Institution:	Newcastle University
Unit of Assessment:	UoA5

a. Context

The staff in our submission perform basic science with a focus on academic scientific excellence. Maximising our non-academic impact thus requires a clear and proactive strategy which has developed into a defined programme in three key areas: **[1] Public Policy and Services**: our broad expertise contributes to wider aspects of science policy; **[2] Culture and Society**: our existing programmes in public engagement inform the debate on the impact of science on society; **[3] Commercial, Economic, Health and Welfare**: the commercial exploitation of our research delivers long-term economic and healthcare benefits. This latter area is where our impact activities are most mature; our first spin out company, Arrow (co-founded by **Hawkins** in 1998), was sold to AstraZeneca for $150M in 2007. Our four current case studies are all commercial: uses of bacteria for industrial protein production (**Harwood**); engineered DNA polymerases for molecular biology (**Connolly**); role of drug transporters in dosage regulations (**Brown**); prostate cancer diagnosis (**Birch-Machin**). We describe below our current impact activity and plans for its future growth.

b. Approach to impact

Our activities are co-ordinated and supported by the Institute Research Strategy Group (IRSG; see REF5) who give feedback on grant outlines, provide a planning forum for potential exploitation/communication and advise on the allocation of funds for impact activities. The IRSG has also instigated our social networking programme, extended links with local schools (Leading Edge, see 2 below) and appointed O'Neill (liaison officer) to optimise outreach with schools/public in the North East. Annual performance development reviews (PDR of PIs by **Lightowlers**; post-docs by PIs) provide an excellent one-on-one environment to encourage and discuss routes to impact (1-3 below). Training in impact delivery is provided by the University Staff Development Unit. Our three major approaches to impact are:

[1] Public Policy and Services. PDRs are an effective route to encourage PI involvement in influential policy/review committees. Our diverse contributions in this area are exemplified by: **Errington**, who served on the influential Government led *Blackett Review on Wide-Area Biological Biodetection* and the BBSRC Health portfolio Working Group (both from 2012); **Whitaker**, who served on the UK Stem Cell Network (until 2011), from 2013 as non-executive Director of the Cell Therapy Catapult, and is on the board of the life sciences business network Bionow; **Harwood**, who serves on an expert panel of the Association of Manufacturers and Formulators of Enzyme Products and on the Executive Board of the European Federation of Biotechnology; **Brown**, who was Chair of the Drug Transporter Group of the American Society of Pharmaceutical Sciences; **Aldridge**, who serves on the Communications Committee of the Society for General Microbiology; **Salgado**, who sits on the Executive Committee of the Science is Vital campaign group.

[2] Culture and Society. The IRSG co-ordinates the communication of our research and ensures exploration of innovative avenues to public engagement. For example, to encourage young people to undertake science careers, we have expanded our existing series of PI/school interactions to include Leading Edge (run by **Aldridge**). Here, our PIs partnered Year 9 school children to design and execute a 6 month research project; in 2012, this culminated in a public event involving ~220 people. Nine of our PhD students also engaged with Year 8 school children to emphasise the importance of biomarkers in life science research (see *Inside Cells and Molecules Blog*, http://tinyurl.com/ICaMB-yr8). We describe our research in generally accessible magazine articles, such as **Lakey** in Catalyst (a magazine for students aged 14-19 years published 10/2012 by the Gatsby Science Enhancement Programme) and **Errington** in New Scientist (01/2013) and The Scientist (07/2013). We are also regularly involved in national scientific festivals. For instance, **Lewis** and co-workers represented the UK structural biology community at the June 2010 London festival commemorating the 350th Anniversary of the Royal Society (~50,000 attendees). Furthermore, many of our PIs/post-docs/PhD students (http://blogs.ncl.ac.uk/icamblog/) represented the University at the 2013 British Science Festival in Newcastle, Europe's largest science event; illustrated by epiFECTION (**Aldridge**), which is an online, interactive epidemic simulator developed in Newcastle. Three hundred members of the public discovered with epiFECTION how data modelling of individuals' decisions can predict the spread of a mock epidemic. We also encourage engagement via the media/press as exemplified by **Gerdes** (BBC1 03/2013 "Bang Goes the Theory") and **Pearson** (GMTV, 03/2010; BBC3 05/2011 "The Big Fat

Truth about Low Fat Foods"; Daily Express front page 03/2010; The Oprah Magazine 07/2011). Our science has been published in international press e.g. the Times of India, the Australian, Australian Daily Telegraph and Australian Herald. To augment these engagement activities IRSG established (via **Aldridge**, **Perkins**, **Salgado**) the use of social media (Blog, Facebook, Twitter). Excitingly, the blog attracted 5,625 unique visitors, 14,798 worldwide views (02/2013-10/2013).

[3] Commercial, Economic, Health and Welfare. Our extensive PhD/CASE studentship programme has for many years been a key mechanism to enable PIs with an industrial partner to develop research towards economic/health impacts. We have been very successful in obtaining CASE awards (23 this REF period, **25% increase from RAE2008**) from the BBSRC (DTA/G, Industrial, Targeted Priority) and MRC (Industrial) with partners such as Orla and Pall Europe (**Lakey**), Prolysis (**Errington**), Novozymes (**Gilbert**, **Harwood**), Unilever (**Gilbert**), Technostics and FMS Corporation (**Pearson**), Replizyme and Bioline (**Connolly**), and Syngenta (**Brown**). The success of this approach is exemplified by the CASE studentships underpinning current case studies (section d) and early stage ventures such as Peptest (**Pearson**) through a BBSRC/Technostics CASE studentship to Parikh. A notable further example is from **Lakey**, co-founder of Orla Protein Technologies Ltd, which designs and manufactures nanoscale interfaces for use in diagnostics. Orla led the Technology Strategy Board-funded VIRASENS project, which included £355K EPSRC funding to **Lakey**, thus capitalising on **Lakey**'s prior BBSRC CASE (Le Brun) and MRC Industrial (Roque) studentships. A novel influenza test using a surface acoustic wave biosensor has subsequently emerged, leading to a joint venture, Oj-Bio (2009), between Orla and the Japan Radio Company. Oj-Bio aims to commercialise mobile phone based diagnostic tests and was recently awarded a £1M Biomedical Catalyst grant to develop the influenza test, £1.1M TSB for a periodontal disease test, and a £1M NIHR Invention for Innovation (i4i) Programme award with UCL to develop an HIV test. In 2013, the BBSRC highlighted Orla and OJ-Bio on their home page as an example of successful impact (http://tinyurl.com/BBSRC-Lakey).

Commercial developments are fully supported at all levels in the University. For example, PIs are encouraged through the annual PDR process to advise industry by providing expertise or expert witness services (e.g. **Brown**, Gilead, Shire; **Connolly**, New England Biolabs, Bioline; **Errington**, Biota Pharmaceuticals; **Hawkins**, Arrow, Avacta; **Lakey**, Pharmathene, Inviragen). The Faculty Enterprise Office ensures IP protection (6 patents filed by our PIs in the REF period) and provides guidance on licensing agreements (**Connolly**). Faculty support includes an Associate-Dean for Innovation and Enterprise (**Whitaker**), who facilitated interactions between **Errington** and Goodfellow (UoA7), leading directly to the establishment of Demuris. This University spinout aims to identify novel antibiotics by exploiting natural products synthesised from a major collection of actinomycetes. Faculty funding for Newcastle University Protein and Proteome Analysis (see REF5), provides biotech with bioprocess optimisation and R&D support. Benefitting companies include Avacta, Demuris, Fujifilm Diosynth, Immunocore, and Selective Antibodies. The Protein Purification and Characterisation Unit (run by **Hawkins**), established with lab infrastructure and instrumentation from Arrow, underpins University-wide research. Notably, a project on biofilm disruption with staff from Marine Biology (Burgess, UoA7), Chemistry (Hall, UoA8) and UoA5 (**Hawkins**, **Lewis**, **Murray**) attracted funds from Unilever and Procter & Gamble. A strength of the Faculty is the close connection between clinicians and PIs, facilitating the bridging of the gap between basic science and the clinic. Notably, this is exemplified by the interactions established prior to 2004 between mitochondrial biologist **Birch-Machin** and local clinicians that underpins the Prostate Core Mitomic Test case (section d), and by **Pearson**'s collaborations with local transplant surgeons which led to Peptest, a new early-stage diagnostic device for gastro-oesophageal reflux.

c. Strategy and plans

The importance of impact has grown enormously in recent years and, as shown here, our efforts have resulted in significant success. To encourage future impact we have developed a 5 point plan to build on our established interactions with policy makers, the general public and our beneficiaries in industry and in schools.

[i] UoA5 PIs are major drivers of basic science research in the Faculty of Medical Sciences and we will support the best science across a broad spectrum, including links to human health. Importantly, our strategy is to increase PI engagement with the wider Faculty and the local NHS Foundation Trusts where appropriate, to exploit their strong history of translating research to the clinic. The IRSG and the PDR process will be used to identify and develop translational opportunities as they

arise. This strategy will be augmented by the recent allocation of Faculty Business Development Managers to each academic unit, to proactively meet PIs to identify opportunities for translation and then to provide the necessary support to maximise the impact of research funding.

[ii] We will continue to nurture start-up companies, e.g. Demuris (**Errington**), Orla (**Lakey**), and projects such as Peptest (**Pearson**). Moreover, the Faculty funded a 3 year post-doctoral position to support **Brown**'s renal tubule models and provided financial incentives (e.g. section d) to attract industrial interest. In addition, the Faculty provides a responsive IP environment and attractive licensing agreements for start-up companies. Progress in current and future ventures will be monitored principally by IRSG and PDRs (section b).

[iii] New industrial links will be forged by continued expansion of our successful PhD programme (sections b, d), targeting research with potential economic and/or health impact, and PIs will be encouraged to identify new CASE industrial partners/funding. This strategy will be supported by an Advisory Group consisting of externally-based industry scientists (Unilever, Procter & Gamble already confirmed) established to guide our current and future BBSRC DTPs (see REF5).

[iv] Impact will be maximised by identifying and exploiting relevant RCUK priority areas. For instance we are integrating our strengths in bacterial cell biology and computing sciences to promote synthetic biology, as evidenced by the new inter-Faculty flagship **Centre for Synthetic Biology and Bioexploitation** (est. 03/2013, Directors **Errington**, Wipat UoA11). The University has committed to purpose-build the Centre adjacent to the Baddiley-Clark building. Several international companies have already been attracted to become associate members of the Centre, including CRODA, Fujifilm Diosynth and Procter & Gamble.

[v] We will expand our school/public engagement portfolio. The success of Leading Edge has led to extra funding which will enable engagement with 15 further schools in Newcastle (6), North Tyneside (6) and Gateshead (3). We also will expand public engagement, building on our involvement at the 2013 British Science Festival by extending our new social media channels (2013) to inform the public of our ongoing research. "Site visit" counts will be monitored by IRSG to judge effective communication with the public and to ensure that material of the highest impact is showcased to its maximum potential.

d. Relationship to case studies

Impact can take decades to emerge. Our case studies highlight how we nurture and maintain long-term development. The following three examples illustrate this process:

[i] Our PhD programme (section b3) has been central to the development of the **Brown** case, which focuses on drug-drug interactions (Windass, AstraZeneca 2000-04); the **Connolly** case, which came from long standing research on DNA polymerases (Fogg, BBSRC/Amersham Pharmacia 1996-2000); and the **Harwood** case, which involves the generation of bacterial strains supporting industrial enzyme manufacturing (Stephenson, BBSRC/Novozymes 1992-95; Rees, Thwaite, Williams BBSRC/DSTL Porton Down 1993-96, 1997-2000, 1998-2001, respectively). The success of these case studies has led to further BBSRC CASE studentships, which support current and future developments/spin out research. For example, archaeal DNA polymerases (**Connolly**) have been the subjects of recent studentships with Replizyme (Richardson, 2007-11) and Bioline (Keith, 2009-13). Furthermore, the continuing development of renal tube models (**Brown**) is currently supported by AstraZeneca (Chung, 2010-present).

[ii] In the Faculty, mitochondrial studies are a cross-UoA (including UoA5) research strength, evolving from the Mitochondrial Research Group, which was established in 1990 by **Lightowlers** and Turnbull (UoA1). Long-standing collaborations and shared expertise within the Newcastle mitochondrial research community, together with Faculty support (IP/market survey/fund raising/coaching), nurtured the **Birch-Machin** case, which links mitochondrial DNA damage to improved prostate cancer diagnosis.

[iii] The University has provided IP protection in our 4 case studies, and is continuing its support to fund further development and commercialisation (section cii) of the renal tubule model (**Brown**). This has led directly to the recent signing of an exclusive distribution licence with Solvo Biotechnology.