Informatics and the Life Sciences
The Scientific Case

Introduction
Informatics studies the representation, processing, and communication of information in natural and man-made systems. The central problems concern structure and resources: How to link structure to behaviour? How much resource is needed to build a particular structure? What are the characteristics of large multi-scale structures (e.g. the internet or an animal brain)? Informatics has developed a distinctive methodology involving mathematical modelling, simulation, experimentation, and observation that is strongly interdisciplinary and is directed to developing understanding at the systems level.

Since the molecular biology revolution, we have gained significant insight into biological systems through their analysis as informational systems. This treatment of biological systems as informational systems is in its infancy, but it will have fundamental effects in the whole of biological and medical science. The effects in Informatics will be no less profound as Informatics researchers are challenged by the scale and complexity of biological systems.

At Edinburgh we have a unique opportunity to drive this research forward. The School of Informatics, with approximately 90 Principal Investigators, achieved the UK’s only 5*A rating in Computer Sciences in the last RAE round and possesses a combination of breadth and strength unparalleled elsewhere in the UK and competitive worldwide. Across the Life Sciences we have in excess of 100 Principal Investigators working on Neuroinformatics, Cognitive Systems, Bioinformatics, Systems Biology and e-Health in units rated 5 or 5* in the last RAE. This combination of scale and excellence is unmatched in the UK.

Our plan is to collocate all our Informatics activity in one new purpose-built location, the Informatics Forum, in three years time. This will maximize interaction amongst Informatics staff, and provide a single point of contact for co-workers in other units in the University. For collaboration in Informatics and the Life Sciences, there is a unique and immediate opportunity for the Wolfson Foundation to create a world-class concentration of researchers in the emerging fields of Neuroinformatics, Cognitive Systems, Bioinformatics, Systems Biology, and e-Health.

What is Informatics?
Informatics’ central notion is the transformation of information – whether by computation or communication, whether by organisms or artefacts. In natural and artificial systems, information is carried at many levels, ranging, for example, from biological molecules and electronic devices through nervous systems and computers and on to societies and large-scale distributed systems. It is characteristic that information carried at higher levels is represented by informational processes at lower levels. Each of these levels is a proper object of study within science or engineering. Informatics aims to develop and apply firm conceptual, theoretical and technological foundations for the study, analysis and design of a wide variety of computational systems.
The scope of Informatics
In its attempts to account for phenomena, science progresses by defining, developing, evaluating and refining new concepts. Informatics is developing its own fundamental concepts of communication, knowledge, data, interaction and information, and relating them to such phenomena as computation, biological processes, thought and language. By developing the computational metaphor, Informatics provides the means to undertake an informational analysis of systems, creating new links between disciplines with their own methodologies and perspectives, based on a new scientific paradigm and common engineering methods.

Computational systems
Computational systems, whether natural or man-made, are distinguished by their great complexity, with regards to both their internal structure and behaviour, and by their rich interaction with the environment. Informatics seeks to understand and to construct (or reconstruct) such systems, using analytic, experimental and engineering methodologies.

Informatics provides an enormous range of problems and opportunities. One challenge is to determine how far, and in what circumstances, theories of information processing in artificial devices can be applied to natural systems. Another is to determine how far principles derived from natural systems are applicable to the development of new kinds of man-made systems. One can also consider systems of mixed character: a question of longer-term interest may be to what extent it is helpful to maintain the distinction between natural and artificial systems. A challenge of a different order is to explore the many ways in which information systems can help to solve problems facing mankind.

Informatics and the Life Sciences
Biologists are developing our understanding of genes, proteins and cells in terms of the information they carry and communicate, and explaining biological development and function in these terms. Informatics has an important role to play in at least three ways:

- In understanding how these computational elements interact to produce complex system behaviours.
- In developing new and efficient computational methods to aid in the analysis of biological systems. Examples of this are: the application of machine learning techniques to gene and pathway identification, the use of rule-based systems for prediction of protein and other molecular structures, the modelling of antibody/antigen interaction sites and the use of computer simulation models of the nerve cell to identify the effect of specific pharmacological intervention.
- In solving the conceptual and engineering problems that arise in creating a computational and informational infrastructure that is adequate to support this kind of science. Examples of this include: text mining of the biological literature to link genetic information to function, and developing database systems that provide adequate provenance information and are capable of supporting the kind of annotation work that is common in biology.

The improved understanding of how natural information systems evolve, grow and function in turn stimulates Informatics research.
Building and exploiting synergy
The University has recognized the huge potential for Informatics and the Life Sciences' interaction in Edinburgh, and has initiated a series of activities to build the synergy and exploit it to drive new discovery. This bid aims to build on these initiatives to create a world-class centre. The basis of the bid is research excellence in:

- The School of Informatics (RAE 5*A, 90 PIs)
- The School of Biological Sciences (RAE 5, 150 PIs)
- The College of Medicine and Veterinary Medicine (Clinical Sciences RAE 5*, 320 PIs)

All of the above are supported by work in Mathematics (mathematical biology), Chemistry (chemical and structural genomics), Physics (complex systems), and Engineering and Electronics (biomedical engineering).

This is supported by an e-Science infrastructure that is unsurpassed in Europe. Clustered around the National e-Science Centre are:

- The National Digital Curation Centre that will provide state of the art solutions to data management issues in e-Science.
- High Performance Computing expertise located in EPCC and Physics including the team providing the HPC-X service and joint projects with IBM to exploit the Blue Gene machine.
- A range of e-Science, application science and infrastructure projects, including Grid, Astoria, edict, OGSA DAI, that provide in-depth expertise in e-Science support for projects.
- A local infrastructure that provides high performance networking and a 150 Terabyte research storage area network.

The integration of Informatics and the Life Sciences at Edinburgh is widespread and multi-faceted. We have substantial existing strengths in neuroinformatics and cognitive systems. We are in the process of restructuring bioinformatics in Edinburgh into a new centre. And we have started new initiatives in systems biology and e-health. For all these initiatives, the University is providing considerable resources, especially in the senior posts that are required to lead them.

We intend that the Informatics component of all the initiatives will be based in the new Informatics Forum building with the UK's National e-Science Centre (NeSC). The wet laboratory science will take place in the adjacent Medical School building in George Square, at the science campus at The King's Buildings, or at the Little France or Western General Hospital sites – depending on the particular needs of the interaction.

The goal of this proposal is to secure financial support that will allow us to address key problems in Neuroscience, Cognition, and Biology by developing the key disciplines that link work in Informatics and the Life Sciences. Financial support from the Wolfson Foundation is essential for establishing a Centre in the Informatics Forum that will support and nourish these key interactions.
Our strategy is to pursue all major initiatives at the Informatics and Life Science interface, including:

- Neuroinformatics, centred on the EPSRC/MRC funded Neuroinformatics Doctoral Training Centre.
- Cognitive Systems, establishing the Centre for Cognitive Systems to enable innovative research that cuts across traditional life science/physical science disciplinary boundaries.
- Bioinformatics, focused on The Edinburgh Centre for Bioinformatics (ECB), which will provide leadership and co-ordination for a very large and wide-ranging activity that has developed ‘bottom-up’ across many different units in the University. We see this as an essential underpinning for all the other initiatives.
- Systems Biology, a new initiative oriented to addressing the fundamental problems in understanding the emergent behaviour of biological systems.
- e-Health, a new initiative involving Medicine and the College of Science and Engineering, together with the Lothian NHS Health Board, aimed at supporting a more evidence-based approach to the provision of healthcare.

1. Neuroinformatics

**What is neuroinformatics?**
Understanding the human brain, the most complex organ known, at all its levels from molecular to cognitive, remains one of the major challenges to be faced in the 21st Century. The abilities of information processing, decision making, perception and action displayed by this biological system dwarf those of man-made systems. Progress in this endeavour will have profound applications in health, education, technology and economic competitiveness.

The new interdisciplinary field of neuroinformatics capitalises on the synergies between the brain-related sciences (e.g. neuroscience, psychology, linguistics) and the information sciences and related disciplines (e.g. computer science, mathematics, statistics, physics and electrical engineering). Neuroinformatics is concerned with:

- Developing and applying computational methods to the study of brain and behaviour (computational neuroscience).
- Applying advanced IT methods to deal with the huge quantity and great complexity of neuroscientific data.
- Exploiting our insights into the principles underlying brain function to develop new IT technologies.

**Neuroinformatics activity in the School of Informatics**
The School of Informatics has a long tradition in the areas of research that now form Neuroinformatics. The University of Edinburgh is now an established national and European leader in Neuroinformatics, and is amongst the leading players worldwide with substantial Neuroinformatics-related research. Most recently, Edinburgh has been chosen as the lead partner of a three-year EPSRC/BBSRC/MRC project to sculpt out the field of Neuroinformatics in the UK and will form the UK node of the International Neuroinformatics Coordinating Facility, recently set up with Science Ministerial approval, under the auspices of the OECD.
The School is committed to maintaining and developing a presence in the field, with one new Readership/Lectureship just advertised and a Professorship planned over the next two years. Neuroinformatics activity at Edinburgh is focussed around the Institute for Adaptive and Neural Computation (ANC), with the following specialisms amongst the various teams:

Computational neuroscience:
• The role of molecular cues in the development of nerve connections; a multilevel attack on modelling synaptic plasticity; modelling nuclei of the basal ganglia and their role in Parkinsonism. D Willshaw, School of Informatics (CV attached)
• Synaptic plasticity, noise in neural systems, sensory systems: modelling the rod-rod bipolar synapse. M van Rossum, School of Informatics
• Analysis of the role of electrical waves in the developing retina, how do developing cells know their correct positions? S Eglen, Wellcome Trust Research Fellow, School of Informatics (CV attached)
• Normal and impaired visual word recognition, reading, and the mental lexicon. R Shillcock, School of Informatics

Databases and tools:
• Flytrap (one of the three Drosophila databases used worldwide). D Armstrong, School of Informatics (CV attached)
• fMRI analysis and the development of neural databases software through the spinout company Axiope. N Goddard, School of Informatics (CV attached)
• Development of neural simulation tools. F Howell, School of Informatics

Neurally inspired systems:
• Motor control in robotic and humanoid and biological systems. S Vijayakumar, School of Informatics
• Sensory systems in invertebrate robotic systems. B Webb, School of Informatics
• Neurally inspired analogue hardware. A Murray, School of Engineering and Electronics

Neuroinformatics training
ANC hosts the EPSRC/MRC Doctoral Training Centre (DTC) in Neuroinformatics. http://www.anc.inf.ed.ac.uk/neuroinformatics/ This unique interdisciplinary training programme trains students from the physical sciences for a career in the neurosciences through a four-year interdisciplinary programme that will deliver 50 newly qualified PhDs over the next six years. The DTC draws together all the relevant units working on neuroinformatics across all the Colleges in Edinburgh.

The many fruitful interactions that have arisen within the University as a result of this initiative make future expansion desirable and achievable, particularly in relation to Cognitive Systems and in Systems Biology, both expansions being very timely given the worldwide interest in these two recently identified research areas.
2. Cognitive Systems

What are Cognitive Systems?
Cognitive Systems was defined by a recent DTI Foresight Project (http://www.foresight.gov.uk/), to which many members of the School of Informatics contributed, as:

“...a collection of emerging information technologies inspired by better understanding of the nature of biologically based information processing in the nervous system, including those responsible for perception, learning, reasoning and decision-making, and both communication and action.”

Interest in this field has developed in several parent disciplines. Neuropsychologists, including the two recently appointed Professors of Cognitive Neuroscience at Edinburgh, S Della-Sala and R Logie, have longstanding interests in the organisation of systems in the human brain responsible for perception, attention and memory, particularly working-memory.

Other areas of research emphasised in the Foresight Project in which Edinburgh has significant Informatics-related strengths are language and speech (J Moore, M Steedman, S Renals (CV attached)), biomimetic systems (B Webb, S Vijayakumar) and self-organising processes (D Willshaw). The value of this interaction between Informatics researchers is access to new ideas about the engineering principles of artificial cognitive systems, and their realisation in software and hardware devices, including robots. A rewarding avenue of current Informatics research has inspired the study of neurobiological systems, as actively pursued in the Institute for Adaptive and Neural Computation (D Armstrong, C Williams – CV attached) and the Institute for Perception, Action and Behaviour (B Webb).

Collaboration across Cognitive Systems
The recent Office of Science and Technology Foresight Project, for which Professor R Morris, Division of Neuroscience, School of Biomedical & Clinical Laboratory Sciences, (CV attached) was the Life Sciences Co-ordinator and to which very important contributions were made by colleagues in Informatics (M Fourman (CV attached), J Moore (CV attached), R Logie, B Webb, M Steedman and D Willshaw), identified Cognitive Systems as a potentially fruitful area of research for the UK. Several Research Councils (BBSRC, EPSRC, ESRC, MRC) and major charities (e.g. The Wellcome Trust) have or are about to have research programs at the life sciences/physical sciences interface as part of renewed interest in integrative approaches to the study of complex systems. The University of Edinburgh is presently developing a proposal for a Centre for Cognitive Systems as a timely institutional vehicle for realising dialogue through innovative research that cuts across traditional life science/physical science disciplinary boundaries. Informatics researchers in the Forum would be key members of this cross-College consortium.

Informatics and Cognitive Systems
The Informatics contribution occurs at several levels. First, the computational metaphor provides a basis for modelling informational processing in natural systems.
Technology provides a basis for challenging these models, and observing their emergent properties by simulation.

Second, informatics provides both technological and conceptual tools for uncovering and understanding information contained in huge volumes of data. Well-established methodologies in neuroscience, linguistics and experimental psychology have provided a range of domain-specific knowledge, but findings that are mainly based on inference from indirect techniques. With the advent of the new multiple single-unit recording and non-invasive imaging, ERP and MEG technologies, living systems can be studied in operation as an individual subject performs cognitive tasks. The combination of state-of-the-art cognitive and behavioural psychology with such direct recording techniques produce a huge amount of data that must be managed, stored, visualised and interpreted.

Finally, Informatics provides a route for application of the insights derived from the study of information processing in natural systems. With exponential growth in power predicted to continue, artificial systems will soon deliver the raw processing power of the human brain. As well as providing improved technologies for analysing natural phenomena, we hope that this will provide a technological basis for implementing new, naturally inspired architectures sharing the robustness and plasticity of natural systems.

The new Informatics Forum will enable scientists using wet labs in adjacent laboratories to collaborate interactively with experts skilled in studying systems at all scales and levels of analysis. These include the excellent JIF-refurbished Neuroscience building and the Department of Psychology – both of which are next door to the proposed Informatics Forum – making it an ideal location for a world-class Centre for Cognitive Systems.

3. Bioinformatics: The Edinburgh Centre for Bioinformatics

Background
There is a thriving Bioinformatics community in Edinburgh. Our website (http://www.bioinformatics.ed.ac.uk) lists 15 Bioinformatics groups in Edinburgh within and out with the University and 66 PIs active in bioinformatics research. This activity evolved ‘bottom up’ and provides intellectual support for recent developments in more specialised areas. We are in the process of creating the Edinburgh Centre for Bioinformatics (ECB) to help shape and co-ordinate diverse activity covering a number of strong themes. The ECB will develop the synergy between individual projects and will help plan and co-ordinate the future direction of Bioinformatics in and around Edinburgh. Senior staff appointed in the area will provide leadership as we develop our Bioinformatics activities.

One of the most important themes is Data Management. The creation of new sensor, storage, processing and network technologies give us the capacity to capture, store, process and communicate biological data in a qualitatively different manner from what was possible even five years ago. The key challenges are how to harness this technology adequately to support the science, and how to provide effective management tools to control the massive volume and complexity of the data.
At The University of Edinburgh, the National e-Science Centre and the National Digital Curation Centre have been established expressly to address these issues. This, coupled with a world-class database group in the School of Informatics, will stimulate both the development of effective solutions to the problems of biological data management and the development of new science in Informatics in order to overcome the scale and complexity of the challenges in Bioinformatics.

Below, we outline our current activities in five areas of Bioinformatics: genomics database development; data management and mining; image analysis; medical genetics and genomics; and structural genomics. Finally, we place Bioinformatics research in its context both in the wider Edinburgh and Scottish research communities.

**Genomics and database development**

Edinburgh is the home to the development and compilation of a number of unique databases. These include: in the genomics of nine animal species; in microarrays; in gene expression and development; and for evolutionary analysis. Projects include:

- Database development for animal species and genetic analysis algorithms. A Law, Roslin Institute
- Image processing, digital atlas, gene-expression, databases, mouse development. R Baldock, MRC Human Genetics Unit
- Databases and their applications in biology. Data integration and curation. P Buneman, School of Informatics (CV attached).
- Use of genome sequence databases for evolutionary analysis. B Charlesworth, Institute of Cell, Animal and Population Biology, School of Biological Sciences
- Microarray database design implementation and data mining. G Grimes, Scottish Centre for Genomic Technology and Informatics, College of Medicine and Veterinary Medicine

**Data management and mining**

Effective data management is a key pre-requisite, but once we have managed the data problem we need to interpret it and link it to other sources of information. One key technology in this area is data mining. This provides us with a means to detect patterns in data and to extract useful information from massive data repositories. The e-Science activity in Edinburgh has already linked the Adaptive and Neural Computation group in Edinburgh to work in Astronomy, and there are a range of projects that are aimed at applying state-of-the-art data mining to knowledge discovery in biological literature and datasets. Projects include:

- Database mining, in-silico drug design, databases of molecular properties. M Walkinshaw, Institute of Cell and Molecular Biology, School of Biological Sciences.
- Biomedical text mining. B Webber, School of Informatics (CV attached).
- Making bio-ontologies: gene expression data, mutant phenotypes, etc. J Bard, School of Biomedical Sciences (CV attached)

**Image analysis**

One key modality for biological data is as images. There is a range of image analysis groups over the University directed to applying the technology in various life-science contexts. The School of Informatics was instrumental in establishing the Centre for
Functional Imaging Studies that aims to exploit fMRI technology, which observes brain activity in real time using high-performance machines to complete the analysis in real time. The management and analysis challenges in this area pose significant technical problems, but the potential benefits are significant. Projects include:

- Real-time fMRI analysis. N Goddard, School of Informatics
- Image analysis, statistical analysis of microarray data. C Glasby, BioSS

**Medical genetics and genomics**

In the longer term the most significant impact of work in this area will be in the medical sciences and medical practice. Already we are seeing the impact of medical genetics on healthcare practice. Much of the science and technology developed in other areas of Bioinformatics will have application in medical science and practice.

Adapting these approaches to the medical domain is not straightforward. The ethical, security and data protection issues pose major additional problems. In addition, the issue of policy and how to deliver policies in health is very problematic. In this area we have considerable experience both in Informatics and in the Research Centre for Social Science that houses the EPSRC funded Innogen Centre studying the policy implications of innovation in genomics. Projects include:

- Integration of health informatics with medical genetics. D Porteous, Molecular Medicine Centre, College of Medicine and Veterinary Medicine (CV attached)
- Statistical genetics and genetic epidemiology. P Visscher, Institute of Cell, Animal and Population Biology, School of Biological Sciences
- Genetic algorithms in cancer risk assessment; e-Health. P O’Brian Holt, Heriot-Watt University
- Dependability of information in bioinformatics; innovation in genomics. R Williams (CV attached), J Tait, Innogen, College of Humanities and Social Science

**Structural genomics**

A key link to work on systems biology is the prediction of structure from genetic data and linking structure to function. Work in Edinburgh includes working with simple physical models in an attempt to develop predictive computer models of protein folding. Projects include:

- Use of physical techniques (e.g. single molecule imaging) to simplify biological data. J Crain, COSMIC, School of Physics
- Protein structure / function prediction, sequence analysis, molecular evolution. D Gerloff, Institute of Cell and Molecular Biology, School of Biological Sciences

**Bioinformatics in Edinburgh and Scotland**

To co-ordinate and develop this wealth and depth of Bioinformatics research in the Edinburgh area, we have formed the Edinburgh Centre for Bioinformatics. This development has been led initially by Vice-Principal G Bulfield, Head of the College of Science and Engineering (CV attached). It encompasses Principal Investigators in all three Colleges of The University of Edinburgh, together with the MRC Human Genetics Unit, Roslin Institute, BioSS and Heriot-Watt University. The Centre is currently based at the National e-Science Centre in The University of Edinburgh and will relocate with NeSC to the Informatics Forum building. We have advertised for a Director and Professor of Bioinformatics to lead the Centre and have had a
substantial response from an international field – we have a long list and are proceeding to interview candidates. The Director will be supported by a range of physical and human resources.

In addition, we are in the process of finalising, with Scottish Higher Education Funding Council (SHEFC), Scottish Enterprise, and SEERAD, a major (over £2M) Strategic Research Development Grant for a Scottish Bioinformatics Research Network (SBRN). This collaborative proposal is led by Professor G Barton and will support the bioinformatics centres at the Universities of Dundee, Edinburgh and Glasgow. The SBRN will work in parallel with the Scottish Bioinformatics Forum (funded by Scottish Enterprise), which has been established to co-ordinate and facilitate bioinformatics research and development in Scotland. Dr J Crain, of the University of Edinburgh’s School of Physics, leads the Scottish Bioinformatics Forum component of the SBRN project.

We believe that we have an excellent opportunity to build on our existing wide strengths in bioinformatics research in Edinburgh. The added value to be gained both now and from future development of our new Centre is enormous, as are the advantages of it being located in our major prestige building: the Informatics Forum.

4. Systems Biology

Background
As we move into the post-genomics era, it is clear that the reductionist strategies that have been successful in sequencing the genome of many species will no longer be adequate to bridge the gap between the genome and the phenotype. This applies to our understanding of how genes interact to control metabolism and development as well as complex characteristics and human inherited disease.

To deal with these problems of complexity, several groups have proposed the integration of the biological and physical sciences in a new approach, termed ‘Systems Biology’. An Institute for Systems Biology has been established in Seattle, under Leroy Hood (http://www.systemsbiology.org), and Harvard University has a newly created Department of Systems Biology with 20-25 faculty positions. In the United Kingdom, the BBSRC previewed the area in its current five-year strategy ‘Towards Predictive Biology’ and with its Metabolomics programme. The BBSRC now has proposals in place for a major Systems Biology initiative.

Despite all this activity, the basic problems being addressed and approaches proposed are not new. These were first mooted by two University of Edinburgh scientists, C H Waddington and H Kacser in the late 1950s (See C H Waddington’s ‘Strategy of the Genes’; Appendix by H Kacser, 1957). It is, therefore, not surprising with these antecedents that the University is establishing a major initiative in Systems Biology led by Vice-Principal Bulfield.

Current position
We have just established a Chair of Systems Biology and have commenced the recruitment process for an international figure to lead and develop this interdisciplinary research initiative. Concurrently with the search to make an outstanding appointment to that position, we have established a Steering Group for a
Centre for Systems Biology. This involves senior academics with current interests in the area, from either a biological sciences or informatics/computing standpoint:

- A Bird FRS  Director, Wellcome Centre for Cell Biology (CV attached)
- P Ghazal  Director, Scottish Centre for Genomic Technology and Informatics (CV attached)
- G Plotkin FRS  School of Informatics (CV attached)
- D Porteous  Director, Centre for Molecular Medicine
- M Shipston  Director, Centre of Integrative Physiology
- J Seckl  Head of School of Molecular and Clinical Medicine (CV attached)
- B Webber  Deputy Head, School of Informatics

At this early stage, there is already considerable interest throughout the University and across many disciplines in Systems Biology, with a strong relationship with computational neuroscience research carried out within the neuroinformatics theme. A number of existing research projects would fall within the Centre’s activity, and these include:

- Modelling complex biological networks. A Pocklington, School of Informatics
- Artificial neural networks and pattern formation. S Eglen, School of Informatics
- High throughput experimentation and system level approaches to clinical genetics. P Ghazal, Genomic Technology & Informatics, College of Medicine and Veterinary Medicine
- Microarray analysis and genetic networks. D Husmeier, BioSS
- Computational Systems Biology: modelling biological systems as concurrent systems – A language for life. G Plotkin, School of Informatics
- Metabolic pathways and Systems Biology. K Robertson, Genomic Technology & Informatics, College of Medicine and Veterinary Medicine
- Function and interactions at different biological levels of selected proteins in endocrine cells. M Shipston, Centre for Integrative Physiology, College of Medicine and Veterinary Medicine (CV attached)
- Probabilistic graphical models for the analysis of genetic data and genetic network inference. C Williams, School of Informatics

These projects form a firm initial platform on which to build our Systems Biology initiative. In addition, we will broaden the integration of the physical and biological sciences. We are about to appoint a Professor in the area of Mathematical Biology to forge links between the Schools of Biological Sciences and Mathematics, and have established a Chair of Complex Systems in the School of Physics.

Our new Centre for Systems Biology will be located in the Informatics Forum alongside the National e-Science Centre and the Edinburgh Centre for Bioinformatics. Like the latter, wet lab facilities will be available at the adjacent laboratories in George Square and the nearby campus at The King’s Buildings. Our objective is to ensure that informatics and mathematical expertise drives the development of the Centre that we intend to establish within the Informatics Forum. It is our intention that Edinburgh will do justice to its pioneers of Systems Biology by becoming an internationally recognised focus for Systems Biology research.
5. e-Health

Background
The concept of e-Health lies at the heart of the NHS’s strategy for the delivery of better healthcare services. As such, e-Health is subject to many different interpretations but its fundamental role may be summarized as providing the means to deliver healthcare that is integrated, responsive and tailored to the needs of the individual citizen. Within this overarching concept, a number of distinct dimensions have now begun to emerge. One is peripatetic healthcare, which focuses on moving away from ‘fixed point’ service delivery through the provision, for example, of remote monitoring and assistive technologies within the home or public access points (‘kiosks’) in the high street. Another dimension is that of ‘virtual’ healthcare services, distributed networks of healthcare professionals and resources implementing personalized patient care pathways. A third targets the linking of clinical research and practice, and especially the exploitation of genetics for personalised patient care. Yet another dimension to e-Health highlights healthcare promotion and patient empowerment through access to high quality public information about services and lifestyle choices.

Current position
The key to realizing any and all of these aspects of e-Health is the application of information and communications technologies across the whole range of functions that affect health. None of the goals of e-Health are achievable without moving from fragmented paper-based patient records to the computer-based, integrated care record.

e-Health provides an ideal and strategically important domain for applied, interdisciplinary research across a wide range of Informatics sub-disciplines and specialities. Projects include:

- Flexible, scalable, manageable and evolvable infrastructures and policies for information integration. M Atkinson, National e-Science Centre and P Buneman, School of Informatics and National Data Curation Centre.
- Secure and dependable healthcare systems. S Anderson, School of Informatics (CV attached)
- Ontological and agent-based support for information access and management in health care. D Robertson, School of Informatics
- On demand generation of tailored representations of patient information. J Moore and J Oberlander, School of Informatics, P Buneman, School of Informatics and National Data Curation Centre
- Development of integrated ambient computing, communicating and sensing devices for remote patient monitoring and peripatetic healthcare. D Arvind, School of Informatics
- Health promotion through personalised information services for patients and public. J Moore, School of Informatics
- Coordination, management and planning of healthcare services. A Tate and R Procter, School of Informatics (CV attached)
- Improved linkages between clinical research and patient care. R Procter; M Atkinson, National e-Science Centre; P Ghazal, Scottish Centre for Genomic Technologies
• Understanding relationships between work practices and technologies; methodologies for designing, developing and evaluating healthcare technologies. R Procter, School of Informatics
• Organisational and cultural issues in the management of change. R Procter, School of Informatics and R Williams, Research Centre for Social Sciences.

Informatics is uniquely placed to deliver practical solutions to these problems. To co-ordinate existing research activity within e-Health and identify new possibilities, a plan for a five-year research programme is currently being finalised in partnership with the College of Medicine and Veterinary Medicine and the Lothian NHS Health Board. Vice-Principal J Savill (CV attached) is leading this e-Health initiative.

Laboratories

The Informatics Forum will house a variety of laboratories for multimodal observation and recording of perception, communication and interaction in both natural (primarily human) and artificial systems. These include robot labs, meeting rooms equipped for multimodal recording, booths for speech and dialogue recording and eye-tracking studies, and a facility for non-invasive brain imaging. Wet laboratories will be housed in existing adjacent buildings, and elsewhere in the University.

Conclusion

Research bridging Informatics and the Life Sciences is gaining momentum at The University of Edinburgh. We are uniquely positioned to lead the world in Neuroinformatics, Cognitive Systems, Bioinformatics, Systems Biology and e-Health research and we invite you to be involved.

A contribution of £5 million from the Wolfson Foundation to a Wolfson Centre for Informatics and the Life Sciences, will secure 2250 m² in the new Informatics Forum, and encourage further collaboration that will continue to revolutionise the way in which biological and informational systems inform one another.