BioImagingUK Strategy Meeting
Summary Report, Nov 2012

Introduction

Imaging is a key technology transforming life sciences and clinical research. Imaging of biological specimens or human subjects now routinely reveals the molecular and biophysical mechanisms that drive fundamental processes in cells, the formation and regeneration of tissues and whole organisms and the pathology, progression and treatment of human disease. Imaging enables spatially localised measurements, in-vivo, over wide ranges of spatial scales (nm → um → mm) and time intervals (msec → years).

In most cases, UK life scientists and medical researchers have access to the imaging infrastructures necessary to support their immediate work and significant investments by UK Research Councils and charities have built a number of world-class imaging facilities in academic departments and institutes across the UK. The imaging facilities at any individual institution, however, are usually driven by the local research priorities and not all imaging modalities at any single institution are at the state of the art. Furthermore, ***over the last decade enormous leaps have been made in imaging technology with advances in resolution, speed, sensitivity, signal processing, functional readouts and biophysical modelling*** – now reaching previously unimagined capabilities. The increasing sophistication and concomitant expense and complexity of this new technology, however, make it ***impractical to build and run cutting edge imaging technology at every site in the UK***. While several individual sites have established specific expertise in one or more of these emerging imaging technologies, no single institution can provide all the imaging capabilities that can now be applied to biological questions and which will become increasingly necessary in modern bioscience. Nonetheless, ***if UK life scientists and medical researchers are going to stay at the international forefront of their fields, they need access to all of these technologies***. Thus there is a ***critical need to define the imaging instrumentation and personnel infrastructure, access policies, and sustainable support mechanisms*** that must underpin UK science going forward.

The UK BioImaging Community and BioImagingUK

To begin this definition, BioImagingUK organized a Strategy Meeting with the key bioscience research sponsors at the offices of the Wellcome Trust, London, on July 2-3, 2012. This meeting brought together, for the first time, leading UK scientists involved in biological and medical imaging and representatives from BBSRC, CRUK, EPSRC, MRC and the Wellcome Trust. Presentations from the BioImagingUK community and the UK funders highlighted the need to define strategic priorities for biological and medical imaging in order to make best use of available financial and intellectual resources. There was also a presentation from Jan Ellenberg on the status and future of Euro-BioImaging (http://eurobioimaging.eu) that described how the European bioimaging community as a whole is working to address the issues outlined above.

This BioImagingUK Strategy Meeting was, to our knowledge, the first gathering of leading UK scientists who depend on and/or develop imaging methodology as a critical tool for their own scientific research. The reports and conclusions detailed below summarise the concerns, priorities and proposed solutions of >70 leading UK scientists. While not absolutely comprehensive, they are the best sampling to date of community-defined priorities for BioImaging and can be used to inform priorities and actions for institutes, universities and funding bodies in the UK.

Executive Summary-- Major Strategic Priorities

A series of breakout discussions discussed different domains of interest to the community. Their conclusions are summarized in the following sections. For the purposes of this summary document, “Bioimaging” represents all aspects of practice, development and

expertise in microscopy, whole organism tomography, spectroscopy, tissue, pre-clinical and clinical imaging.

Overall, three major themes emerged from the meeting:

I. ***Bioimaging facilities*** are needed in the UK – including National Facilities, Centres of Excellence, and, critically, Department or Institute level facilities. These serve different complementary roles and an active, world-class, scientific infrastructure requires multiple levels to be developed and sustained.

II. ***Training programmes*** that cover all aspects of bioimaging - EM, optical, ultrasound, X-ray CT, MRI, PET/SPECT, detector technology, probe development, image processing and analysis, modeling, and data management - are the foundation for continued world class performance of UK science. Training programmes that build a sustainable pool of scientific and technical talent must be a developed and, for at least some fields, coordinated on regional or national levels.

III. ***Career structures and opportunities*** for bioimaging staff must be developed, to nurture and sustain the critical expertise needed to design, build, run and further develop bioimaging infrastructure and technologies.

Alongside discussions of specific bioimaging technologies and applications, the BioImagingUK Strategy meeting highlighted the critical need for training programmes and career structures for technology-focused, non-academic research staff across all imaging technologies domains. Together, the development of a coherent plan for bioimaging infrastructure and the provision of training programmes and career structures should ensure the sustainable success of bioimaging in the UK and thus underpin much of UK life sciences and clinical research. For this reason, training and career structures are treated with the same priority as bioimaging facilities in this report.

Inaction - what are the Risks?

If these issues are not addressed there are a number of predictable outcomes.

- Inefficient allocation of resources to bioimaging will impede progress, social and economic impact and world competitiveness; the UK will simply not achieve the expertise, research output performance and, in rapidly developing fields, the critical mass necessary to compete internationally at the forefront of life science and clinical research. Thus we will not enjoy the economic, intellectual, and social impact associated with world-leading scientific programmes.

- There will be a significant loss of momentum for a substantial portion of current active, promising bioscience research.

- Poor training or limited expertise in the development and application of imaging technology will result in improperly followed procedures, misinterpretation of data, and improper equipment use and maintenance - thus diminishing the return on research investment.

- Academics and expert staff alike will leave the UK for countries where imaging technology and academic and research staff careers are better supported, such as the USA, Australia and EU countries that are actively adopting strategic, national-level bioimaging strategies (e.g., EuroBioImaging, AMMRF, NIM).

- The pharmaceutical industry will look elsewhere for preclinical and clinical drug studies, further driving the exodus of biopharma and associated industries from the UK.

- The bioimaging instrumentation and software industries will look elsewhere to invest in the development of new methods and technologies, reducing opportunities for growth of highly skilled jobs and high technology companies in these rapidly growing sectors.

- Especially for pre-clinical & medical imaging, diagnosis and patient treatment will suffer, with accompanying negative social and economic impacts.

Details of Strategic Priorities

The sections below detail the major conclusions from presentations, discussions, and Breakout groups at the BioImagingUK Strategy Meeting. The original reports from the various Breakout groups are attached in Appendix 1.

I. UK Bioimaging Facilities

Several breakout sessions, covering Electron Microscopy, Light Microscopy, Pre-Clinical/Model System Imaging, Medical Imaging, Data and Software Tools, independently concluded that future investment in BioImaging infrastructure should be targeted at three different levels: National Facilities, Centres of Excellence and Department/Institute level facilities.

National Facilities are resources that house specific, advanced and expensive (>>£1M) technology that is complex, often novel, and for which access is critical for a number of scientific groups in the UK. An example is an ultra-high field clinical whole body imaging system where the financial resources, scale of infrastructure and expertise required are probably not achievable beyond a small number of institutions. National Facilities would probably be placed at ~1-2 sites in the UK. A major portion (at least 50%) of a National Facility's activity should be devoted to external investigators and to running training programs for external scientists at all levels. In some cases, technologies provided by National Facilities will become more common throughout the UK as costs reduce and expertise and demand increase. This diffusion of the technology reflects a natural progression that occurs as technology becomes better established, easier to use and maintain, and less costly.

Centres of Excellence are sites distributed across the UK (~3 – 10) that house advanced imaging technology and provide the necessary expertise, support personnel and associated supporting technologies (e.g., wet bench, sample preparation, data analysis and management, etc.) to enable users to take advantage of the imaging capabilities. The imaging technology in Centres of Excellence would be accessed on a local, regional and ideally national scale and would require substantial investment. In general, Centres of Excellence would be associated with academic laboratories whose research is strongly coupled with the imaging technology of the Centre. This technology may diffuse over time and become more widely available in UK laboratories. As happens with National Facilities, this is the natural progression of technology as it becomes more mainstream, cost effective and requires less specific expertise to deliver.

Explicit, strategic efforts to network and share developments and know-how with other Centres housing imaging technologies should be a critical part of the activities of every Centre of Excellence. These efforts should including physical and virtual scientific meetings and training programmes.

Department/Institute-level imaging facilities are similar to existing facilities that are currently associated with many research labs across the UK but need to have upgraded capabilities. These facilities currently are and will continue to be the mainstay of the UK bioimaging provision, providing access to advanced imaging technology and expertise for running instruments and training. The vast majority (estimate at least 80%) of the world-class UK research that is published within the peer-reviewed journals is performed in these facilities. This broad based community is where the majority of future bioscientists - - from technicians to principal investigators – will get their first experience with bioimaging and probably will undertake most of their work. In many cases, Department/Institute-level facilities will enable preliminary experiments that will be the starting point for activities that are later extrapolated to Centres of Excellence or National Facilities. ***The BioImagingUK Strategy Meeting and the subsequent breakout reports expressed strong consensus that, to date, much of the most important and innovative scientific output of the UK has resulted from strategic investment in academic institutions, where scientific leaders have driven critical scientific applications.*** This "bottom-up" approach must be maintained. Indeed we expect that in many cases it is exactly these Department/Institute-level facilities that will mature into Centres of Excellence or National Facilities.

Strategic Technologies and Activities for National Facilities and Centres of Excellence were consistently identified by the Breakout Groups as being appropriate for either National Facilities or Centres of Excellence. Table 1 highlights these suggested technologies and prioritised activities that were identified because of their potential impact on UK scientific output and excellence. BioImagingUK recommends that these identified Facilities and Centres should be funded at appropriate sites and could convene committees based on our existing expert community to define and recommend principles and policies for building and running these resources.

Evaluation and Sustainability of National Facilities and Centres of Excellence

National Facilities and Centres of Excellence are sites providing access to advanced, world-class technology critical for cutting edge scientific research. These sites should be identified, funded and reviewed using the established, proven, peer-review mechanisms that have built UK science. The BioImagingUK Strategy Meeting highlighted the need for periodic review of these resources where utility, impact and strategic importance are evaluated. No Facility or Centre should be a permanent institution and, as technology matures, diffuses or is superseded, Facilities and Centres would either evolve or be wound down in favour of new sites providing the next generation of imaging technology.

II. Training

As the field of bioimaging advances, the demand for multidisciplinary scientists, able to exploit the complexity and power of advanced imaging techniques and to design and produce the imaging technologies of the future, will continue to increase. There will be a need for more scientists who can combine biological, medical and physical insight and knowledge with the development and refinement of imaging technologies. These multidisciplinary scientists will ensure that future imaging technologies and methodologies contribute to the improvement of human health through scientific discovery and clinical application. From the bioscience perspective, an increased exposure to more specialised biologists and medical students to bioimaging imaging training (encompassing probe design, underlying physics and signal processing aspects of the technologies) would help them to realise the true potential of these technologies and result in more effective usage. Similarly, a basic understanding of cellular, molecular and systems biology would improve the ability of imaging technologists (physicists, mathematicians and engineers) to collaborate with

bioscience users (biologists, clinicians and non-clinicians). This cross-fertilisation will provide insights into the technology requirements for the foreseeable future.

New student training programmes in imaging-based research at multiple levels will be important for the continued growth in this field and to ensure that emerging technologies are used and applied to their full potential. Imaging training offered at both undergraduate, postgraduate levels and continuing professional development, with short courses ranging from basic, advanced, to highly specialised, would be beneficial to the biomedical imaging community as a whole.

Post-graduate training

Implementing MSc/PhD training programmes with a strong imaging component would not only help produce the multidisciplinary imaging scientists of tomorrow but would also help build links between supervising academics from different disciplines. If structured effectively, new postgraduate student training programmes would help enhance current multidisciplinary collaborations and boost the application of imaging technologies. This may be achieved on a number of levels and will depend on the technology and level of student involvement. In imaging-intensive research projects, students would have at least two supervisors for their PhD project (e.g. a laser physicist and a developmental biologist) and work in two or more different research environments.

The increasingly widely used 1+3 year MRes+PhD training format could be adopted, providing time for specialised training across the different intellectual cultures demanded by imaging-based science. Such a programme could begin with a one-year full-time MRes, to encompass taught lecture modules on elementary and advanced aspects of biomedicine, imaging techniques and applications. Students would therefore be exposed to different scientific cultures and ensure that they experience technological development as well as bioscience application.

New approaches to teaching and learning

With the rise of new types of media for teaching and learning (e.g., MIT's OpenCourseware, http://ocw.mit.edu), the appearance of on-line video journals (JoVE, http://www.jove.com/) on-line and even University-branded YouTube channels, the opportunity for using new types of media as a training reference can now be seriously proposed. Indeed reference sites of microscopy are now routinely used for teaching. These types of resources can be accessed by students from the UK and beyond, and could help establish the UK as a hub for knowledge and usage of bioimaging.

III. Careers

Expert staff with the experience and skills to provide access to high level instrumentation, including imaging technology, are increasingly critical to the research mission. For imaging-based science, this includes experts in hardware and software. These staff are critical for sustaining an imaging capability and ensuring experience and know-how can be transferred to users. Long-term career (>5 years) development is essential to attract and retain highly qualified staff in a global market. Many excellent scientists would prefer a career working hands-on with technology rather to the regular PI track and such a career track would provide more opportunities for good scientists to contribute to the research mission. It should thus be presented as a career option at postdoctoral level.

Imaging staff scientists are in demand globally. In line with its international competitors, the UK needs to recognise that such staff are an essential part of any investment in advanced imaging technology. A strong point of consensus in the Strategy Meeting discussions and Breakout reports is that these staff will migrate towards the best and most stable positions in

spite of geographic or national boundaries. UK imaging science thus depends on strategically providing sustainable career structures to attract and retain these staff.

The **main needs** with respect to careers of imaging (and similar) staff are:

- a new job description and career track ('imaging technologist', 'scientific officer', ‘research engineer’ or similar) – that is distinct from a PI research scientist but also distinct from a technician. Imaging technologists should be PhD level scientists for whom a long-term career structure makes this career choice viable and attractive. This exists to some extent in research institutes but is particularly needed in universities. Some universities and institutions already have such job descriptions that could be used as a model, e.g. CRUK or the University of Bristol.
- the job description of an imaging technologist has to be wide enough to cover all types of roles involved in making advanced technology accessible to research scientists, e.g. application of novel technologies for new biological / medical projects, participation in technological development (hardware, probes, analysis tools, ...), software development and image processing.
- funding bodies and institutions must both agree on responsibilities towards such staff; for example, universities provide the positions and guarantee long-term commitment, while funding bodies contribute directly or indirectly through user charges in research grants.
- performance criteria need to be adjusted to the specific roles, recognising that an imaging technologist facilitates, rather than leads, research and that first or senior authorship may not be a relevant metric of contribution or performance.
- this “new” career track does not need to be exclusive of 'academic research', and lateral mobility between career tracks would be useful.
- development of instruments and techniques by such staff (including that which does not directly leading to publications) should be encouraged and be regarded as a normal part of the role.
- the new career option needs dedicated models for training and continuing professional development, taking into account the highly interdisciplinary role (biological and medical research, physics, computing, mathematics, chemistry, management).

Role of BioImagingUK in Future Strategic Definition, Funding and Operation

BioImagingUK is a grass roots, “bottom-up” organization of scientists and imaging specialists representing the range of research imaging facilities in the UK. It has no funding or administrative authority and this will not change in the future. Its efforts have been and will be focussed on collating, organising and articulating the priorities and needs of scientists who use imaging technology in the life and clinical research sciences. These priorities are presented in open, public reports available to any of the members of the UK scientific community for use in defining strategic priorities for funding and scientific activity.