Institution: University of Dundee
Unit of Assessment: UoA1 Clinical Medicine
A. Overview

Research in Clinical Medicine is focused in the **Medical Research Institute**; together with the Medical Education Institute this forms the School of Medicine at the University of Dundee (Dean, **Morris)**, part of the College of Medicine, Dentistry and Nursing (CMDN). The Institute is characterised by internationally-recognised high impact research on mechanisms of disease, health informatics, genomics, clinical trials and translational research. Principal Investigators (PIs) are organised into five research divisions: **Cancer Research**, **Cardiovascular & Diabetes Medicine** (both returned here), Imaging & Technology (UoA15), Neuroscience (UoA4) and Population Health Sciences (UoA2). Dermatology research (also returned here) is conducted jointly with Cancer Research and forms a sixth division (Molecular Medicine) shared with the College of Life Sciences (CLS). The Institute collaborates closely with cognate research groups within CLS (UoA5), Nursing and Dentistry (UoA3) and the College of Art, Science and Engineering (the latter through the theme of Medical Imaging and Technology, UoA15).

The Institute is led jointly by a clinician and a scientist (**Belch**, **Wolf**), as are each of the research divisions, ensuring integration of laboratory and clinical research. This organisational structure, established in 2011, was coupled to significant investment in new research facilities. Our laboratories are located at Ninewells Hospital, one of the largest teaching hospitals in the UK, and our research strategy is strongly informed by our close working relationship with NHS Tayside, with whom we have established the Tayside Academic Health Sciences Network. This Network is led by the Head of College (**Connell**), who is also Vice Principal for Research for the University, ensuring that medical research is at the heart of the strategy of the University.

B. Research Strategy

i. Objectives

We aim to improve health outcomes by an improved understanding of the mechanisms of disease, including key genetic, social and environmental factors. Our approach drives the translation of research between the laboratory and the clinic, with fundamental research being informed by important clinical problems. Our strategy is to concentrate resources in areas of research where we have impact in order to sustain and grow a world-class reputation. This ethos is also reflected in our approach to medical education; the School is consistently rated as one of the best for medical training in the UK and this reputation is enhanced by our strong focus on research.

Our overall objectives are:

- To undertake research from molecules to populations to identify mechanisms underlying major diseases.
- To translate fundamental discoveries between the laboratory and the clinic to develop stratified/personalised medicine.
- To improve the diagnosis and treatment of disease, thereby improving health.

To accomplish these goals we have:

- Implemented the highest standards for the recruitment and development of staff and research students.
- Provided state-of-the-art infrastructure for research, including core facilities.
- Created an inspiring and collaborative environment for multidisciplinary research.
- Ensured the sustainability and growth of our research though sound financial planning and rigorous assessment of activities.
- Developed partnerships of mutual benefit with funding agencies, industry, the NHS and international collaborators.
- Enhanced our excellent interactions with the local population, promoting health via public education and engagement, including recruitment to clinical trials and population studies.

ii. Achievement of strategic aims for research during the assessment period

At RAE2008 our submission to UoA5 (Other Laboratory Based Clinical Subjects) focused on six key objectives, namely: foundation of a Cancer Centre; development of research imaging; establishment of an interdisciplinary Centre for Neuroscience; creation of a Pharmacogenomics and Pharmacogenetics Centre; funding for a Centre for the Genetics and Therapy of Skin Diseases; and improvement of research support infrastructure through the development of a Scottish network of clinical research nodes. These aims have all been met during the period of assessment, providing the framework for a major structural reorganisation and the focussing of research in areas of strength and strategic importance over the last three years.

iii. Significant changes to research environment

In 2011 we established the Medical Research Institute to carry out world-class research at fundamental, translational and clinical levels, capitalising on existing strengths and developing new areas of multidisciplinary research. We have focused on major disease mechanisms, bringing clinical and non-clinical academics into a common organisation exemplified by disease-focused, multidisciplinary research divisions with cross-cutting themes of informatics, imaging and stratified medicine. We have invested strongly in improved laboratories, core facilities and research support. Researchers have been accommodated in the Clinical Research Centre (2010) and adjacent Jacqui Wood Cancer Centre (2012), with extensive consolidation and refurbishment of existing laboratories (total cost >£7.5M). The Institute includes around 500 research staff and 180 postgraduate students.

iv. Strategic development and sustainability

Our overall goal is to sustain and develop world-leading research that has high impact through measurable improvements in health outcomes. Our strategy is to make new appointments and invest in infrastructure in areas where we have existing strengths and which are key to our future development. This strategy enables us to respond to and indeed lead initiatives in Scotland, the UK and internationally in order to bring in substantial new investment from major funding agencies. We have four key aims over the next five years:-

Strategic aim 1: To exploit the informatics and genomics revolutions for improved medicine and healthcare

Health informatics, in which we have established a world-class reputation, is one of our major strengths. This is particularly true in diabetes medicine; to quote Sir Mark Walport, then Director of the Wellcome Trust (The Times, 30th May 2011): “If you live in Dundee and suffer from diabetes, you have recently been taking part in a medical revolution”. Prime examples include the Scottish Care Information-Diabetes Collaboration, developed in partnership with NHS Tayside (£6M), which collates clinical information on over 271,000 diabetics in Scotland and represents the world’s most comprehensive eHealth record for the care of people with diabetes. This Collaboration has facilitated studies that include the £3.7M Scottish Health Informatics Programme (2008-2012) funded by the Wellcome Trust, Medical Research Council (MRC) and Economic and Social Research Council (ESRC); the €43M DIRECT (DIabetes REsearCh on patient stratification) study (led by **Pearson**); the €32M Innovative Medicines Initiative SUrrogate Markers for Micro- and macro-vascular hard endpoints for Innovative diabetes Tools (SUMMIT) study on biomarkers for diabetes complications (co-led by Dundee); and the €48M EU Innovative Medicines Initiative award on the pharmacogenetics of Type 2 diabetes (also led by **Pearson**). The Scottish Care Information-Diabetes Collaboration also formed the basis for the **Scottish Diabetes Research Network** (led by **McCrimmon**, £415K p.a.). In the last two years the University has invested >£1M to develop capacity in health informatics, building on the existing strengths of the **Health Informatics Centre (HIC)**. Recently (2013), Dundee became one of four UK-wide **Farr Institutes of Health Informatics Research** (**Morris**, **Macdonald**; £10.5M) and co-ordinator of the UK network (£39M from the MRC and nine other funders; led by **Morris**). The Farr Institute will be a high profile interface between academia, the public, practice, policy and industry with the potential to translate academic strengths rapidly into benefits for patients and population health. A notable commercial success in this area is the start-up company **Aridhia Informatics** (co-founded in 2008 by **Morris**; see impact case study), which now has 82 employees and operates internationally.

Aligned with our eHealth expertise we have developed world-leading bio-repositories, with blood samples pre-consented for genetic research. **Generation Scotland**, a collaboration led from Dundee (Chief Scientist Office, Scotland, £8.9M; Scottish Funding Council £3.8M), has established a world-class resource for researching the genetics of health and illness. We will develop these resources further through the Scottish Health Research Register (**SHARE**) of people who agree to allow the use the coded data in their NHS computer records. In Tayside, **GoSHARE** (led by **Palmer**) allows investigators to access spare blood from routine investigations to perform genome-wide association studies. This developing bioresource will provide a platform for new research in cancer, cardiovascular disease and diabetes, as well as asthma, skin disorders and other diseases. We will couple our strengths in informatics and genomics with molecular, cellular and organismal analysis of the mechanisms of diseases. We will strengthen our capacity in these areas with new senior appointments to link informatics with cardiovascular disease, diabetes and cancer, and are actively recruiting to these positions.

Strategic aim 2: To develop multi-disciplinary research themes across disease boundaries

A major part of our strategy is to build cross-disciplinary research to exploit developing fields. We aim to do this through bringing together teams working in different disciplines to focus on a common clinical or scientific question. To promote such interactions and practical initiatives ('Grand Challenges') we have established a £40K p.a. **Development Fund**. The University has also established substantial pump-priming support for interdisciplinary and translational research projects from the **Welcome Trust Institutional Strategic Support Fund** and internal matching resources (£360K p.a.) which we manage jointly with the College of Life Sciences. We will develop further interactions between clinicians and those working in the physical sciences, engineering and mathematics; we will ensure impact in Clinical Medicine through a pathway for the application of scientific discoveries to *in vivo* models and patients. A major initiative for the next five years will be the application of research in **Stratified Medicine** to the major diseases of cancer, cardiovascular disease and diabetes; we are partners in the Scotland-wide Stratified Medicine Innovation Centre, along with the Universities of Aberdeen, Glasgow and Edinburgh. In 2010 we established a **Centre for Pharmacogenomics and Pharmacogenetics** (section D). From this initiative we aim to build on our existing strengths in Dundee to establish a new world-class institute that will bring together genomics and genetics, proteomics and informatics to provide a comprehensive approach to understand the development of disease and responses of individuals to drugs.

Strategic aim 3: To develop translational research between the laboratory and the clinic

The Medical Research Institute forms a bridge between the clinic and the strong biomedical research portfolio of CMDN and CLS. Our aim is to extend the traditional translational model through actively supporting both bench-to-bedside and bedside-to-bench research using shared expertise to elucidate the biological mechanisms underlying the role of candidate susceptibility genes (Translational Genomics). Our translational research is supported by the Tayside Medical Science Centre (TASC), the Tayside Tissue Bank and core research facilities for biomarker development. The Drug Discovery Unit in CLS offers facilities for pre-clinical drug discovery following target identification, and our PIs have a number of projects that exploit this resource. We will strengthen this theme through the targeted recruitment of research staff to facilitate translation in areas including medical oncology and cellular metabolism.

Strategic aim 4: Engage with the NHS and industry to deliver improvements in healthcare

An exciting new strategic alignment is the development of the Tayside Academic Health Science Network (TAHSN), which allows us to work in closer synergy with our key NHS partner to support the development of clinical trials and translational research (primed by funding from the Scottish Government). As the exemplar for Scotland, we will work with other Scottish Medical Schools and their NHS partners (as part of Health Sciences Scotland) to extend the TAHSN model to other regions. Key developments that contribute to TAHSN include the establishment of the Centre for Applied Health Research Health (co-developed with Sullivan, UoA2; and Renfrew & Clarkson, UoA3) and the Improvement Academy to support Quality Improvement in the NHS (www.t-coe.org.uk/_page.php?id=5). The appointment of nine early NHS consultant research fellows with protected research time will build further clinical research capacity. The Chief Scientist Office supports these translational research activities with £10M per annum. In addition, we will develop specific projects and strategic partnerships with industry ranging from studentships with local

small-medium enterprises to alliances with major pharmaceutical companies.

v. Research Groupings

Two main research groupings encompass staff submitted in this Unit:

Division of Cancer Research. This Division includes 32 PIs, >100 research staff, around 30 postgraduate students and 12 support staff. Its remit is to understand the biological and behavioural mechanisms underlying cancer and to translate this research to the clinic to improve the prevention, diagnosis and treatment of disease. Joint leadership by a cell biologist (**Clarke**), a pathologist (**Herrington**) and a surgeon (**Steele**) ensures a multidisciplinary and translational approach to research. During the period of assessment, the Division relocated to new laboratories in the Clinical Research Centre (2010) and the adjacent Jacqui Wood Cancer Centre (2012). Guided by an external review (2011), our research focuses on the three major clinical areas of colorectal, breast and skin cancer. The cross-college theme of dermatology includes members of the Divisions of Cancer Research (**Leigh**, **Proby**, **South**) and Molecular Medicine (**McLean**, **Brown** and **Leslie Pedrioli** who are included with Cancer Research in this submission). Six teams hold **Cancer Research UK (CR-UK) Programme Grants** (two initiated during the last three years; **Clarke**, **Hiom**) and three team leaders hold career development awards/fellowships. In the last five years, **Wolf** and **Leigh** have been awarded highly prestigious **European Research Council (ERC) Senior Investigator Awards**. **Wolf's** work has led to two successful spin-out companies (see impact case study) and has been further enhanced by renewal of CR-UK and EU Framework Programme 7 funding totalling £3.6M. Research on non-melanoma skin cancer and skin diseases has been strengthened by a renewed CR-UK programme for **Leigh** (£1M), MRC and Wellcome Trust programme grants for **McLean** (£7.3M) and a Wellcome Trust strategic grant of £6M in 2012 for a Centre for Dermatology and Genetic Medicine. Our strength in breast cancer research was recently recognized by the establishment of a Breakthrough Breast Cancer Programme (2013) led by **Thompson**. Research into the behavioural mechanisms, prevention and surveillance of cancer (**Anderson**, **Steele**) is included in UoA2 and we interact with Imaging through four new senior academic appointments (UoA15). The Division forms a pillar of the **Dundee Cancer Centre** (Director, **Herrington**), awarded Centre status by CRUK in 2009. Translational cancer research is promoted by the **Experimental Cancer Medicine Centre,** established with Edinburgh in 2012 with CR-UK Drug Development funding, and the Dundee Edinburgh Cancer Informatics Programme: Harnessing Excellent Research (**DECIPHER**) project, a £2.1M Technology Strategy Board Development Fund collaboration providing a research safe haven, clinical application and patient portal allied to the CR-UK Stratified Medicine Programme. The **Tayside Tissue Bank** houses the highest recruiting component of the Breast Cancer Campaign Breast Tissue Bank, services trial blood sample acquisition/storage for the CR-UK Clinical Trials Awards and Advisory Committee-funded radiotherapy trial and is among the largest providers for Sanger Centre initiatives in breast cancer.

Division of Cardiovascular and Diabetes Medicine. The Division of Cardiovascular and Diabetes Medicine has 26 PIs, >100 research and support staff and around 20 postgraduate students led by a scientist (**Ashford**) and a clinical cardiologist (**Struthers**). It brings together clinicians and translational scientists in single location, facilitating research into common factors underlying metabolic diseases and enabling close collaboration and sharing of resource infrastructure. Its research strategy has strong links with major pharmaceutical companies which contribute to funding of applied research and is guided by an external review conducted in 2011. It focuses on four themes: **(1) Health Informatics:** This theme has a strong international reputation and major external funding (see above section B, iv, Aim 1); **(2) Molecular Epidemiology and Genomics:** We have led the way in creating links between phenotypic data from eHealth records and genome wide association studies. In addition to the research described above, key examples are the CSO/Diabetes UK-funded Scottish Diabetes Research Network-Type 1 Diabetes Bioresource, Tayside Screening for Cardiac Events (TASCFORCE; **Belch**), and a Systems Biology Study to Tailored Treatment in Chronic Heart Failure (BioStat-CHF; **Lang**, **Struthers**). Other epidemiological resources include the Scottish Diabetes Research Network-Epidemiology, a grouping that has produced 17 high impact papers in the last five years, and the Scottish Heart Health Extended Cohort. **(3) Translational Genomics**: Divisional restructuring brought together

translational scientists who focus on cardiometabolic diseases, working to enhance collaborative research and exploit human genome wide association study data by investigating the molecular biology of candidate genes (**Palmer**, **Pearson**). Infrastructure developments include the Metabolic Phenotyping Centre (led by **McCrimmon**), which allows *in vivo* assessment of glucose and energy metabolism in genetic models. **(4) Translational Clinical Science and Clinical Trials**: The **MEMO Unit,** a purpose-built research centre with a focus on pharmaco-epidemiology and safety trials (**McDonald**, **Mackenzie**) runs the British Heart Foundation-funded PATHWAY project, large streamlined safety studies (e.g. the SCOT trial examining the cardiovascular safety of non-steroidal anti-inflammatory drugs; www.scottrial.co.uk/) and the FAST study (£18M) on safety of treatments for gout. Health informatics has enabled large-scale academic and commercial clinical trials with impacts on the use of aspirin in diabetes for primary cardiovascular event prevention, allopurinol as a new anti-ischaemic therapy in angina, and the validation of B-type natriuretic peptide as a prognostic marker for silent cardiac end-organ damage (**Lang, Struthers;** see impact case study).

vi. Mechanisms and practices for promoting research.

The recent reorganisation of research activity of the School of Medicine provides a new administrative structure that focuses on the sustainability and development of research. Having established this structure, the research environment is further enhanced by several approaches:-

a) Recruiting and developing researchers to build capacity. We believe that we can only achieve our goals by attracting and nurturing the very best researchers. We have established a robust system to identify and evaluate targets for recruitment and implemented a comprehensive staff development strategy (see Section C, i) to assist the establishment and development of new junior PIs through five year Discovery Fellowships with mentoring and institutional support.

b) Training the next generation of medical researchers. We consider the training and nurturing of postgraduate research students to be a key role for the School of Medicine. Training of postgraduate research students takes place at the level of MRes, MD and PhD degrees. A cross-college PhD programme for Clinical Fellows (run together with CLS) is integrated with non-clinical PhD training and forms a key stage in the Dundee Clinical Academic Track, a pathway for clinical training and development of the next generation of research-active clinical academics.

c) Building core facilities and support for research. We have improved the range, accessibility and performance of our research support services and core facilities (Section D). Core research facilities each have an academic lead, an operations manager and additional support staff, and respond to requirements through a user group. Each has a business plan that determines access charges and is encouraged to develop external contract work, thus ensuring financial sustainability. Research infrastructure is provided by core support staff led by an Institute manager who reports to the Institute Directors. Each division has an operations manager and an administration office. A School Finance Office supports cost analysis for all grant applications and provides post-award administration of grants supported by TASC, which calculates clinical and NHS costs. Institutional approval of applications is provided by CMDN-assigned Research and Innovation Services staff and a Business Development Manager who facilitates commercialisation and grant acquisition.

d) Ensuring the international competitiveness of our research programmes. The Medical Research Institute's External Scientific Advisory Board provides invaluable advice on its overall research portfolio and the strategy of each division. Regular members include Nicholas Hastie CBE FRS (Edinburgh), Sir Stephen O'Rahilly FRS (Cambridge), Sir Tim Hunt FRS (CR-UK London Research Institute) and Ron Hay FRS (CLS, Dundee). The Scientific Advisory Board conducts an annual strategic review at a two-day retreat with senior research staff. New recruits and junior investigators are also invited to present their research programmes. From 2011, each Division will undergo major quinquennial reviews with independent external assessors. In addition, each programme-supported unit undergoes a comprehensive external review by its funders, typically on a five-year cycle.

e) Establishing multidisciplinary centres. The Institute strongly encourages multi- and interdisciplinary research activity through a joint research management structure and cross-divisional research themes. We promote multidisciplinary research via a Division that spans CMDN and CLS (**Molecular Medicine)** and have established Cross-College Research Centres which are exemplified by the **Centre for Dermatology and Genetic Medicine**. This initiative is supported by

a Wellcome Trust strategic grant and aims to translate basic science discoveries in genetic skin disease into clinical applications. It includes support for core next generation sequencing facilities; treatment routes involving siRNA, protein, cell and *ex vivo* gene approaches (**McLean**, **Brown;** see impact case study); and identification of new molecules with the Drug Discovery Unit in CLS.

f) Developing research collaborations through a vibrant culture of communication. Each Division runs a seminar programme in which prominent scientists, especially those spanning discipline boundaries, present lectures on their latest research; attendance by the entire academic staff of the Institute is strongly encouraged. Weekly internal divisional research talks allow students and researchers to present their own work. Divisions and cross-college interest groups hold retreats to review current research activity and develop future plans. The School of Medicine also hosts named annual lectures in Cancer Research, Diabetes Medicine, Cardiovascular Medicine, Neuroscience and Population Health Science throughout the year; these are delivered by distinguished scientists and clinicians and are aimed at a broad audience including medical students, postgraduate students, researchers and academics. The CMDN Annual Research Symposium, at which PhD students, postdoctoral fellows and technology providers present posters, gives researchers an overview of research and teaching activities across the College.

g) Promoting open access and public engagement. CMDN has an active open access policy and supports PIs to ensure open access publication; additional costs are supported by the University where necessary. The College employs a full time Communications Officer to support public engagement activities and website development. Our public engagement activities include open-doors days, visits by local politicians, talks at our local 'Café Science', school visits, summer projects and work experience for school students, and interactive exhibitions like those held at the Dundee science centre 'Sensation'. Many students, researchers and academics take part in local fundraising activities and public information meetings: **Henderson** was awarded a Flame of Hope Award in 2012 by CR-UK for his public engagement work.

C. People

i. Staffing strategy and staff development

Our strategy is to recruit world-class researchers to develop specific areas with the paramount criteria of excellence; to foster the development of existing research staff through infrastructure support, mentoring and pathways for promotion; to facilitate the transition from postgraduate researcher or clinician to academic staff member; and to train the next generation of medical researchers through postgraduate studentships as well as clinical lectureships and fellowships.

a) Recruitment of Researchers

We are committed to developing our research capacity by recruiting the most talented research clinicians and scientists. Principal investigators are recruited by the Institute Recruitment Committee: short-listed candidates are invited to give a formal seminar followed by a 'round table' discussion to discuss current research and future plans. New PIs are either tenured (for senior appointments), given an initial fixed-term appointment or placed on a tenure-track with a five-year appointment ('Discovery Fellowship') and tenure review at the end of year four. For clinical academics, the recruitment process also involves assessment of clinical capabilities and opportunities in consultation with NHS Tayside. Over the period of assessment we have recruited 13 PIs submitted in clinical medicine (UoA1): **Brown** (Clinical Senior Lecturer and Wellcome Trust Intermediate Fellow 2009), **Chalmers** (Wellcome Trust Postdoctoral Clinical Fellow and Clinical Lecturer 2012), **de la Vega** (Discovery Fellow 2013), **Herrington** (Clinical Professor 2010), **Hiom** (Professor 2009), **Inman** (Reader 2010), **Leslie Pedrioli** (Independent Investigator 2009), **Mackenzie** (Clinical Senior Lecturer 2008), **McCrimmon** (Clinical Professor 2013), **Pearson** (Clinical Professor 2008), **Saurin** (Lecturer 2013), **Saville** (Lecturer 2011), **Short** (Clinical Lecturer 2012).

Key areas for development in the next five years where we are already are targeting recruitment are: medical oncology; cell metabolism (linking metabolic research in cancer with diabetes and cardiovascular medicine); cellular responses to stress and drugs. We will strengthen links between informatics/epidemiology (UoA2), and diabetes & cardiovascular medicine and

cancer through additional core-funded senior posts in informatics/biostatistics. The Institute will also continue to recruit tenure-track PIs who hold or are strong candidates for external salary support through fellowship schemes; our primary criterion is research excellence in priority fields.

b) Development of researchers

Support for Principal Investigators. We encourage postdoctoral and clinical researchers to become PIs by supporting applications for personal fellowships and academic posts. New PIs are allocated senior mentors and provided with start-up packages including studentships to found their research teams and pump-prime grant applications. Our flexible laboratory space is allocated on the basis of research need determined by the number of researchers in a team. Established PIs are encouraged to achieve programme-level support to sustain their research teams, as informed by external Scientific Advisory Board review and research symposia with colleagues. Before submission all grant applications are peer-reviewed internally in keeping with Research Council expectations and we carry out mock interviews where appropriate. Candidates for promotion are reviewed each year; specific goals to achieve this are defined in discussion between each PI and his/her Head of Division. Special consideration is given to PIs whose research output may have been limited or affected by personal circumstances, including absence due to maternity leave.

Implementation of the Concordat to Support the Career Development of Researchers. The Vice Principal of CMDN and representatives of research academics, researchers and the Organisational and Professional Development unit form the University Steering Group for the Concordat. Recent key achievements include a commitment to move research staff on fixed term contracts with more than four years' continuous service onto open-ended contracts. Dundee has been recognised by the European Commission for "HR Excellence in Research" (renewed November 2013), demonstrating ongoing development of a working environment that supports research excellence and increases focus and impact. We have implemented an action plan detailing the steps required to ensure effective support and mentoring of women at all stages of their career. The University is committed to the Athena SWAN charter: an application for the institutional bronze award has been submitted and a new full-time position has been appointed to support this initiative. All academic staff receive training to ensure full commitment to the University precepts that support equality and diversity.

Training the next generation of clinical academic researchers. The development of future leaders of bioscience and health research is a major strategic aim expressed in the University's Translational Medicine Research Strategy. The Dundee Clinical Academic Track (medicine.dundee.ac.uk/dcat/) has been implemented to address this strategy by providing a pathway for the training and development of clinical academics; it is now one of the best-developed schemes of its type in the UK. In 2013 the School of Medicine had 11 Clinical Lecturers and 12 Clinical Fellows.

Fostering a culture that engages research staff. We believe that a culture that engages all research staff is critical, both for their development and for the overall success of our endeavours. Researchers have an Association with divisional representatives who encourage their peers to participate in research meetings and social activities; elected members sit on School and College Board meetings. Each Division holds regular academic staff meetings that provide a forum for the discussion of research strategy and offer feedback to the Institute Management Team, which meets on a monthly basis to discuss all issues concerning the operations and strategy of the Institute. We have an active programme to encourage discussion and dissemination of the impact of our research, from training for PhD students to facilitation of public engagement by academics.

A clear process for objective setting and review. All staff undergo an annual Objective Setting and Review evaluation to identify measurable targets and specific learning needs for the coming year and assess achievement of the previous year's objectives. Organisational and Professional Development provides training and development opportunities, including pathways for career development and succession planning, to academic staff and postgraduate researchers. This helps staff and postgraduate researchers to fulfil their potential, develop their careers and skills and improve the focus and impact of their research. 171 researchers attended one or more courses on the Organisational and Professional Development Programme between 01-09-12 and 31-08-13.

ii. Research Students

The training and nurturing of the next generation of medical researchers is a key role of the School of Medicine. The MRes and PhD programmes in each Division are linked: for example, students on the one year MRes in Cancer Biology (annual intake ~10) can progress to the three year PhD programme, providing a 1+3 model that will be extended to other research themes and marketed externally. A cross-college PhD programme for clinical fellows (run together with CLS) is integrated with non-clinical PhD training and forms a key stage in Dundee Clinical Academic Track.

Funding: Our programmes offer non-clinical studentships to UK, EU and overseas applicants via a variety of funding mechanisms including University-wide MRC and Biotechnology and Biological Sciences Research Council (EastBio) doctoral accounts, competitive Research Council CASE awards, CR-UK, A*Star (in which students spend two years in Dundee and two more in Singapore), CAPES (for Brazilian students), Medical Research Scotland (with industrial partners), other charities and the University itself. We actively seek self-funding students and those able to compete for schemes such as Carnegie/Caledonian Scholarships. Support for clinicians is provided by various schemes under the aegis of the Dundee Clinical Academic Track.

Programme: The School currently has 128 PhD, 30 MD, 18 MSc and 2 MPhil students. The induction programme for new students includes bioinformatics, statistics and a wide choice of Generic Skills training modules. PhD students spend 3-4 years on a single research project under the direction of two supervisors. The Thesis Monitoring Committee system provides a structured framework which supports, mentors and monitors doctoral students. Integrated student activities include journal clubs, an annual postgraduate student symposium and a competitive travel grant scheme supporting presentations at international meetings and an active Postgraduate Student Society with representation on the School Board. All postgraduate students are required to attend Division seminars given by external speakers and present their own work at Divisional talks (in a joint programme with postdoctoral researchers) and annually at the College Student Symposium. Students are expected to attend at least one relevant meeting (UK or abroad) that includes international participation, usually in years two or three. The strength of our programme is evidenced by the 25 prizes awarded to our postgraduate students during the assessment period.

Industrial interactions: Many PIs have strong links with industry; during the assessment period we have hosted a total of 22 CASE and 3 other industrially sponsored studentships with a variety of commercial partners from small biotechnology enterprises to major pharmaceutical companies. Several of our graduates now hold senior positions in the pharmaceutical industries.

D. Income, infrastructure and facilities

Research income: Total research income for UoA1 in the period of assessment was £93,251,952. Income from specific bodies funding health research was £6,085,340, i.e. £122,936/submitted staff FTE (£119,320/submitted staff member). This includes £6,083,215 from the CSO that was misallocated to BIS Research Councils in the HESA returns and is therefore not shown in under Health Research in REF4b (the remaining £2,126 in this category is correctly allocated income from the NIHR). Excluding CSO income, the period's BIS Research Council income was £6,576,258, equating to £132,854/FTE (£128,946/submitted staff member).

Research Infrastructure: The reorganisation of the Medical School since 2008 has been coupled to an extensive refurbishment of existing laboratory space (£1.2M), the establishment of core research facilities laboratories and the opening of a new laboratory building, the Jacqui Wood Cancer Centre, formerly the Scottish Translational Medicine Research Collaboration hub building, built in 2010. The adjacent Clinical Research Centre (2008) contains the laboratories of the Centre for Molecular Medicine (£2.6M building costs) and clinical imaging suites (£4M). In 2013-2014, high-quality space near the Jacqui Wood Cancer Centre complex at Ninewells will be refurbished to create an interdisciplinary health informatics research environment; together with new facilities in Edinburgh this will act as the hub of the Scottish Farr Institute (Farr@Scotland).

Core facilities and support: A key aim of the recent restructuring and space rationalisation within the School of Medicine has been to improve the range, accessibility and performance of our

research support services and core facilities. These facilities are supported by core staff, operated on a cost-recovery basis and accept external contract work:

- **Biomarker and Drug Analysis** has advanced mass spectrometry and immunoassay capability for absolute quantification of drug compounds and metabolites (for pharmacokinetic analyses, biomarker discovery and mechanistic studies) and endogenous biomarkers in serum or tissues.
- **Flow Cytometry** and **Genetics** provide technical support and managed equipment access for cell and DNA analysis, including Next Generation Sequencing with Illumina based infrastructure supported by a Wellcome Trust award to **Leigh** and **McLean.**
- **Advanced Microscopy:** As a significant improvement in facilities for microscopy, a new centre will be established in 2013-14 with the purchase of two Deltavision systems and an advanced Zeiss LSM710 confocal to supplement the existing two Leica confocals and other microscopes as part of a £0.45M investment funded by CR-UK as part of two programme awards (£0.2M), Ninewells Cancer Campaign (£0.15M) and the University (£0.1M). This core facility will be jointly managed with CLS and will provide access for Institute researchers to additional instruments such as Deltavision OMX and multi-photon microscopes based in CLS.

Dundee Cancer Centre: The Dundee Cancer Centre (cancercentre.dundee.ac.uk/; Director, **Herrington**) was created in 2010 in conjunction with a CR-UK initiative to promote cancer research across the UK through a network of centres. It provides a hub to facilitate collaboration and communication of cancer-related activities across the University, NHS Tayside and partner organisations. The Dundee Cancer Centre promotes interactions between clinicians and scientists by organising meetings and provides training for the next generation of cancer researchers through two PhD studentships and a clinical fellowship each year. It promotes cancer awareness and prevention through public engagement and distributes a regular newsletter to >600 recipients.

Health Informatics Centre (HIC): The HIC exploits Tayside and Scotland's exceptional data resources and tradition of excellence in eHealth informatics to support data linkage projects at scale; manage a research safe haven for the secure analysis of non-consented datasets; write bespoke software applications for research groups; and support recruitment to clinical trials. In the last two years, there has been substantial internal investment by the University (£1.22M) to fund eight new programmers and the installation of high performance computing infrastructure. The expanded multidisciplinary team includes bioinformatics, software development, high performance computing, statistics, medicine, genomics, and large-scale, industrial system development. This inward investment has leveraged substantial further external support: in 2012, the MRC and nine other funders established four Health Informatics Research Centres across the UK (a total of £19M led from Dundee by **Morris** and **Macdonald**). Further capital funding has come from the MRC to create of a single UK institute (Farr Institute for Health Informatics Research), with the Scottish consortium receiving £5M of capital funding from the MRC and an additional £2.5M of leveraged funds to create Farr@Scotland (**Morris**, with **Sullivan** and **Colhoun**, UoA2).

Tayside Medical Science Centre (TASC): The University of Dundee, in partnership with NHS Tayside, played a leading role in the establishment of Health Science Scotland, a national platform for the promotion of excellence in patient-oriented research through the **Scottish Academic Health Science Centres** involving the four Scottish (clinical) Medical Schools. Within Dundee, this activity is channelled via TASC (www.tasc-research.org; established in January 2010 and led by **Connell** and **Belch**), which oversees clinical research facilities (Clinical Research Centre, Clinical Imaging Centre, Tayside Clinical Trials Unit, Tayside Tissue Bank) and provides a supportive governance framework for all clinical research carried out in Dundee. The TASC R&D office manages the >£7M per annum that goes into developing and supporting our excellent patient-oriented research infrastructure. TASC aims to provide infrastructure to facilitate research for all health professionals and to promote a strong culture of research within the NHS. It has brought together, within a single organisational framework, the existing functions of several existing groups:

- **The Tayside Clinical Trials Unit** (TCTU), established in 2008 by the University of Dundee and NHS Tayside, delivers excellence in the design, conduct and governance of clinical trials. It supports researchers undertaking clinical trials of investigational medicinal products and other randomised controlled trials, offering scientific, funding, technical and information technology expertise from concept to analysis and reporting. In 2009, the TCTU became one of only 45

Clinical Trials Units registered under the UKCRC Clinical Trials Unit Registration Process.

- **The Clinical Research Centre** (CRC; Director, **Belch**) provides state-of-the-art facilities and a dedicated professional infrastructure to facilitate high-quality clinical research and experimental medicine across Tayside. It is housed in a purpose-built building with a participant-focused environment including outpatient and specialist investigation areas as well as administration and training facilities. The CRC's Clinical Imaging and Intervention Centre, one of only a few such centres worldwide, houses an advanced 3T Magnetic Resonance Imaging scanner with fMRI, Positron Emission Tomography–Computed Tomography and a fully-equipped interventional suite. The CRC is integrated with existing NHS facilities and is a collaborative partner with Tayside Clinical Trials Unit, providing an effective operational framework within which clinical studies are conducted safely to the highest standards of Good Clinical Practice and research governance.
- **The Pat McPherson Centre for Pharmacogenetics and Pharmacogenomics:** This £3.2M research centre opened in 2010 and houses teams working on genetic and personalised medicine, particularly in cancer and diabetes. Half of its initial funding (£1.6M) was raised locally; matching investment came from the University. The Centre houses the **Tayside Bioresource**, a major component of the **Tayside Tissue Bank** (www.tissuebank.dundee.ac.uk), one of the four biorepositories supported by NHS Scotland through the CSO. It holds DNA donated by >40,000 individuals (>10% of the total Tayside population) for use in future research and matched biosamples such as serum, plasma, urine and RNA. It has established a CSO-funded platform with robotic liquid handling systems and hardware for high-throughput genotyping; the pipeline has been optimised for throughput of 10,000 genotyping reactions in a morning. The surrounding infrastructure includes sophisticated web-based informatics, scheduling, data capture, and reporting. A unique and robust sample anonymisation system, which barcodes all clinical biosamples from the point of collection, has been established in collaboration with HIC. This infrastructure has supported recruitment to Generation Scotland and TASCFORCE.
- **Dundee Epidemiology and Biostatistics Unit:** This group of biostatisticians and epidemiologists forms one of the core research facilities within the Institute, offering internationally renowned expertise in eHealth solutions and analysis of large patient database. The Unit is led by Donnan (UoA2) and provides collaborative input for the design and analysis of regional and national trials and pharmaco-epidemiology and genetic studies funded by MRC, Wellcome Trust, CSO and the pharmaceutical industry.

Policy and practice in relation to research governance: UoA1 is represented on the University Research Governance and Policy Sub-Committee, which optimizes governance and policy for non-clinical research within the University. In line with 3Rs principles, it includes an animal usage ethics committee. The Clinical Research Governance Committee, which receives reports from the Data Governance and Privacy Committee and from TASC, reports to the NHS Tayside Improvement and Quality Committee and the Research Governance and Policy Sub-committee. UoA1 clinical research governance has twice been approved following formal inspection by the Medical and Healthcare products Regulatory Agency and TCTU has UK Clinical Research Network certification, as has the Tissue Bank/Biorepository. All research clinicians hold recent (within two years) Good Clinical Practice training certificates and regular training seminars occur monthly which must be recorded in the Researcher's Training log, reviewed during the Objective Setting and Review. All clinical trials governance is run out through TASC and the full process is on view in the Clinical Trials Governance and Approvals road map (www.tasc-research.org.uk/_page.php?id=303).

E. Collaboration and contribution to the discipline or research base

As well as collaborating within the University, we have close links with other Scottish and UK universities (e.g. **Herrington's** joint CR-UK programme with physicists at St Andrews) and Scottish Medical Schools via initiatives such as Health Science Scotland, Scottish Academic Health Science Centres and Generation Scotland. We lead in the establishment of Academic Health Science Networks in collaboration with NHS Tayside and the Scottish Government. We also have global reach and ambition; for example, our international collaboration with Kuwait secured

significant income (>£20M) and was shortlisted for the Times Higher Education Supplement International Collaboration of the Year 2012 (www.dasmaninstitute.org/kuwait-scotland).

Markers of esteem for staff submitted in the Unit in the period 2008-2013 include:-

Awards: CBE for **Leigh** (2012) and OBE for **Wolf** (2010); Fellowship of the Academy of Medical Sciences (**McLean** 2009, **Morris** 2009, **Struthers** 2011); Fellowship of the Royal Society of Edinburgh (**Belch** 2011, **Hayes** 2008, **Leigh** 2009, **Struthers** 2009); Fellowship of the British Pharmacological Society (**MacDonald** 2012); Fellowship of the Society of Biology (**Clarke** 2012, **Fuller-Pace** 2010, **Hayes** 2013, **Keyse** 2012, **Woof** 2013).

Prizes: Arthur C. Neish Young Investigator Award of the Phytochemical Society of North America (**Dinkova-Kostova** 2011); Sims-Woodhead Medal for Outstanding Contribution to the Journal of Pathology (**Herrington** 2010); British Toxicological Society John Barnes Prize Lectureship (**Wolf** 2011); Clinical Endocrinology Trust Lecturer (**Connell**, 2009); CR-UK 'Flame of Hope' award (**Henderson** 2012); Diabetes UK R.D. Lawrence Lecture (**Pearson** 2013).

Positions of responsibility: Chief Scientist for Scotland (**Morris** since 2012); Convener, Scottish Academic Health Science Collaboration (**Morris** since 2010); Governor, Health Foundation (**Morris**); Association for International Cancer Research Board (**Herrington** since 2007); Member of Council, Academy of Medical Sciences (**Leigh** 2007-10; **Connell** 2008-11); CSO Lead, National Research Governance implementation (**Belch** since 2010); Health Science Scotland (**Belch**); Scottish Government Departmental Speciality Adviser in Clinical Pharmacology & Therapeutics (**MacDonald** 2007-13); Vice-President (2011-13) and President of British Hypertension Society (**MacDonald** 2013-15); Scotland lead for NIHR Cardiovascular Speciality Group (**Struthers** 2010-13); Tenovus National Scientific Advisory Committee Chair (**Struthers** since 2004); Chair, Clinical Endocrine Trust (**Connell** since 2012), Chair, Education and Training Board, General Medical Council (**Connell** since 2013); Clinical Chair, American Endocrine Society (**Connell**, 2009-10).

Research Fellowships: AICR Research Fellowship (**Inman** 2003-09), Breast Cancer Research Fellowship (**Bourdon** since 2012); CR-UK Career Establishment Award (**Dinkova-Kostova** 2009-14), Senior Clinical Research Fellowship (**Crook** 2012-2016); Wellcome Trust Intermediate Clinical Fellow (**Brown**, 2009-14); Wellcome Trust Postdoctoral Clinical Fellow (**Chalmers**, 2012-14).

Peer review panels: Chair, Wellcome Trust Expert Review on Genetics, Genomics and Population Research (**Morris**, current); CR-UK Science Funding Committee (**Herrington** 2006-08, since 2011); CR-UK Programme Awards Specialist Review Committee (**Hiom** 2010, **Clarke** 2013); BBSRC Committee D (**Clarke** 2010-13); MRC Clinical Fellowships (**Belch** 2003-2009; **McCrimmon** since 2013); MRC Industrial Collaboration Awards (**Clarke** 2008); MRC Strategy Board Scoping Group on Environmental Exposure and Chronic Disease (**Wolf** 2011); MRC Integrative Toxicology Training Partnership Scientific Committee (**Wolf** 2011); NIHR College of Experts for Programme Grants for Applied Research (**McMurdo** since 2011); Age UK/Research into Ageing Research Advisory Committee (**McMurdo** since 2011); AICR Scientific Advisory Board (**Clarke** 2010, **Hiom** since 2011); Diabetes Research & Wellness Foundation Research Advisory Board (**McCrimmon** 2012); Leukaemia Lymphoma Research Fund site visit committee (**Hiom** 2010); EC FP7 Health Systems Biology (**Clarke** 2009); Royal Society International Grants (**Clarke** 2005-10); Royal Society of Edinburgh Fellowship Review (**Belch**); Academy of Medical Sciences Fellowships (**Struthers**); Diabetes UK Grants (**Sutherland** 2010-12); Technology Strategy Board Assessment (**Palmer** 2012, 2013); CSO Experimental Medicine (**Sutherland** 2010-15); Science Foundation Ireland Biochemistry (**Clarke** 2009, 2011); Tenovus Scotland Symposium and Medal Committee (**Inman** 2005-13); International Advisory Board of the Hannover Biomedical Research School (**Keyse** since 2010)**;** French National Cancer Institute Cancer Biology Grants Committee (**Keyse** since 2007); Catalan Cancer Research Grants (**Smith** 2013); British Skin Foundation Large Grants Advisory Committee (**South** 2012); Health Research Board and Science Foundation Ireland Translational Research Award Programme (**Wolf** 2011); Asthma UK Research Review Panel (**Woof** since 2010); >20 other review panels and advisory groups.

Journal Editorships: Submitted staff are members of editorial boards on >40 medical and scientific journals.