect of the IADR PBRN (*Burke*), Treasurer of the UK Oral & Dental Research Trust (*Chapple*), European Federation of Periodontology Treasurer & Core Executive Committee member (*Chapple*, 2007-2012), IADR Periodontal Research Group Program Chair (*Chapple*, 2011-2015), President of the British Society of Periodontology (*Chapple* – 2014/15). Our researchers also **guide national and international agendas** through: invitations to address the All Party Parliamentary Group for Dentistry in the Houses of Parliament (*Burke*), to sit on the Guidance Committee of the Fund for Scientific Research, Belgium (*Palin*); peer review for research council of the Hong Kong Government and Dutch Technology Foundation STW (*Walmsley*); Peer review for Natural Sciences and Engineering Research Council of Canada (*Palin*). **Expert advice and consultancy is provided to industry**, influencing their R&D programmes (evidenced in impact case studies) such as: representation on the Global Advisory Board's of Unilever, Philips Oral Healthcare, Johnson & Johnson (*Chapple*), consultancy/advice to Colgate-Palmolive Company & Dentsply on dental ultrasonics (*Walmsley*), consultancy/advice to Dental Alloys & Betts Metals Group (*Palin*).

Our **research excellence** is also evident through senior editorial positions (eg, Editors-in-Chief include: J Dent Res - *Smith*, to 2010; J Dent- *Walmsley*, to 2011; Dental Update- *Burke. Associate Editors:* J Clin Perio, Perio 2000, J Perio Res- *Chapple*, Eur J Prosth- *Stewardson*) *Editorial boards* (J Endod & J Perio Res- *Cooper*; Arch Oral Biol- *Smith*; Int Endod J- *Lumley*; The Fractal Lab J, & J Oral Maxfac Surg, Med & Path- *Landi*ni; Int J Adhes Adhesives, Dent Mat & J Biomat Appl- *Palin,* J of Public Health Dentistry- *Dietrich,* Eur J of Dent Ed - *White*).

Our researchers continue to be recognised at the highest levels internationally as reflected in **awards and prizes:** *Cooper*- IADR Young Investigator Award; *Chapple*- RCS Eng Charles Tomes medal; *Ling*- John Zamet Memorial Prize in periodontal research offered in conjunction with the Alpha Omega London Chapter and Charitable Trust. The internationally-leading profiles of many of our researchers have led to numerous invited keynote lectures at (inter)national conferences, society meetings and other Universities. Our further strong engagement with the discipline and leadership is evidenced by our involvement in the **scientific organisation of conferences and symposia** (eg European Dental Materials Conference – *Addison, Palin*; UK Society for Biomaterials – *Sammons, Shelton, Hofmann, Palin*)**.**