



The Royal Academy
of Engineering

COOKSEY REVIEW OF UK HEALTH RESEARCH

Consultation Document:

response on behalf of the Royal Academy of Engineering

Introduction

The Royal Academy of Engineering has a number of Fellows working in the broad field of Medical Engineering including imaging, tissue engineering, blood flow measurement, joint replacement, assistive and monitoring devices, modelling and robotic surgery. In addition, the Academy hosts the UK Focus for Biomedical Engineering, which facilitates communication and exchanges between the many organisations working in the area of medical engineering research and its applications.

This Academy wishes to draw particular attention to the importance of Biomedical Engineering and its scope; the medical advances that have resulted from innovations in engineering, through both clinical pull and technology push; the major UK achievements in medical engineering; the number of research-active medical engineers working in the NHS, in the universities and in industry; and the size of the medical devices and related markets.

However, **notwithstanding the size of the health technology sector, the extent to which this and most, if not all, areas of medicine and biology are affected by Biomedical Engineering, it needs to be pointed out that, being a highly interdisciplinary research subject, Biomedical Engineering is in danger of falling in between the cracks and so is its funding. There exists serious concern with regard to the lack of public funding for research related to engineering-based health technology sector and it is hoped that the creation of a Single Health Research Fund will allow more funding for Biomedical Engineering.**

1. What are the strengths and weaknesses of the MRC and NHS R&D programmes at present? How do each of these support the research and training needs of the NHS, social care, industry and academia? Does more need to be done?

The scientific excellence of MRC funded research is acknowledged and applauded worldwide. Its rigorous peer review system is very effective in the selection of high quality research and it is important that this is left in place. As medicine and basic medical science become more and more technologically based, there is a need to change both the breadth and depth of the review committees to encompass significant input from the engineering and physical sciences.

MRC Technology Ltd (MRCT, the technology transfer company of the MRC) has been highly successful in bridging research excellence to commercial exploitation and accelerating translational research. MRCT currently focuses largely on antibody drugs¹ and any new arrangement should ensure that it can expand its activities to other areas of knowledge transfer, especially in health technologies. The MRC itself should be encouraged to be more active in the sector of engineering-based health technologies, especially in collaboration with other Research Councils, particularly the EPSRC. The MRC shortage of financial resources and its consequent policy of prioritising research areas are recognised. An increase in the budget of the MRC would enable it to deal better with the demand on its funds across the whole of biomedical research as well as to increase its investment in clinical research and

¹ Humira, Herceptin, Synagis, Campath, Avastin, Tysabri and Actemra, several of which are classified as blockbuster drugs.

health technologies. Government should ensure that research areas at the boundaries of the remits of individual Research Councils (e.g. biomedical engineering) receive more funding, especially in support of the translational stages of research (follow-on funding).

The NHS R&D is to be congratulated for co-ordinating diverse research activities and shaping them into more structured programmes. However, its main focus is on infrastructure within the NHS and on applied research close to the point of delivery. Moreover, its functioning has been hindered by the ever-increasing diversion of its funds towards provision of services beyond its remit, a circumstance that has had an obvious negative impact on DH R&D output.

There is a wide consensus around the need to protect the DH R&D budget by ring-fencing it, and around using the budget to support health research more effectively.

A strongly held view is that, at present too much emphasis is placed on long term molecular biology research; whereas, for example, effective near term engineering solutions to problems in surgery receive little attention.

- 2. What do you believe are the key scientific and organisational challenges facing health research, and underpinning training, in the UK over the next decade? How might the UK Government best help address those challenges? What do you believe should be the Government's objectives for health research, and why?**

Diversity of research portfolio and interdisciplinarity

The proposed creation of a Single Health Research Fund is welcomed as an opportunity for the UK to build on its excellent medical science base and to abolish what has hitherto been an artificial separation between basic and clinical research on the one hand and clinical practice on the other. The Academy perceives research as a *continuum* originating from purely curiosity-driven projects and extending to the delivery of healthcare (drugs, assistive and diagnostic devices, etc). Inevitably the *continuum* involves cross-fertilisation between research areas and, with it, the creation of fuzzy boundaries that act as incubators of interdisciplinary projects. The MRC's aim to "foster links across disciplines (physical sciences, mathematics, computing, economics, social sciences) and between basic and applied biomedical sciences"² is supported strongly and is seen as one of the key objectives that need to be achieved over the next decade. However, the creation of an environment that favours the blossoming of interdisciplinary and innovative research will require changes at many levels, not least cultural changes within the academic community and the expertise of funding bodies' committees. Training of the next generation of scientists and technologists will also, necessarily, have to be adapted to the emerging interdisciplinary and innovative trends, and the academic silo culture must be counteracted and transformed into more fluid, dynamic and flexible practices.

Being highly interdisciplinary, researchers in the fields of Medical Physics and Bioengineering, for instance, have faced significant difficulties in obtaining funding.

² http://extra.mrc.ac.uk/forms/shrf/success_criteria.htm

Their main Research Council support is the small component of EPSRC funding allocated to medical research, and, in particular, the Health Technology Devices (HTD) and New and Emerging Applications of Technology (NEAT) programmes, both operated by DH, and both with rather small budgets). However, Medical Physics and Bioengineering partially fall under the remit of other Research Councils as well. This Academy recommends that all the Research Councils, and funding bodies in general, should coordinate their efforts in order to prevent important research being lost at the interface between Research Councils (i.e., the phenomenon of “falling between the crack”). A more recent example of an interdisciplinary subject whose development is facing similar obstacles is Systems Biology: the BBSRC and the EPSRC are leading in promoting the development of this research area and their cross-councils funding initiatives are commended. The MRC also supports some work in this field and is keen to do more, especially in areas of Systems Biology and Physiomics of importance to translational research and to the pharmaceutical and biotechnology industries.

Both the MRC and the DH R&D have hitherto had to concentrate their resources on *priority areas*: predictably, this system has led to some research areas being neglected. Hence, it is recommended that a wide, *assorted* research portfolio with mechanisms to encourage and support interdisciplinary research be mandatory for the effective implementation of the Single Fund. It is acknowledged that Research Councils other than the MRC (BBSRC, ESRC, EPSRC and even PPARC) have elements of their portfolios that are relevant to health research. It is recommended that such funds should not be diverted to the Single Health Research Fund. Research Councils other than the MRC should be allowed to pursue such research, at the interface with medical research, outside the MRC/DH R&D partnership. Moreover, systems should be in place to allow cross-council funding between MRC/DH R&D and the other Research Councils.

Strategy

If the Single Health Research Fund is to deliver what is expected, a *multidimensional* strategy will be mandatory. One dimension encompasses the concept of the *research continuum* discussed above: a balanced portfolio is necessary to ensure that most aspects of medical research advance together and in a coordinated fashion. *Time* and a *vision for the future* are other very important, interlinked dimensions. Milestones should be set in the short, medium and long term, and systematic (but not burdensome) review mechanisms should be put in place to ensure that research adapts promptly to changes in the healthcare scenario. Indeed, even long term strategies in the healthcare sector cannot extend beyond a ten year period. Circumstances may change rapidly and the research trends that are currently addressed as priorities (e.g. bird flu) may well assume secondary relevance within a few years. Strategies are not plans and therefore should be applied flexibly, acknowledging changes in both research options and developments in healthcare. Further, whilst a *vision for the future* should be based on real needs, strategies must also reflect the impact that new science, engineering and technology have on clinical practice. Models that predict the economic and social impact of changes to healthcare need to be developed, refined and their output used to inform the strategy. A final dimension is *space*: strategic planning should take into account the activities of all funding bodies and charities other than the MRC and DH R&D. Healthcare research is too fragmented at present: more information sharing and

coordination of activities are required if the added value (in economical terms as well as in terms of healthcare provision) of the whole sector is to improve.

- 3. What should be the Government's priorities for health research? Is there anything it should stop doing or funding? What is it not doing or funding that it should do, and, in the absence of further sources of support, what can it lower in order to release the necessary funds?**

An ageing population is an obvious problem that affects many countries, including the UK. In this country, the demographic changes are increasingly stretching the NHS resources in terms of drugs as well as medical technologies. On the other hand, there are concerns that UK life expectancy, especially in some regions and among some social groups, is increasing less quickly than in other European countries, and that health expectancy is not increasing in proportion to life expectancy. The Prime Minister is calling for changes in lifestyle and is seeking to place more responsibility on the individual. Moreover, the sentiment among the public is that research on prevention should receive more support, with the hope that this will lead to healthier lives and less demand on healthcare. The Academy recognises the MRC's lead in recently establishing the National Prevention Research Initiative. An increased budget for the MRC through the new funding arrangements for health research would help this important initiative to grow. Further it would also enable the MRC to invest more in engineering research into better lifestyle assist devices.

- 4. How should decisions be taken on the balance between the long-term economic and social benefits of a high quality biomedical research base; and the needs for research to improve healthcare and other public services? What is the appropriate balance between public funding for investigator-led and priorities led research? How do we balance funding for basic science, translational science and applied science? Is this something that should vary over time? What mechanisms should be used to make judgments about this balance?**

Commercial exploitation of the science base

HM Treasury is currently scrutinising the effectiveness of Research Councils and assessing the return on public investment in science and technology. A highly debated issue is whether Research Council funds should be mainly invested in idea-driven research or whether the focus should be on customer-led demand. To the MRC, like the other Research Councils, scientific excellence is the highest priority. They operate under the principle of placing most decisions on scientific funding at arms-length from Government (the Haldane Principle), and ensuring rigorous scrutiny of strategic and funding decisions. This arrangement has served the UK well and the "Next Steps" document³ contains a clear commitment to maintaining this principle as the basis of decision making within the Single Fund.

³ http://www.hm-treasury.gov.uk/media/D2E/4B/bud06_science_332v1.pdf
Accessed on 28 July 2006

Notwithstanding the importance of Research Councils' independence from Government, they increasingly recognise that their remit extends beyond the science base and includes IP exploitation and commercialisation of research developments (see answer to Q. 1). Within the context of the Single Health Research Fund, the MRC has stated that it seeks to "provide an even stronger body of professional input to knowledge transfer and IP exploitation, across the breadth of health research, including at a preclinical level"² as a component of effective funding strategies for research and infrastructures. However, especially in the biomedical research sector, links with industry, the gateway to the market economy, need to be strengthened if the excellent UK medical science base is to contribute as fully as possible to the UK plc in the way MIT contributes to the US economy. The MRC is to be applauded for having brought to market several blockbuster drugs through MRCT: indeed, MRC data show that it exceeds MIT in its total income from knowledge transfer and has a return on investment more than twice that of MIT. The Academy hopes that the MRC can extend this success to the engineering-based healthcare sector and liaise more widely with SMEs in this sector. Consideration should also be to ensuring that any changes are in line with the recommendations of the Healthcare Industries Task Force (HITF) report.

Some Fellows of this Academy consider that, at present, across the sciences, too few resources are devoted to research aimed at meeting customer-led demand. Hence, while no measure should be taken that could undermine the research excellence of the UK science base, the adoption of an approach that responds better to the market economy, and that takes into account customer demand as well as innovative trends, should become key aspects of the strategy of every Research Council. The proportion of funding allocated to basic, translational and applied research respectively should remain fluid and vary over time according to the dynamics, changes and development in the healthcare scenario.

5. In your experience, how have the results of publicly-funded health research in the UK been used, both in the development of new treatments and to influence / change wider policy and healthcare practices? What lessons can usefully be learned to improve the uptake of advances in science and medicine?

Biomedical imaging is an area where major developments were all initiated in the UK. MRC-funded researchers were centrally involved in the invention and development of both Positron Emission Tomography Magnetic Resonance and Computed Tomography, and the pioneering work of Sir Peter Mansfield in the field of Magnetic Resonance Imaging (MRI) was entirely funded by the MRC. The implementation of these technologies in healthcare was funded by DH (or DHSS as it then was). However, commercial exploitation in the UK was minimal, whereas foreign companies successfully took the technologies to market and are still benefiting from them. In the case of MRI, in particular, the development was not taken on by the NHS until relatively late. Unfortunately, this has been a general trend within the NHS, which has consequently attracted criticisms for being a slow adopter of technology and for delaying access of patients to advances in healthcare. As a result, a very small number of hospitals may, at any one time, have cutting-edge procedures and facilities; the rest trail behind. In the case of MRI, even when machines did start to enter general hospital service, operators found themselves inadequately trained and unprepared, and many systems were therefore poorly utilized in spite of the huge need and demand. There is a need to change the culture

entirely in the NHS towards the adoption of new technology, and especially in district general hospitals. If novel treatments and/or devices are to be introduced rapidly, of the benefit of patients, the attitudes of hospital managers must be reformed.

- 6. How might better links be forged between ‘basic’, translational and applied researchers, working across the whole field of health research, from the laboratory bench to the front line of the NHS? How might better links be forged across disciplines, e.g. with engineers, physicists, and social scientists?**

The answer to Q. 6 is combined with that to Q. 7.

- 7. How can the Government encourage translation, entrepreneurship and innovation in health research to improve public services in the UK?**

Research as a continuum

Notwithstanding the importance of biomedical engineering in basic as well as clinical research, investments in this research area are still insufficient. In particular, a gap exists between basic technological research and implementation of the resulting developments. It is often the case that MRC funds the former and EPSRC the latter, but the resources needed for supporting the intermediate stages of technology development (follow-on funds for evaluation and testing) are often difficult to obtain. Inevitably this hinders innovation and prevents patients and the public in general from accessing the most advanced medical technology.

Translational research is an issue that affects every area of science and technology. The MRC's intention to “improve strategic planning and support for all areas of translation between basic and applied health research”² within the context of the Single Research Fund is laudable. However, obstacles exist and the interdisciplinary research areas, often high-risk but with an innovative potential, are the ones most in danger. Thus, while bearing in mind that MRC-funded research is primarily idea-driven, and applauding the MRC/EPSRC partnership in co-funding several major projects in the field of biomedical engineering, the MRC should be encouraged to play a bigger role in the funding of *translational* biomedical engineering. This could be done by establishing *ad-hoc* positions and recruiting individuals whose unique role should be to assist researchers in the transition of their project from “proof-of-concept” stage to a more applied level. Such people should have an industry background and a thorough knowledge of the healthcare market economy.

The NHS regards itself as an icon of public service and is perceived as suspicious of entrepreneurial interests. The Medical Device Agency (MDA), for instance, raises all sorts of barriers, including being more expensive than equivalent agencies elsewhere in Europe, and certainly less welcoming. In addition, the NHS will not procure new treatments or devices until the National Institute for Health and Clinical Excellence (NICE) has approved it. This is a paradoxical situation for the manufacturers of devices and equipment, since it is not clear how a company can obtain the clinical data it needs to support an application to NICE without having the opportunity to market its equipment to hospitals. The company itself will then have to fund the evaluation of the device. Finally, hospitals will not purchase the technology until another branch of MDA has evaluated it and prepared a report on it. By the

time this process is complete, UK Health Services and Research have missed the opportunity to innovate successfully. In the face of this barrier to evaluation and innovation in the UK, large companies are likely to decide to take advantage of the global market and to commercialize their products and services elsewhere. Small companies may not be able to enter the global market and therefore are likely to fail.

The DH R&D system is undoubtedly conservative and actively discriminates against innovation. Whatever part of the Single Fund is responsible for innovation within the health service should be encouraged to adopt a more welcoming approach to the introduction of newly developing and innovative technologies if patients are to be offered the most advanced healthcare. For instance, Technology Readiness Levels mapped against technology roadmaps, currently used within MoD, could assist in assessing the maturity of evolving technologies. A more dynamic acceptance of technology by the NHS would also stimulate and foster interdisciplinary interactions within academic community and industry. Hence, the linkages between the present functions of DH R&D should be more closely linked with those of the MRC, so that the research pipeline can be accelerated.

In summary, the work of MRC and DH R&D should be brought together and coordinated with the aim of reducing the gap between proof-of-concept and delivery of clinical practice. Presently, the British healthcare industry sector is too fragmented to take on such a role and unless the gap is addressed with public funds (at least in the beginning) biomedical engineering in the UK will continue to deliver too slowly to be competitive. This will inevitably impact on UK healthcare as well as the UK economy.

Bureaucracy

The reduction of the bureaucracy would certainly benefit the links between basic, translational and applied researcher. But while this question is being asked, other agencies, such as the MDA in its interpretation of the EU Medical Device Directives, are making collaboration even less feasible. Rather than focusing purely on forging links, more effort is needed on ensuring that the links can operate. The changes to the Ethics process, which is now much more bureaucratic and centralized, is another deterrent.

- 8. How can UK health research funding be most effectively used to provide the appropriate infrastructure for basic, translational and applied research, whether funded by the UK public sector or other sectors? How can UK health research funding be most effectively used to support the work of NICE, facilitate innovation and collaboration with industry, and address market failures in the application of healthcare?**

UK health research should not be used simply to support NICE: this is essentially a reviewing body whose work rests on the final output of research carried out by other parties. However, UK health research funding could be, and needs to be, coordinated in a better manner. Research Councils other than the MRC, and several medical charities (Wellcome Trust, Cancer Research UK, etc) make significant contributions to biomedical research. The proposed MRC/DH R&D partnership should coordinate its effort with those of all the other stakeholders and ensure that

the most recent research output can be passed to NICE swiftly, and that delays in the production of new guidelines are avoided.

9. What lessons should the UK learn from other countries in making the proposed changes to the institutional arrangements for the funding of health research?

A good example of a feasible solution exists at Oulu in Finland, where a major University research programme is paralleled by an industrial complex. Small companies are incubated, developing products from their own ideas or those of the local academic community, while the nearby University Hospital is charged with their evaluation. All activities are funded in parallel, and operate seamlessly. The UK could consider establishing three or four similar, but much more powerful, programmes. These should be run by top medical schools, e.g. Cambridge, Imperial College, etc.

10. In implementing the single fund for health research, to what extent should the MRC and DH / NHS R&D be merged or brought together? And to whom should the single, ring-fenced fund be accountable? Please provide reasons and any supporting evidence for your response.

As for the structure, administration and organisation, the two bodies do not necessarily need to be merged. However, a two-body system would presumably require the creation of an overarching structure to monitor and supervise the partnership between the two bodies, therefore adding an extra layer of complexity and bureaucracy to the system. Alternatively, the DH R&D should be incorporated into MRC, whose remit would therefore expand significantly. This model would require changes in the constitution of the MRC Council and Committees to allow a more significant representation of expertise covering clinical practice, public health and health technologies. Whether a one-body or a two-body arrangement is adopted, research within the NHS, undertaken by and with clinicians, should be managed and funded by the MRC. The strict and effective, world-renowned, peer review process of the MRC and its experience as a grant giving body, make the MRC the ideal candidate for the management of the Single Fund. Unfortunately, DH R&D cannot claim the same effectiveness in the management of its research funds, which have frequently been eroded for other needs.

11. To what extent does the success of recent innovations in health research (e.g. Clinical Research Networks) and the proposed structures rely on the new Connecting for Health NHS IT system, and to what extent should it do so?

The Fellows who contributed to this response questioned the evidence of this success. Both the Clinical Research Networks (CRN) and the Connecting for Health (CfH) NHS IT system are not perceived as successful accomplishments. The broad objectives of both are recognised but the implementation of these projects is questioned. For instance, the current state of the CfH programme is a far cry from the original specification, and the Picture Archiving Communication Systems (PACS) programme has now been reduced to installing standard departmental PACS.

Hence, they should be re-assessed in the context of the establishment of the Single Fund. If necessary additional resources should be devoted to their more effective implementation, and efforts should be made to coordinate the work of the CRN and Connecting for Health with the broader strategy of the Single Fund.

12. Given that NHS R&D is currently devolved, but that the work of Research Councils is not, how can these functions work best together to maximise the health and economic benefits to the UK.

As discussed in the paragraphs above, the MRC/DH R&D partnership should coordinate its efforts with those of all the other main stakeholders. The work of R&D divisions in devolved administrations complements that of DH R&D England. It is important that the closer combination of R&D England with the MRC should not impede the efficient funding of research within the NHS anywhere in the UK. It is not advisable to split the current MRC funds among all the administrations in the UK. Not only would it be difficult to reach agreement on a formula for the percentage to allocate to each administration, but it would also reduce the overall efficiency and productivity of health research in the UK. The MRC should remain free to fund high quality research wherever it can be carried out within the whole of the UK, even if part of funding is transferred from the Department of Health.

APPENDIX

Translational research and cross-council follow-on funding: case studies

While acknowledging the fact that cross-council funding of interdisciplinary and translational research is becoming more common, translational healthcare research is still likely to face the barriers created by the sharp boundaries of Research Council remits. For example, while EPSRC does not fund clinical trials, MRC does not support device development. In these circumstances, the full development and evaluation of new devices requires grants from two different Research Councils. The following three examples illustrate the present lack of satisfactory mechanisms for funding the development and evaluation of significant technological innovations of potential medical significance (as distinct from minor improvements to established techniques).

A number of years ago one of the Academy Fellows devised a technique for replacing voxel-based computed tomography, and its hundreds of coplanar, very high-intensity irradiating views, by an object-based technique, requiring only about 10 moderate-intensity X-ray projections, taken from viewing directions distributed uniformly in two-dimensional angular space. In most scenarios, this provides essentially the same information, with about 1/5 the cost of equipment and a several hundred-fold reduction in radiation dose. Following a successful proof-of-principle demonstration on a knee-joint phantom, Imperial College patented the technique and sought funding for its development. However, the EPSRC felt that, since it was addressing a medical problem, it fell within the purview of the MRC. However, the MRC ruled that, while the eventual clinical evaluation might be within its remit, in the meantime it was an engineering development appropriate to the EPSRC.

Imperial College Innovations is now hoping to set up a spinout company for its development and exploitation, but has not yet found an appropriate source of funding.

At about the same time, the same Fellow became aware that the X-ray contrast between healthy and malignant tissue was very small, resulting in around 20% “false negatives” and about the same proportion of “false positives” in cancer diagnosis. He postulated that since malignancy is associated with metabolic hyperactivity, and hence an enhanced concentration of saline fluid, there should be quite a strong microwave contrast. This was confirmed by further experiments carried out by other researchers, but the techniques then available did not yield either an adequate depth of penetration or the requisite 3D resolution. The Fellow proposed overcoming both these limitations by using a multi-antenna array, time-shared so as to observe and record separately the signals as received by each antenna. This permitted retrospective focusing on to each 3D “resolution cell”, compensating the individual signal, for each such two-way path, for its assessed propagation losses. In addition to the resulting coherent processing gain, this focusing, with a convergence angle of radiation of 120°, yielded a resolution of $\frac{1}{4}$ wavelength in all three dimensions. However, Imperial College was not able to pursue this technology because, at that time, there was an unbridgeable gap between the Medical Electronics and Microwaves Departments.

In due course, the project was taken on by Bristol University, where it was also patented. However, Bristol University encountered the same problem of dead ground between the domains of the EPSRC and the MRC as Imperial College as experienced with the X-ray project described above. Eventually Bristol University did manage to establish a spinout company, which is now pursuing the technique and which should be starting the first clinical trials shortly.

Other bioengineers with more extensive experience of medical applications find that there is little support in the NHS for new technology (see above). Further, the NHS has inadequate funds for innovative technological development or its evaluation. Thus there is no source of funding innovation, except by exploiting demonstrated commercial potential. The microwave imaging project is a good example. Commercial potential had to be demonstrated in order to enable the development of a more effective, less harmful, and eventually cheaper system.

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