Foresight in science : an experiment in the field of cardiovascular research : project overview / J. Anderson and N. Williams.

Foresight in Science

An experiment in the field of cardiovascular research

Project Overview

RISM
for Policy Research in Science and Medicine

FORESIGHT IN SCIENCE

An experiment in the field of cardiovascular research

Project Overview

PRISM Report No. 3
J Anderson and N Williams

March 1995

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This report presents an overview of the main findings of an experimental foresight project on the future of cardiovascular research in the UK. Full details of the key components have been published elsewhere in a number of reports and papers.

The project team comprised Dr Joe Anderson, Dr Nigel Williams and Dr Lesley Rogers. The team are grateful to the project steering committee, Professor Andrew Henderson, Professor Philip A Poole-Wilson, Professor Desmond Julian, Dr Laurence H Smaje and Dr Megan B Davies for their guidance; Dr Jane Rogers and Dr Mary Phillips for identifying postdoctoral fellows and Dr Mairéad O'Driscoll, Ms Rachel Blenkiron, Ms Sally Driscoll, Ms Dagmar Jeschin and Ms Rose Trevelyan for data processing and analysis.

The foresight project was funded by the Wellcome Trust, the British Heart Foundation and the Medical Research Council.

Strategic planning and priority-setting have become inevitable for UK research funding bodies in 1990s. But they are activities that are ill-suited to scientific research; an endeavour characterized by uncertainty and discovery. There is considerable interest, therefore, in the promise of foresight techniques as an alternative approach to conventional strategic planning. In the broadest sense foresight is a structured process through which funding bodies, researchers and research users can consult with one another to assess scientific opportunities and needs.

This report presents an overview of a project that aimed to explore the usefulness of foresight analysis for research funding bodies in their periodic reviews of priorities for specific research fields. The test field chosen for this experiment was cardiovascular science – a broad, multidisciplinary field of considerable strategic importance – covering basic science as well as clinical subjects, industrial as well as academic research, and laboratory as well as population-based studies.

The project involved developing techniques of consultation and analysis systematically to assess the UK's international position in cardiovascular research, and identify key scientific opportunities as well as areas of greatest need for more research in this field. The aim was to examine a range of possible futures for cardiovascular research, and explore present policy options for strengthening the UK's future support infrastructure for this field.

Crucially, and more generally, the project also aimed to assess the value of this approach to priority-setting in other fields of research, at a time when many funding agencies in the UK and elsewhere are considering implementing foresight methodologies.

Main stages of the project

The project involved several distinct stages, which included:

- Defining the boundaries of the field under study through consultation and feedback from various interest groups and producing 'benchmarking' data on UK activity internationally.
- Structured interviews with research users (e.g. clinicians, health service managers, industrial R&D executives).
- A postal opinion survey of a large sample of cardiovascular researchers on the main issues raised in interviews with users.
- A foresight workshop of senior policy makers, academics and industrial researchers bringing together data and survey results in a novel format to identify priorities for the field.

Main outcomes of the project

The project produced a variety of new data on activity in the field of cardiovascular research, and sampled opinion within a wide cross section of the scientific community on future opportunities and needs for the field.

Assessment of UK research activity

International research activity was assessed in terms of the output of research papers. Although the UK had the third highest output (after the USA and Japan), British papers only accounted for 6% of the world total. Nevertheless, these papers (along with those from the USA) had the highest citation impact internationally. However within the UK, cardiovascular research did not stand out as a specially active field when compared with all biomedical fields together. In Germany and Japan, cardiovascular research appeared to have much greater prominence in the national research portfolios than was the case in the UK. In addition, research activity was heavily concentrated in London, with 69 of the 100 authors producing the greatest number of research papers based at addresses in the Capital.

Identification of scientific opportunities (science push)

Over 300 active cardiovascular researchers responded to a questionnaire survey. Among these, there was widespread agreement that substantial scientific advances would be made over the next five years in the cellular and molecular topics of cardiovascular disease. Specifically, there was expectation for improved understanding in three subfields, namely: (i) the functions of the vascular endothelium, (ii) the mechanisms of atherogenesis and (iii) the molecular genetics of cardiovascular disease. In contrast, this research community saw little prospect over the coming five years for scientific research to contribute more than it already has to our understanding of the role of non-dietary environmental risk factors.

Identification of opportunities for improved disease interventions (demand pull)

Survey respondents were most optimistic over the prospects for developing new drugs to treat and reduce the risk of heart disease, and for new molecular techniques to screen the disease risk of individuals (a development on inferring risk through population studies). However, there was also widespread agreement that there is a strong opportunity for improving the use of existing scientific knowledge through developing enhanced methods of treatment evaluation and medical audit. In contrast, respondents were collectively less optimistic that public health measures, heart transplants from animal donors, or artificial hearts, would be developed as effective interventions over the next five years.

Identification of a skills gap

The survey also revealed that rapid developments in the techniques of molecular and cellular biology have failed adequately to penetrate the field of cardiovascular research. More than 40% of the respondents, currently active in cardiovascular research, stated that skills in molecular biology were currently unavailable to them, but anticipated that such skills would be essential for their future research plans. Another skills gap was identified in bioengineering, specifically in imaging and scanning skills.

Recommendations for reforming the support infrastructure

There was little support from the majority of the research community for the creation of a national research institute for cardivascular science. There was, instead, strong support for the development of smaller multidisciplinary centres, or funded networks as the most effective means of strengthening the field.

Synthesis of findings and assessment of priorities

The workshop brought together the three main funding bodies supporting cardiovascular research along with leading representatives of the relevant scientific and research user communities. Using a combination of scenario analysis, guided visualization, real-time 'Delphi' techniques and colour voting, participants worked with data produced in the foresight project to arrive at a set of priorities. These fell into two categories:

Scientific priorities.
Scientific priorities followed closely those emerging from the postal survey of scientists – viz. studies of:

- the vascular endothelium,
- the molecular genetics of disease risk, and
- the mechanisms of atherogenesis.

Infrastructure priorities.
The top priorities for strengthening cardiovascular research against a range of possible future scenarios were to:

- establish a small number of multidisciplinary groups, or a funded research network;
- provide more long-term funding for research projects;
- protect curiosity-driven ('blue skies') research.

Overall, the project met its immediate aims of producing an information base on which priorities for the field of cardiovascular research could be established. More generally, lessons were learned which may be of value to future priority-setting exercises using foresight techniques in other fields of scientific research.

Lessons learned for developing future foresight studies

A clear finding was that the process of analysis, consultation and wide debate on priorities can provide strong, coherent signals to policy makers on options for new initiatives that are likely to strengthen their field against a number of possible futures. The foresight project enabled a large number of researchers, users and policy-makers to learn through exploration and analysis, and this process was at least as important as the list of options that were the tangible output of the project. Furthermore, because the process was fact-driven, and consultation methods open, a sense of ownership of the project was encouraged among those involved.

More specifically, the process of analysis and survey provided a vehicle for partnership between the funding bodies involved, and an opportunity to consider coordinated national policy for the field under study. It provided a structured mechanism for involving users in the policy process, and enabled funding bodies to explore common priorities, while maintaining the independence of their individual policies.

The project deliberately focused on developing foresight techniques at the level of an individual scientific field, (micro-level foresight) because the Boards and Committees of funding bodies have an increased need for priority-setting at this level. The project was also designed to test foresight methods for organizations concerned with supporting the science-base. Within this context, a number of recommendations can be made concerning the methods and techniques used, for consideration in future foresight studies at the micro-level:

Consult users in early stage of project

Researchers and users have quite different perspectives on the future of a research field, and it is not easy to explore technical judgements and potential markets for research findings in a single survey instrument. An effective approach is first to consult users on their needs and concerns through structured interviews, then explore the potential of science to address these concerns through questionnaire survey of a large number of researchers.

Survey spread of scientific opinion as well as consensus

Foresight studies in applied areas of science often have a focus on developing a consensus – e.g. on judging the timing of likely technological advances using 'Delphi' techniques. When applying foresight in areas that include more basic research, it is important also to capture the minority (possibly maverick) views. To this end, an effective approach is to conduct a one-stage survey of scientific opinion, and present the full spectrum of results for interpretation to an interactive workshop of users and researchers.

Emphasize non-scientific and infrastructural priorities

Traditional peer review committees of scientists, if composed well, can be very effective at identifying hot areas of science, and foresight appears to have little to add to the work of such expert groups in identifying areas of science. A strength of foresight in the science-base appears to be more in identifying infrastructural changes that need to be made today, to strengthen the field tomorrow – e.g. in identifying skills needs, or institutional reforms needed to bring scientists and users into closer contact. However, it is necessary to be sensitive to the potential for self-interest to emerge in questionnaire surveys on these issues. The foresight project found that it is important not to rely solely on surveys of academic scientists when exploring options, for infrastructural reform; other interested parties such as research administrators, and research users should also be consulted.

Give more emphasis to methods that encourage direct interaction between users and researchers

The foresight workshop was carefully structured and employed novel techniques of group facilitation to encourage creative debate between users and researchers. Special techniques were needed to permit meaningful dialogue between these two communities, but the foresight workshop proved to be a very positive and crucial stage in the overall project. There is scope for further development of such techniques, and the emphasis in future foresight projects should be on developing more opportunities for contact between users and researchers. It is recommended that to achieve the goals of foresight more effectively, future projects should place greater emphasis on creating opportunities for direct contact between users and researchers, with a smaller effort being reserved for postal opinion survey and data analysis.

Developing foresight as an evidence-based approach to policy making

Overall, the methods described in this project should be transferable to foresight studies in other fields of academic science (biomedical or otherwise). It is hoped that such techniques may provide one way of developing a more evidence-based approach to policy making and priority setting than has traditionally been the case in science.

1.1 Background

With the ever-rising costs of research and growing opportunities in biomedicine generated by the revolution in biological sciences,[1] funding bodies are beginning to develop more explicit funding strategies and research priorities.[2]

The development of funding strategies has traditionally drawn heavily on the work of expert groups of scientists, convened to conduct in-depth reviews of specific scientific fields. But with increased competition for funds and the increasing interdependence of research fields, it is becoming more difficult for subject-specific expert committees to obtain a broad overview of research needs and opportunities and gather the hard data to support their recommendations in the face of competing interests.

A recent study by the former Science and Engineering Research Council of more than 100 documents produced by expert groups for the Council's boards and committees over a five-year period found that most had been of little value for forward planning.[3] The study concluded that the function of the typical field review was to 'promote the excellence of the programme to such a degree to ensure its continuation in terms of further injection of funds'. With this purpose, it is not surprising that field reviews by expert groups may not contain a balanced overview of weaknesses as well as strengths; needs as well as opportunities.

Against this background, there is increasing pressure on funding organizations to identify who benefits from research and to take account of the views of these 'research users' when establishing priorities. The Government's White Paper on science and technology, 'Realising Our Potential',[4] highlights the importance of this aim and the Office of Science and Technology is developing novel methods to help identify appropriate research users in its technology foresight programme.

In anticipation of these developments, support for the present study arose from a joint working group comprising the Medical Research Council (MRC), the Wellcome Trust and the British Heart Foundation (BHF). This working group had previously completed a field review of cardiovascular biology in 1990. Although the review report appeared to have the elements necessary to influence policy, the working group acknowledged that future funding strategies might be better developed on the basis of more systematic data and broader consultation, including users, on the needs and opportunities for the field. It was decided that an experiment in foresight analysis was justified.

The challenge was to develop methodologies to address some of the perceived weaknesses in traditional field reviews. The two key needs were for data on the status of the field in question within the national and international context, and the development of a framework to consult widely

and openly with both researchers and users of research. Following the main data and opinion gathering stages of the project, novel means of facilitating discussion on future policy options and priorities were also to be tested.

The Wellcome Trust, the Medical Research Council and the British Heart Foundation therefore decided to support a 'foresight study' as an experiment to address these needs, and the original cardiovascular working group of administrators and scientists formed the project steering committee (appendix 1).

1.2 Research foresight

The experience of research policy-making bodies in several countries is that it is possible to use systematic techniques of data gathering, consultation and analysis to help develop research strategies and to provide a framework within which priorities can be determined.[5] Such approaches, collectively called foresight analysis, broadly aim to obtain expert opinion on the future of a field and hard data on its status and trends, nationally and internationally. Generally foresight analysis includes identifying and gathering data on:[6]

- national strengths and weaknesses,
- needs for research (demand pull),
- scientific opportunities (science push),
- the country's ability to exploit research findings,
- the necessary skills base.

Techniques of foresight analysis have previously been used in industry to help develop research strategies for individual companies. But a number of public-sector organizations have also used these techniques to help inform policy for academic areas of science.[6]

In Japan, research foresight has had a long-standing role in the development of policy. A well-publicized exercise, the Science and Technology Agency's 30-year technology survey, has informed a wide audience on trends and future issues. This exercise comprises a structured, two-round 'Delphi' survey of more than 3000 experts on more than 1000 topics including some of relevance to cardiovascular research (appendix 2). The term Delphi refers to the process of providing feedback on the results of the first round of the consultation before respondents give their views a second time. This major exercise has been repeated every five years since 1971 and is believed to have helped Japan gain notice, for example, of early trends on the potential in the development of robotics and flexible manufacturing systems more rapidly than its competitors.[7]

In Germany there has been growing interest recently in the development of foresight activities and the federal government has collaborated with Japan to carry out its own 30-year exercise using the same topics with

1000 German experts. The results, published in 1993, revealed extensive agreement between the two countries on likely timings of technical and scientific developments.[8] Another, more informal, initiative by the federal government has led to a fundamental shift in the balance of support away from the physical sciences to the life sciences.[9] Large, systematic foresight exercises were recently launched in a number of other countries.[5]

A technology foresight exercise was also launched by the UK government in 1993 as a major activity following the publication of the science and technology White Paper.[6] The aim of this foresight study was to identify main areas of underpinning, 'generic' technologies and their related scientific research, in terms of long-term impacts on economic and social benefits. Panels of specialists from industry and academia in 15 areas of technology were set up to oversee an extensive process of consultation with their respective researcher and user communities.

A central assumption of foresight analysis is that although views are sought on trends and potential developments, it is impossible to predict the future accurately. Instead, the foresight process assumes that many futures are possible but the one that emerges is likely to do so as a result of policy choices made today. The emphasis is on shaping the future of science and technology by making informed decisions on needs and opportunities.

This notion of 'creating the future' is particularly appropriate to science funding organizations, as they are well placed to assess what is possible in the future, which through the foresight process, can be placed in the broader context of what is desirable.

1.3 Scope of the project

The challenge for this project was to select and develop techniques of foresight analysis appropriate for the multidisciplinary field of cardiovascular research in the UK and test their usefulness in the support of policy development for the field.

It is important to note, however, that this is foresight analysis at the 'micro' level – that is focused on one specific field of research and aimed at the interests of a committee of scientists and funding body officials. The emphasis was therefore on science push rather than demand pull with greater consideration given to scientific rather than technological priorities, and on infrastructural reform for supporting this field of academic research, rather than commercial goals.

Project outline

The final project methodology comprised four main components (Figure 1):

1. Developing a definition of the field in consultation with a steering committee of experts and customers of the study to determine publication outputs and trends of activity in the UK in comparison with other countries.

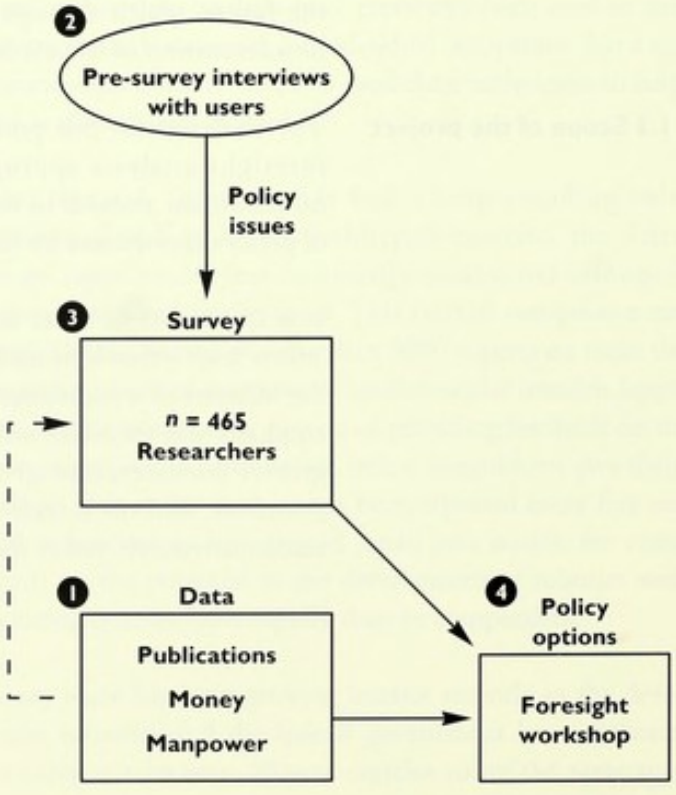
2. Structured interviews with a broad range of people with an interest in cardiovascular research, including researchers and research users such as health planners, managers and industry R & D executives, to identify issues facing the future of the field.

3. An opinion survey of a large sample of cardiovascular researchers on the main issues raised in face to face interviews.

4. A foresight workshop of senior policy makers, academics and industrial researchers bringing together data and survey findings in a novel format to identify priorities for the field.

Reports and papers on each of these stages of the project have been produced.[10–12] This report presents an overview of the project, synthesizes key findings, outlines policy options, and draws several lessons for future foresight studies of this nature.

Figure 1 **Cardiovascular foresight project outline**



2.1 What is cardiovascular research?

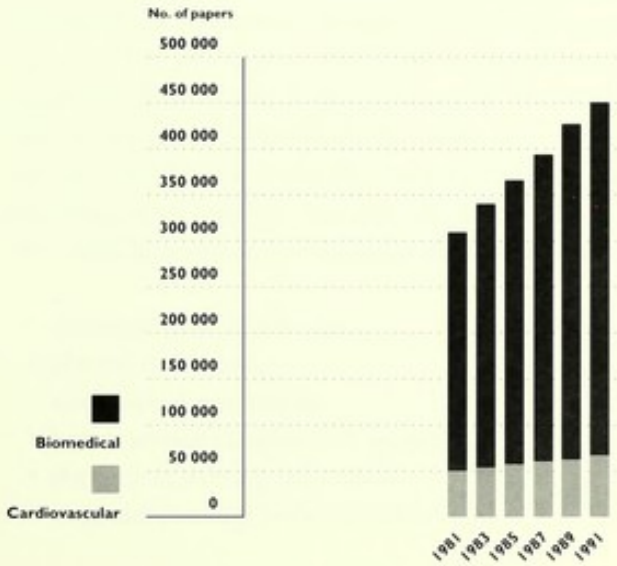
One of the first tasks of the project was to develop a working definition of what comprises cardiovascular research, particularly in relation to the UK funding bodies that represent this field. The approach taken was to define the field through the general scientific literature in biomedicine. A 'filter' was developed to capture cardiovascular research publications as a means of defining the field and determining research outputs. The approach adopted was to use the Medical Subject Headings (MeSH) that classify papers on the Medline database.[10] The key challenge was to select MeSH terms that would include all appropriate papers but exclude work not considered to be of cardiovascular relevance. This was a substantial task as there was no precedent for defining a broad multidisciplinary field in this way and there are many hundreds of thousands of biomedical papers recorded on the two databases, Science Citation Index (SCI) and Medline, used for the project. As with other fields of clinical medicine, the research literature is also highly dispersed.

A substantial iterative process with expert assessment by the steering committee was used to devise the terms for the filter. The filter was tested on the known output of several laboratories carrying out cardiovascular and other research and was found to be effective at selecting only cardiovascular research from laboratories known to be working also in other scientific areas.[10]

2.2 Cardiovascular publications

Figure 2 shows the total number of biomedical papers worldwide throughout the 1980s and the proportion captured as cardiovascular research using the filter of MeSH terms. Overall, cardiovascular papers accounted for 19 per cent of biomedical papers – an average of 65 000 per year over this period – and the UK published 6 per cent of the world cardiovascular total.

Figure 2 **Biomedical and cardiovascular publications for all countries: 1981–1991 (Medline analysis)**



This definition of cardiovascular research was adopted by the project steering committee, and served as a point of communication between the three funding bodies involved. Moreover, the publications database produced by this definition provided a pool of 'cardiovascular' researchers from which the majority or respondents for the opinion survey was drawn.

The purpose of this survey[11] was an attempt to secure wide involvement within the research community. It was also an exercise to test whether it was possible to generate coherent opinions on a range of issues from a broad-based sample of researchers that could be used to inform policy discussions.

3.1 Consulting users

The issues explored in the survey of cardiovascular researchers were first identified through structured interviews with a group of research users and other 'stakeholders' representing various interests in cardiovascular research. Questions used in these interviews were designed to 'trigger' thoughts on strategic issues confronting the field without leading respondents in any direction (see Box 1).

Box 1

Questions used in interviews with stakeholders

- If you could talk to someone who actually knew the future of your field, a genuine 'Delphian' as if such existed, what sort of questions might you wish to ask?
- If things went very well in your field, looking at it optimistically, what sort of achievements might be possible?
- If things do not go so well, what do you see as the pitfalls which might limit research success?
- Looking at the ways research is now carried out, what changes might be needed to help ensure that the optimistic targets are achieved?
- Looking back, what do you see as the most significant events that have advanced research in your field to its current state – and what have been the major disappointments?
- Looking forward, what do you see as the most immediate and pressing actions needed to strengthen your field?
- If all of the constraints, financial or otherwise, could be removed, what more would you suggest should be done in addition to what has already been mentioned?

Stakeholders were defined as people who have a professional interest in the field from researchers themselves across the spectrum to the users of research. For this survey, the users included health service managers, planners and industrial R & D managers. The distinction between users and practitioners, however, is not clear cut; industrial researchers, for example, bridge the boundary as both users of academic science and practitioners of research. For the stakeholder group, 4–5 leading experts were identified within the following five categories:

- industrial R & D managers,
- clinical researchers,
- non-clinical researchers,
- health service planners and managers,
- the project steering committee (includes funding body administrators).

More than 60 000 words were transcribed from recordings of these interviews covering 1000 points in four main areas: science, infrastructure, manpower and dissemination of research findings[11]. A questionnaire was then developed, based on these issues to put to the sample of cardiovascular researchers for the main survey.

3.2 Consulting scientists

A sample of researchers was identified, comprising three subgroups:

- the 100 most 'visible' cardiovascular researchers whose names appeared most frequently within the list of cardiovascular publications between 1988–91 (see section 4 of this report);
- 250 other researchers whose name appeared as first author on at least two publications during this period;
- 120 new researchers who had won competitive postdoctoral fellowships in cardiovascular research either from the British Heart Foundation, the Medical Research Council, or the Wellcome Trust who may not have had chance to build up a publication record.

The final sample was 465 researchers and the response rate to the survey was 73 per cent.[11] The profile of the respondents (see Box 2) ranged from young researchers at the beginning of their career to established senior scientists.

Box 2

Respondent profile

Respondents were spread across all age groups. With the inclusion of the junior research fellows supported by the funding bodies, 15 per cent of respondents were under 30. Sixteen per cent of all the respondents were female and these were skewed towards the younger age groups. The divide between the medically and non-medically qualified was almost two thirds to one third with 64 per cent of respondents recording a medical qualification. This division was less marked in the respondents' current posts as just over half held clinical or honorary clinical posts and described their laboratory setting as in a medical school. One third held academic posts and the rest were industrial researchers and managers, and postdoctoral staff.

There was a broad range of expertise among respondents who were asked to list no more than three main areas. The two main areas of expertise were pharmacology and physiology (including electrophysiology). These two areas were each scored by almost a third of respondents. Just less than a quarter scored cell biology as a main area of expertise. Just over a third scored clinical expertise; 28 per cent scoring clinical cardiology and diagnosis, and 8 per cent for surgery. Among the 22 per cent claiming other skills, pathology, immunology and nutrition were the most frequently mentioned. Only 10 per cent claimed expertise in molecular biology and less than 5 per cent scored genetics. Epidemiology was scored by 11 per cent of respondents and engineering and instrumentation by 6.5 per cent (see Figure 6).

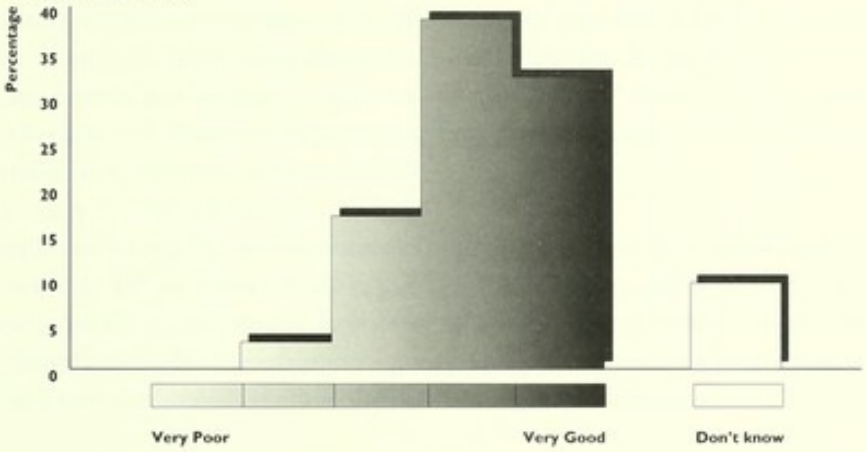
3.3 Key results

Scientific opportunities

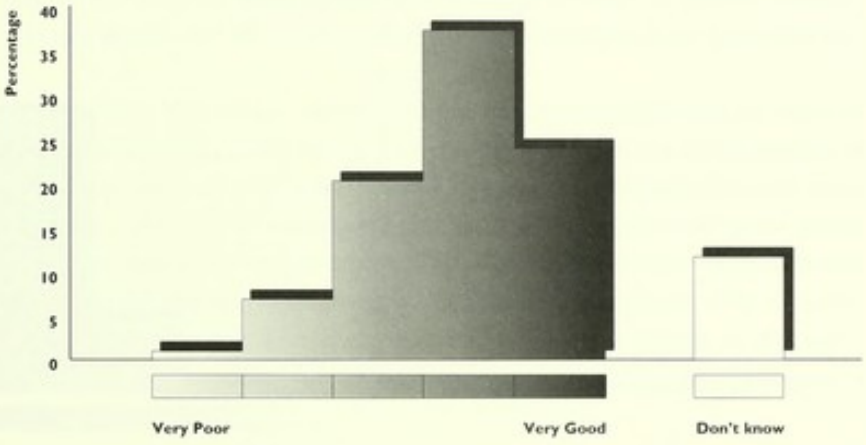
Respondents' views were gathered on the prospects for advance over the next five years in a number of research areas that had been highlighted in the pre-survey interviews.[11] The results for three areas seen most positively by respondents are shown in Figure 3.

Figure 3 **What do you see as the prospects for advancing understanding in the following areas over the next five years?**

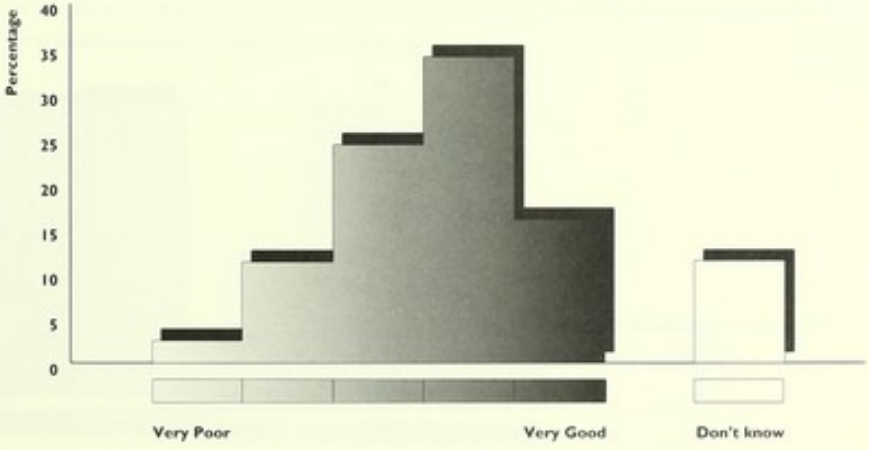
Functions of the vascular endothelium



The biological mechanism of artherogenesis



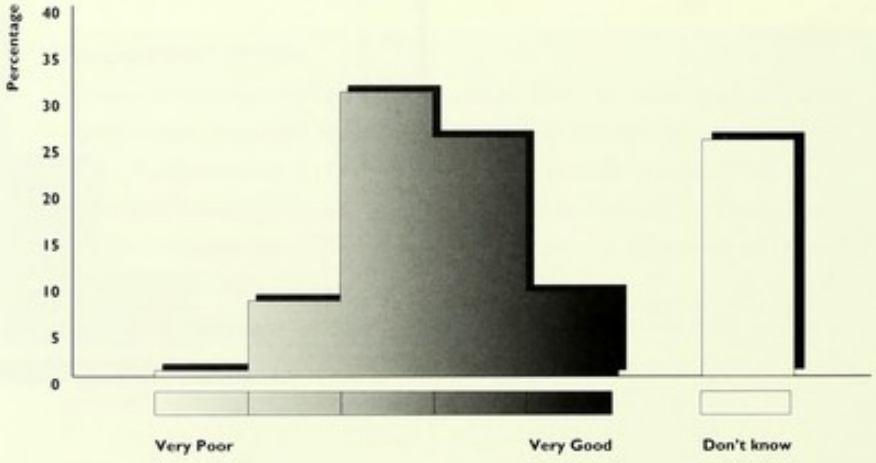
The molecular genetics of cardiovascular disease susceptibility



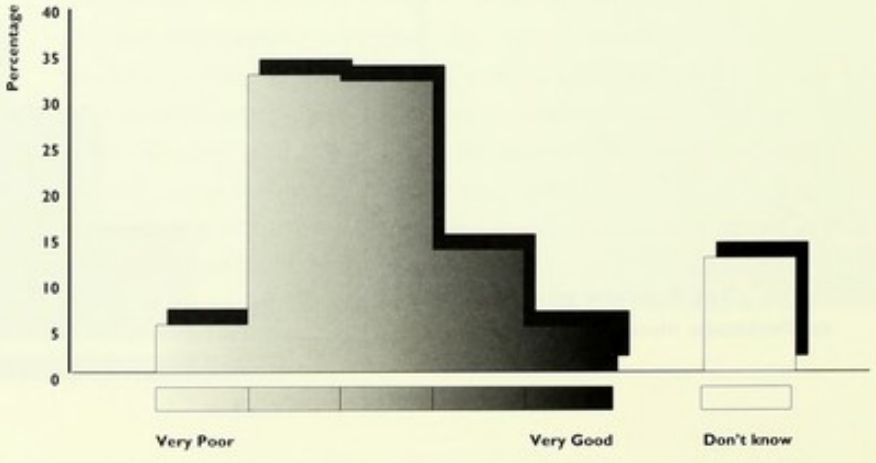
Respondents were asked to record their views on a five-point scale from very good to very poor. More than half of the respondents were optimistic on the prospects for advance in understanding three topics at the molecular and cellular end of the cardiovascular research spectrum; the biological mechanisms of atherogenesis, the molecular genetics of cardiovascular disease susceptibility and understanding the functions of the vascular endothelium. Research on the vascular endothelium was seen as particularly ripe for advance with almost 70 per cent of respondents scoring prospects for advance as good and only 3 per cent scoring them as poor. As expected, given the range of respondents' expertise and interests, opinion was broadly spread on some questions and the results of two further topics are shown in Figure 4. On the question of prospects for advance in understanding the mechanisms of angiogenesis, for example, 25 per cent of respondents answered 'don't know'. On analysis of subgroups by stated expertise, epidemiologists gave the highest rate of 'don't knows' on this question and cell biologists gave the lowest rate, which suggested that respondents were being cautious in their opinions on topics outside their expertise. Overall, among respondents who did answer the question, the prospects for advance in angiogenesis were seen to be good.

Figure 4 **What do you see as the prospects for advancing understanding in the following areas over the next five years?**

The mechanism of angiogenesis



The role of non-dietary environmental risk factors in cardiovascular disease



Not all scientific topics were seen as promising. On advances in understanding the role of non-dietary environmental risk factors almost 40 per cent of respondents scored prospects as poor over the next 5 years (Figure 4).

Asked in an open question about advances over the longer term of 5–10 years, respondents further highlighted the unravelling of the functions of the vascular endothelium and understanding, screening and intervention in atherogenesis. Further progress on understanding the genetic factors in cardiovascular disease and advances in organ and cell transplantation, gene therapy and the role of developmental factors in cardiovascular disease risks were also cited.

Opportunities for disease interventions

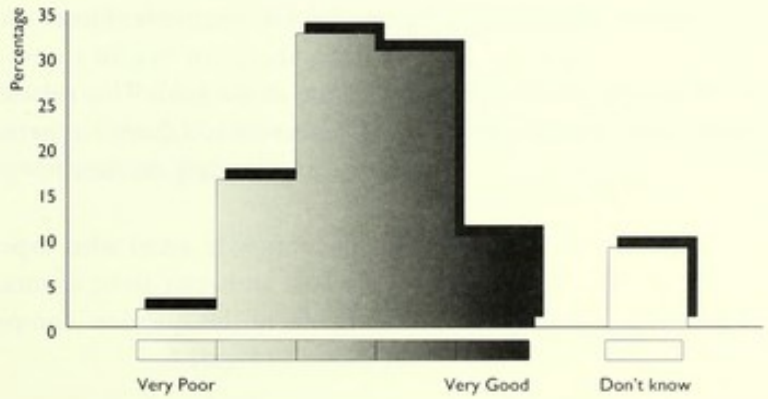
This section of the survey focused on the interests of users of cardiovascular research, that is, those with responsibility for delivering improved healthcare for cardiovascular disease. A number of possible disease interventions were identified in the pre-survey interviews and put to the scientists for their views on the likelihood of development over the next five years.

Views were sought on the prospects for advance in the feasibility of developing donor organs from animals, new drugs to treat or prevent cardiovascular disease and the development of artificial hearts or heart assist devices.

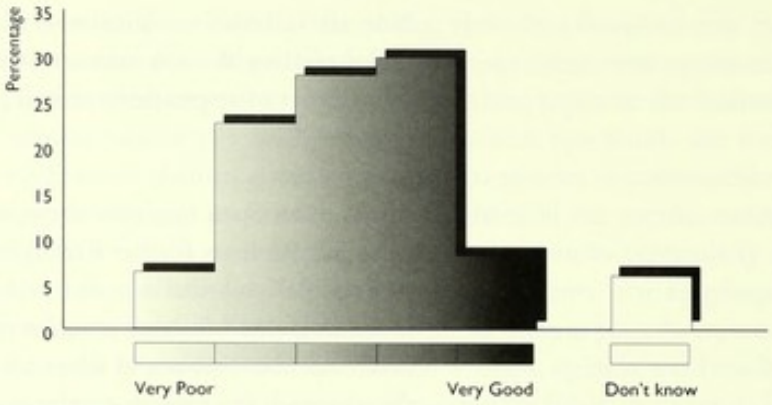
Opinion on these issues, not surprisingly, was more spread than on many of the scientific topics (Figure 5). But the prospects for the development of new drug treatments were seen overall to be good. Prospects for new drugs to reduce the risk of coronary heart disease were also seen to be good. However, views on the development of artificial hearts were more negative. Prospects for the development of animal-derived transplants were also seen to be poor over the next five years, although, in response to the open question, opportunities for advance were seen as more promising over a longer timescale.

Figure 5 **What do you see as the prospects for advance in the feasibility of developing the following interventions over the next five years?**

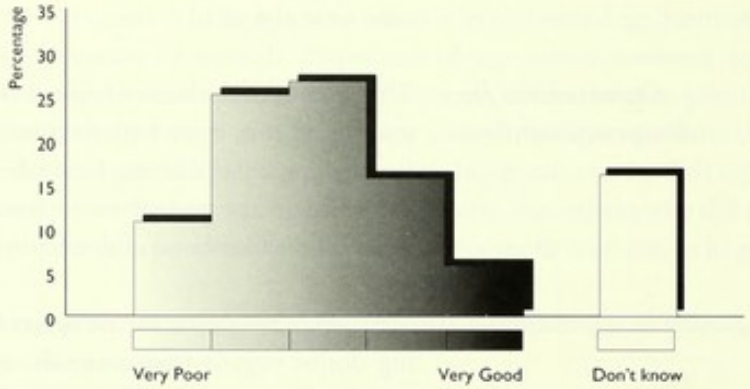
New drugs that will substantially improve treatment of coronary heart disease



New drugs that will substantially reduce the risk of coronary heart disease



Artificial hearts and heart-assist devices



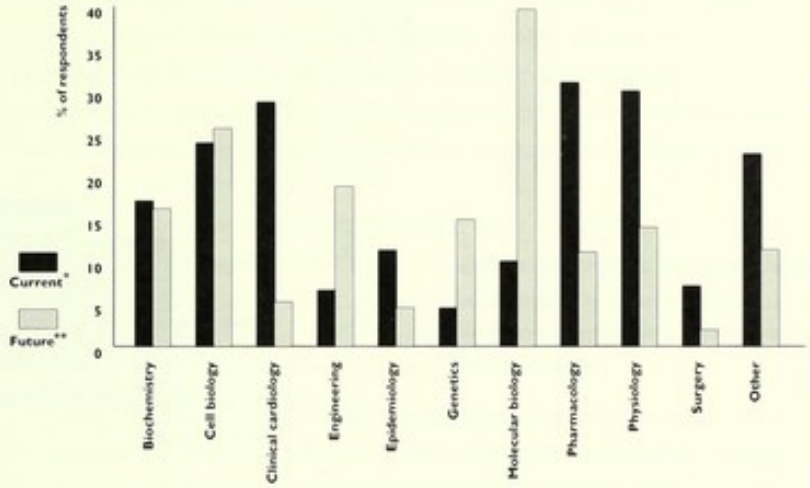
Heart transplants to humans from animal donors

Skills for the future

Having identified the most promising areas for scientific advance and the potential for alternative disease interventions over the next five years it was then important to gain a view on the skills that would be needed for the future of the field. This represents an area where, through a training programme or collaborative network, funding bodies could exert an influence on shaping the future.

Respondents were asked what expertise, not presently available to them, they would anticipate to be of most value for their future research plans. The results of this question, compared to the skills held by respondents, are shown in Figure 6.

Figure 6 **Current expertise among respondents and anticipated additional needs**



* Respondents were asked to score not more than three areas from the list as their main areas of expertise.

** Respondents were asked what expertise from the list, not available to them now, would be most valuable for their future research plans.

The most striking result was that 40 per cent said they would need molecular biology expertise in contrast to 10 per cent of respondents who claimed they already had expertise in this area. A quarter of respondents also anticipated that they would need additional expertise in cell biology, which they currently do not have access to.

Almost 20 per cent of respondents anticipated the need for engineering and instrumentation skills while only 6.5 per cent of respondents claimed current expertise in this area.

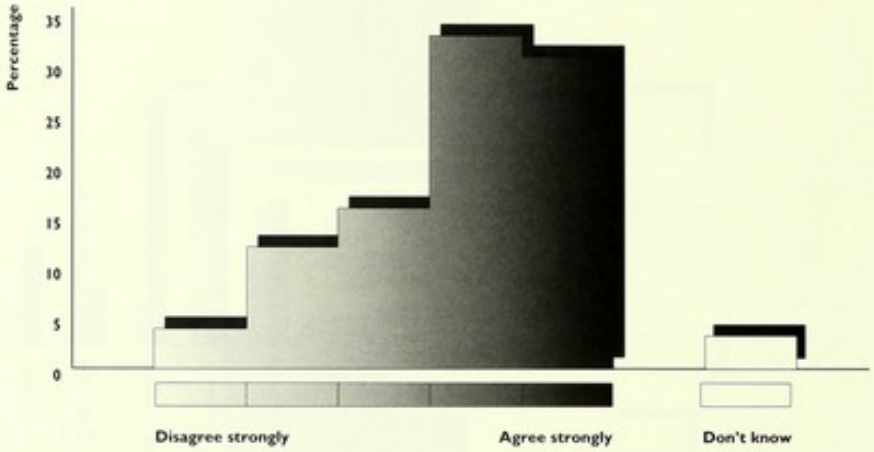
Infrastructural support

Having identified the skills needed to strengthen the field, it was then necessary to gain a view on the most desirable organizational structure for supporting the future development of cardiovascular research.

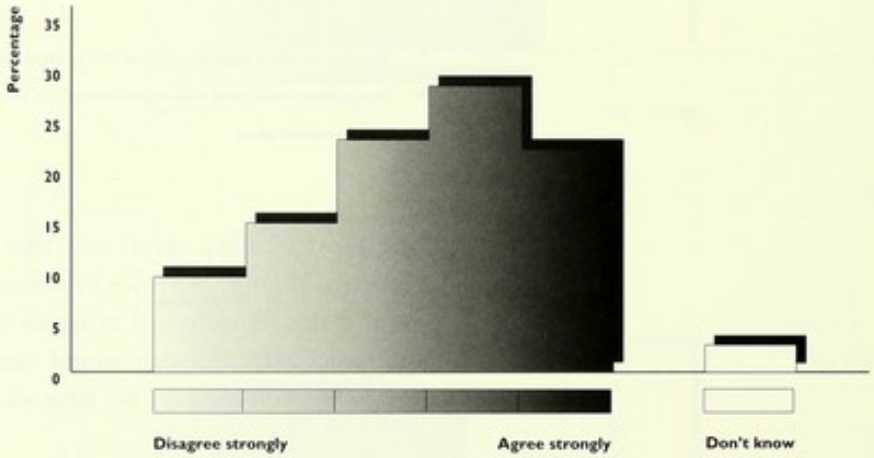
Views on three options, which emerged from the pre-survey interviews, for providing additional infrastructural support were sought in the questionnaire (Figure 7).

Figure 7 What is your opinion of the following suggestions for strengthening UK cardiovascular research?

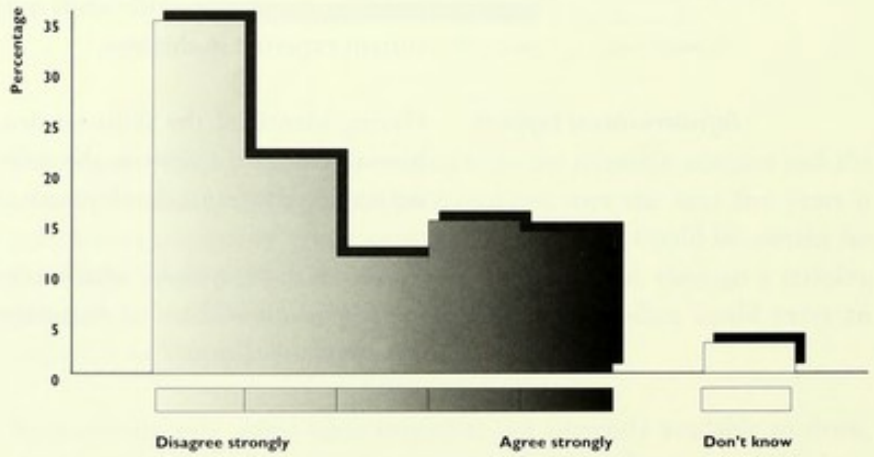
'Set up a small number of cardiovascular research centres of sufficient size to mount multidisciplinary programmes at each centre'



'Fund multicentred, topic-oriented programmes among existing groups'



'Establish a national institute for cardiovascular research'



There was strong support – more than 65 per cent agreeing or agreeing strongly – with the suggested establishment of a small number of multidisciplinary cardiovascular research centres. There was also majority support for the funding of topic-oriented projects among existing research groups although the number opposed to this (25 per cent) was higher. But the suggestion of establishing a new national centre for cardiovascular research drew an overall negative response. It is important, however, in interpreting these results to take into account the potential self-interest of respondents who may not benefit directly from some of the suggested infrastructural changes.

Inevitably, the questionnaire recorded concern about the more general issues of the relationship between clinical and basic research and clinical practice which has been an issue of serious concern.[1] The following suggestions illustrate many of the comments received:

- "Set up a basic/clinical collaborating research fund to support projects designed to overcome the communication gap. It should be organized to respond swiftly to good proposals, the emphasis being on salaries for identified and keen link researchers"

- "Fund adequately resourced and patient-based research units that would have enough multidisciplinary expertise to cut across traditional specialist boundaries and provide excellence in research methodologies and outputs"

- "Create strategic alliances between small research teams by funding collaborative projects that would utilize the various strengths and facilities that each team possesses"

Another approach, suggested by several respondents, was to identify clearly the strongest research groups and increase their funding to build them into multidisciplinary cardiovascular research centres or incorporate them into a structured research network.

Many respondents pointed out that development of molecular and cellular technologies could help break down the barriers between clinical and basic research and help tackle the mismatch, in molecular biology, between the availability of present skills and anticipated needs.

A possible model along these lines has been established at the Institute of Molecular Medicine in Oxford. The Institute has developed a central research facility for groups from different clinical departments large enough to attract and house a critical mass of basic science and where clinical scientists can be trained.[13] Another potential model is the Max Delbrück Centre for Molecular Medicine in Berlin, which has cardiovascular research as one of its central topics and has set up a non-departmental, matrix organization (see appendix 3).

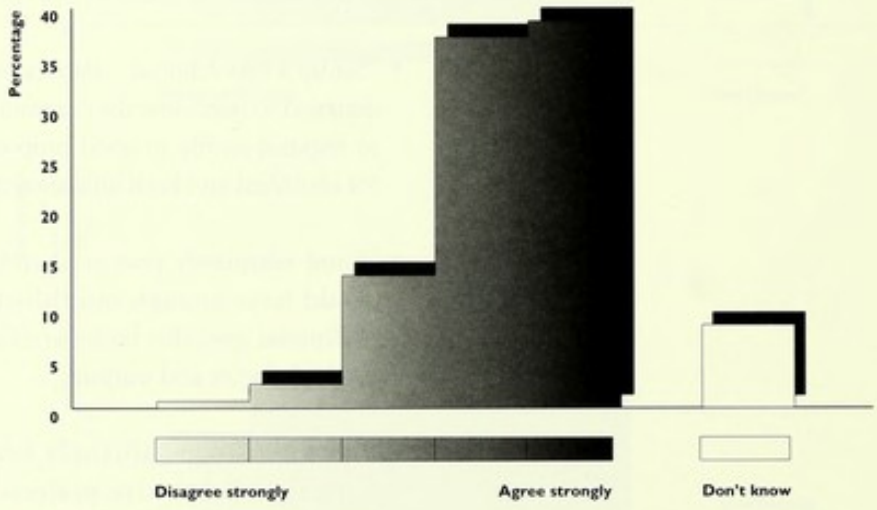
Making better use of the outcomes of research

Respondents were asked about the need to strengthen evaluation and audit research within the cardiovascular field. The importance of these issues, which were of particular concern to the research users in the pre-survey interviews, was strongly endorsed by respondents. On sub-group analysis, more than 80 per cent of clinical cardiologists agreed on the need for new, clear evaluation programmes for new diagnostic and treatment technologies (Figure 8).

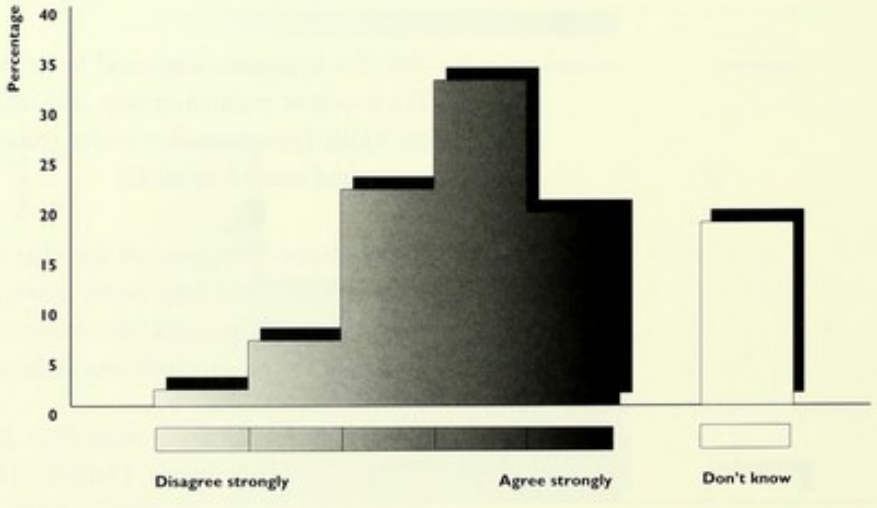
Figure 8

Extent of agreement with statements concerning the evaluation and utilization of research results

'Clear programmes of evaluation of new diagnostic and treatment technologies are needed before these get into widespread clinical practice'



'A greater measure of potential resource consequence than just drug or treatment costs should be made before clinical trials are set up'



The aim of this part of the project was to assist discussions on the status of UK cardiovascular research by producing internationally comparable data. Data on funding for cardiovascular research in different countries proved unreliable because of the many different conventions for collecting figures and varying definitions of cardiovascular research. Even within the UK, it proved difficult to compare funding levels for cardiovascular research in different agencies because of the differences in research classification systems.

A more reliable approach is to focus on research outputs in the form of scientific publications. For funding bodies with a mission to advance knowledge in the field of cardiovascular research, scientific publications were seen to be an appropriate measure (for more applied research and development other indicators would be needed). Large databases exist that index hundreds of thousands of papers from laboratories around the world. The challenge was to identify those papers that were (a) from the UK, and (b) focused on cardiovascular research.

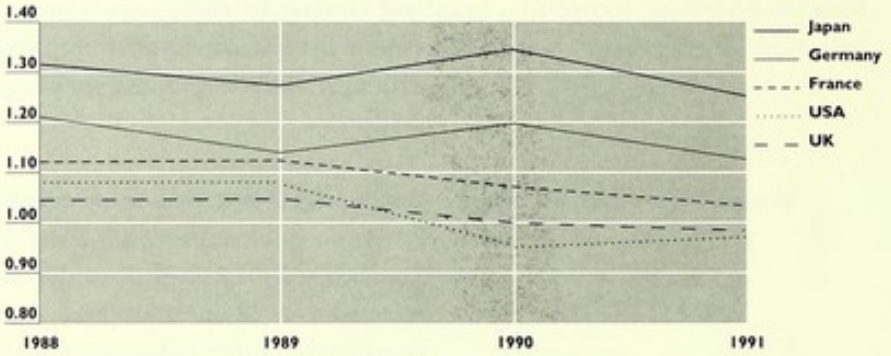
From the cardiovascular publications data, a number of analyses were carried out to determine trends in national activities, citation impact, international collaboration and 'hot spots' of UK activity. (Full details of these analyses are given in reference 12).

4.1 UK in the international scene

Analysis of national share for five countries from 1988 to 1991 was carried out. The results revealed that the field, as with biomedical research overall, was dominated by the US whose average share of the world's cardiovascular publications was 27 per cent. The UK had 6 per cent, Germany had 5 per cent and France had 3 per cent over this period. The only country to increase its share clearly over this period was Japan (from 6 per cent to 8 per cent).

An 'activity index' was calculated to examine whether cardiovascular research publications featured more prominently within national portfolios than the world average of 19 per cent. Figure 9 shows greater than expected cardiovascular research activity in Japan and Germany but close to world average activity for the UK and the US.[12] This suggests that cardiovascular research occupies no particular prominence, in terms of volume of publication outputs, in the UK national portfolio of research.

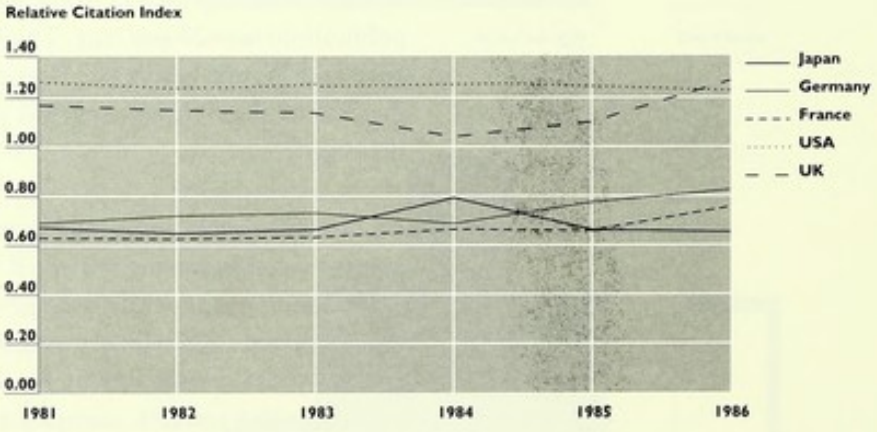
Figure 9 **International comparison of cardiovascular publications activity indices: 1988–1991 (Medline analysis)**



$$\text{Cardiovascular Research Activity Index} = \frac{\text{Number of national cardiovascular papers / Number of national biomedical papers}}{\text{Number of world cardiovascular papers / Number of world biomedical papers}}$$

In contrast, citation analysis of cardiovascular publications show the US and the UK achieved the highest number of citations and Japan the lowest (Figure 10).

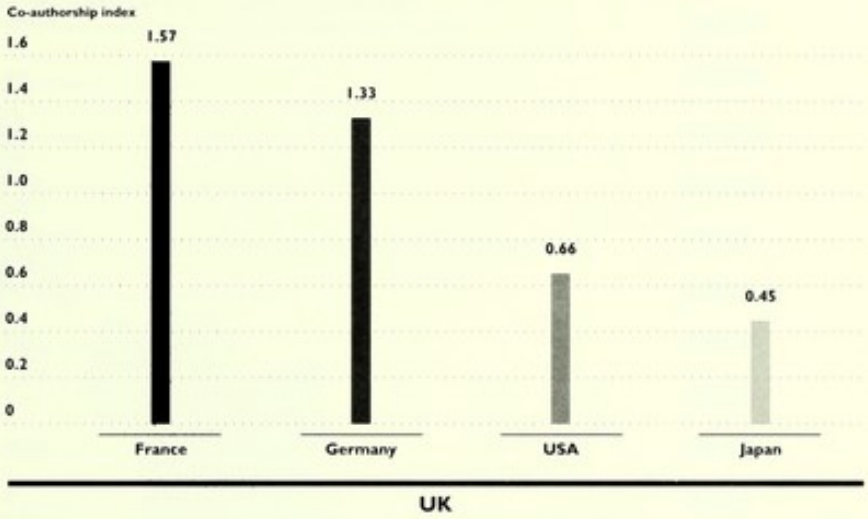
Figure 10 **Citation impact of cardiovascular papers: 1981–1986 (SCI analysis)**



$$\text{Relative Citation Index (RCI)} = \frac{\text{Citations per paper for country A}}{\text{Citations per paper for all countries}}$$

Figure 11 shows an analysis of the address fields of cardiovascular publications. From this it was possible to get a measure of international collaboration by use of a co-authorship index. This measure revealed that UK authors co-published most frequently with French authors followed closely by Germany. UK papers with US and Japanese co-authors were less common than expected.

Figure 11 **International collaboration in cardiovascular research: 1981–1986 (SCI analysis)**



$$\text{Co-authorship Index} = \frac{\text{Number of UK papers co-authored with country X / Number of UK papers internationally co-authored}}{\text{Total number of papers with at least one country X author / Number of world's papers - number of papers with UK authors}}$$

4.2 UK domestic scene

A map of 'hot spots' of cardiovascular activity was drawn from the publications data. During 1988–91 Medline indexed 14 064 UK cardiovascular papers carrying the names of 21 000 authors. The 100 most frequently appearing names in this list were identified as the most 'visible' cardiovascular researchers in the UK during this period. Their institutional locations were recorded and are shown in the map (Figure 12). The most striking finding was the dominance of London; 69 of the 100 most visible authors were located at addresses in the capital.

An attempt was also made to look at the distribution of publications across institutions within the UK (Figure 13). The SCI database was used as it is the only one to provide addresses for all authors on a paper. The results show the total number of cardiovascular papers and the total number of citations during the period studied: 1981–86. The institutions are ranked by average citations per paper.

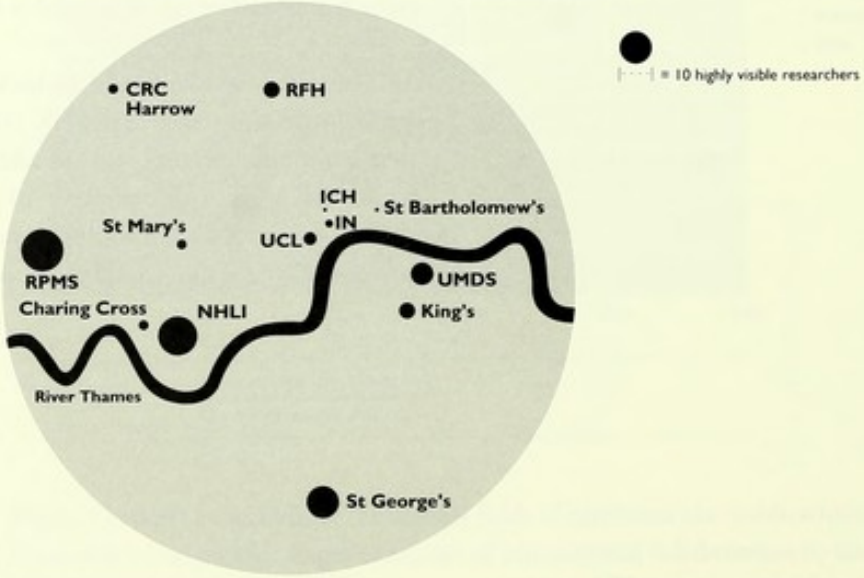
Figure 12(a) **Hot spots of publication activity in UK cardiovascular research: 1988–1991 inclusive (Medline analysis)**

(Diameter of circles relate to the number of highly visible researchers in country's top 100)

* Denotes that London is not represented on this map. It is shown in Figure 12(b)

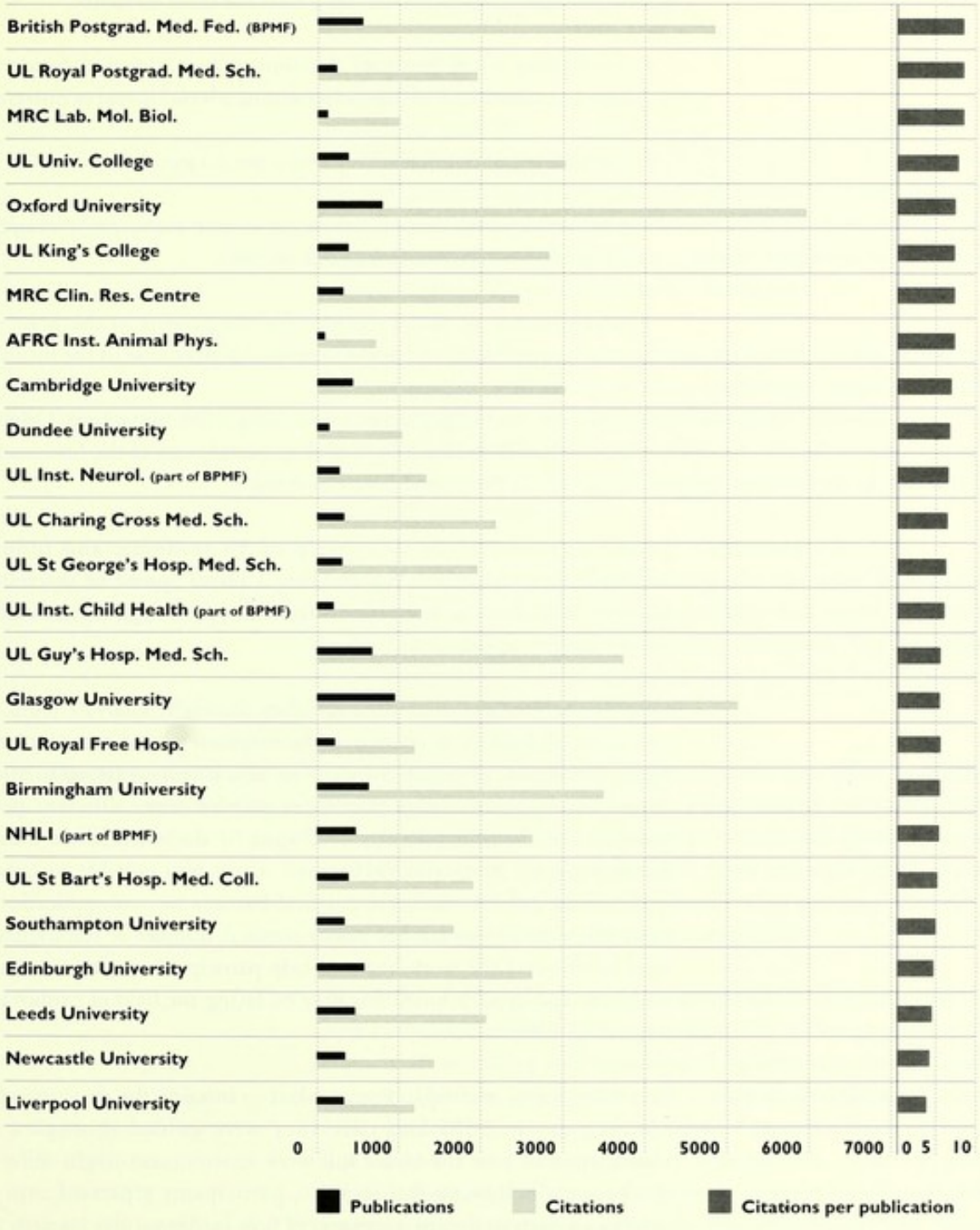
Figure 12(b) **London centres of publication activity in cardiovascular research: 1988–1991 (Medline analysis)**

(Diameter of circles relate to the number of highly visible researchers in country's top 100)



Key:
CRC Clinical Research Centre (MRC) **ICH** Institute of Child Health **IN** Institute of Neurology **NHLI** National Heart and Lung Institute **RFH** Royal Free Hospital **RPMS** Royal Postgraduate Medical School **UCL** University College London **UMDS** United Medical and Dental School (Guy's and St Thomas's)

Figure 13 The 25 top producers of publications relevant to cardiovascular science: 1981–1986 (SCI analysis)



BPMF = British Postgraduate Medical Federation. It is a school of the University of London and comprises eight research and teaching institutes, the Departments of Postgraduate Medicine and Dentistry for the four Thames Health Regions and a central administrative office. Papers where only the BPMF was specified were attributed to the BPMF. Where a specific institution falling under the BPMF umbrella was listed the paper, or fraction thereof, was attributed to the institution specified.

The vast majority of cardiovascular publications listed above were produced by researchers working in departments forming part of the medical faculty or school in each university. The publications from teaching hospitals which were associated with each medical faculty or school were also attributed to the relevant university.

London medical schools are listed separately from the University of London publications.

The final component of the project was a workshop to draw together the project results and test methods of supporting the discussion of policy options and priorities. The following were the main elements:

- Assembling a key group of decision makers, opinion formers, scientists, clinicians and users, representing a broad spread of interests.
- Presentation of opinion survey and other project data.
- A test of novel facilitation techniques to help participants imagine the field of cardiovascular research in 2005.
- Consideration of policy options for the present in the light of potential problems and opportunities that may arise in the future.
- Discussion and voting on priorities using a live two-round 'Delphi' approach with feedback to workshop participants of the first-round results before the second round of voting.

5.1 Methods

Invitations were made to a group of 35 academic and industrial cardiovascular researchers representing a broad spread of interests and expertise and senior policy officials from the three organizations funding the project (see appendix 4).

One of the features that distinguishes foresight analysis from more conventional analysis of strategy is the emphasis placed on techniques to highlight long-range future issues. The aim is not to try to predict the future but to acknowledge that there may be many different possible 'futures' but the outcome can be shaped by decisions made today. By focusing on the long-term (>10 years) it was also possible to overcome some of the institutional and political barriers to communication that inevitably exist in this kind of policy arena. A number of techniques were used to structure the workshop and help participants explore some of the problems and opportunities that may be facing the field of cardiovascular research in 2005.

Guided visualization

To set the scene, participants were asked to imagine the structure of their working day in 2005 and then they were guided through a short visualization of how the home and work environment might differ from the present. Following this exercise, participants separated into three subgroups, each to discuss a scenario of how cardiovascular research might look within a framework of biomedical research in 2005.

Cardiovascular research in 2005: scenario analysis

Prior to the workshop, three scenarios were developed, each containing a list of assumptions and trends common to all, in addition to the specific details of

each scenario. These scenarios focused on three alternative socioeconomic backgrounds within which future scientific research might be conducted. These scenarios were labelled:

- Free market,
- Regulated market,
- Lifestyle concerns.

The full scenarios are reproduced in Appendix 5. Each attempted to describe an internally consistent view of how the future might look in broad terms and consider what the possible implications for biomedical research might be. None was meant as a prediction.

To assist the imagination of participants, each scenario was supported by a mock newspaper with stories of what might have happened under that scenario (see appendix 5). No attempt was made to predict what research may have been achieved by 2005 although several 'driving forces' were assumed, for example, that the human genome mapping and sequencing project had been completed.

During the workshop each scenario subgroup was asked to produce a list of five topics and five infrastructural measures that would best strengthen the field now, in light of the future trends discussed. The lists from each of the scenarios were then compiled into two lists for discussion in a plenary session by the whole workshop.

Assessment of priorities: colour voting

The two lists were produced on special forms that allow participants to vote on each of the options using a computerized colour-based system. (see appendix 6). Participants gave their view on each option by marking a scale of five colours ranging from dark green (strongly agree) to dark red (strongly disagree). Two further options of white and grey were offered to record 'can't answer' and 'won't answer', respectively.

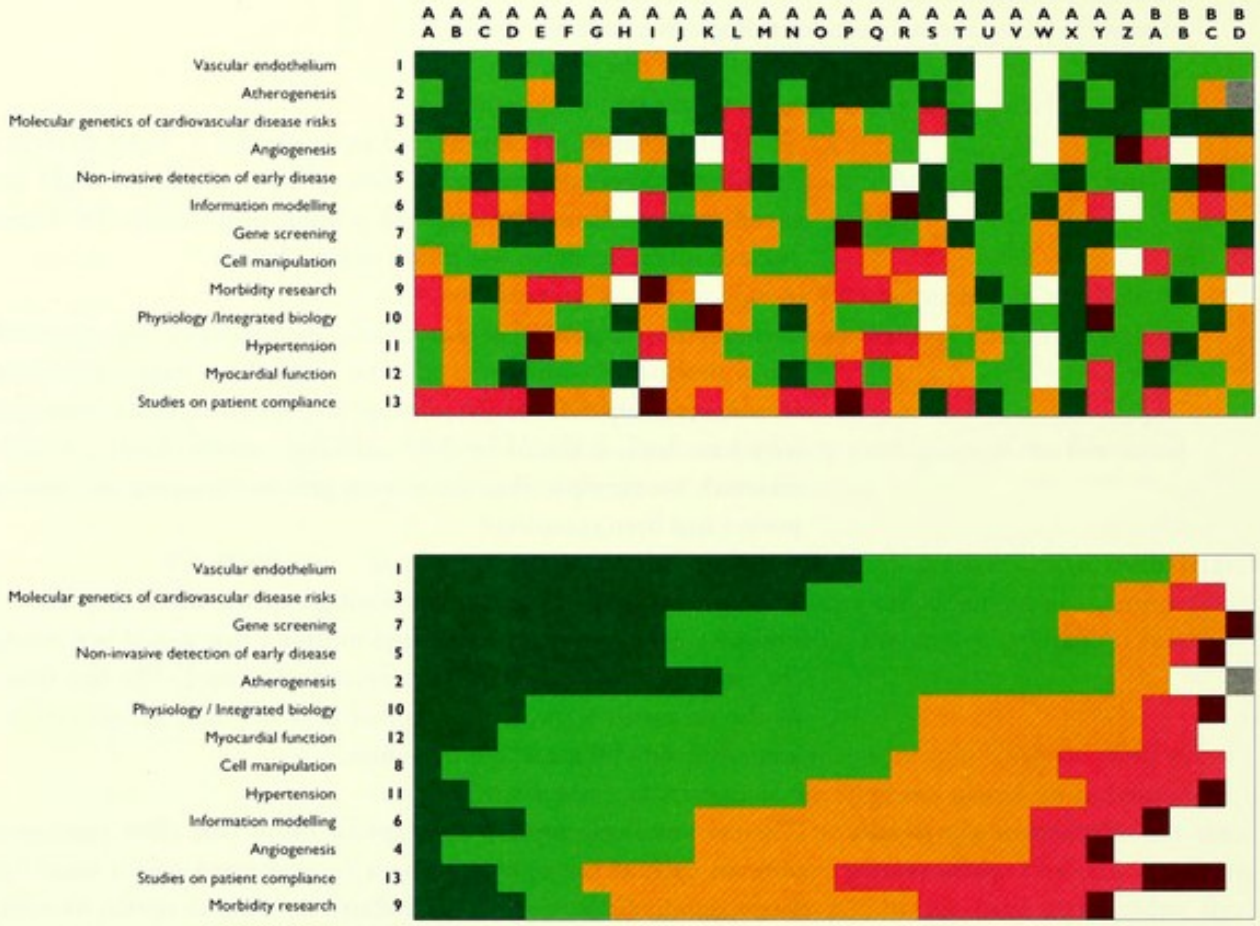
The results of this voting session were entered on computer and collated using a specialist program (Abacsys, Paris). The system provides a detailed colour chart recording each participant's opinion for detailed analysis if required. The raw data appeared as a 'patchwork' of colours with each block of colour representing the opinion of one participant on one issue. This patchwork was then processed to aggregate the colours on each issue and rank them on the basis of the amount of green or red recorded. The results were projected on a screen in real time to facilitate discussion (Figures 14 and 15).

Figure 14(a)

Workshop outcomes

Topics: 1st vote

Participants' views on the suggestions listed below for priority topics for strengthening cardiovascular research



Top: **Each two-letter code on the horizontal axis represents a participant and the numbers on the vertical axis refer to each item on the voting sheet. The views of the participants on each item are represented as a block of colour. Dark green represents a strongly positive view by the participant; dark red represents a strongly negative view with other colours representing shades of opinion in between. White represents 'can't answer' and black represents 'won't answer'.**

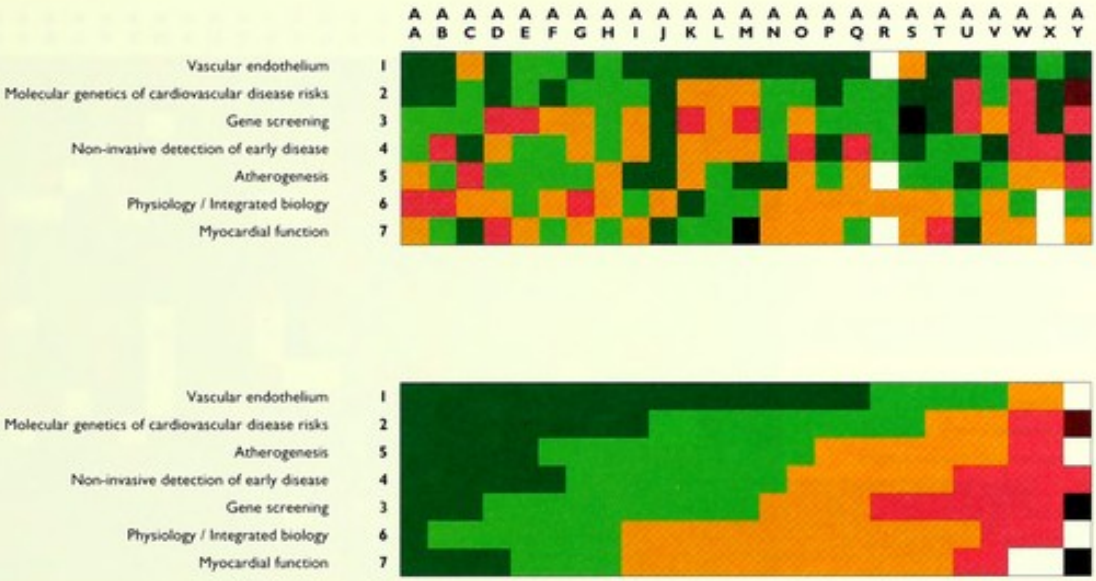
Bottom: **This is the processed image of the same data. The blocks for each item have been aggregated by colour and the items have been ranked from those seen most positively (most green, least red) at the top to those seen least positively (least green, most red) at the bottom.**

Figure 14(b)

Workshop outcomes

Topics: 2nd vote

Participants' views on the suggestions listed below for priority topics for strengthening cardiovascular research



Top: **Each two-letter code on the horizontal axis represents a participant and the numbers on the vertical axis refer to each item on the voting sheet. The views of the participants on each item are represented as a block of colour. Dark green represents a strongly positive view by the participant; dark red represents a strongly negative view with other colours representing shades of opinion in between. White represents 'can't answer' and black represents 'won't answer'.**

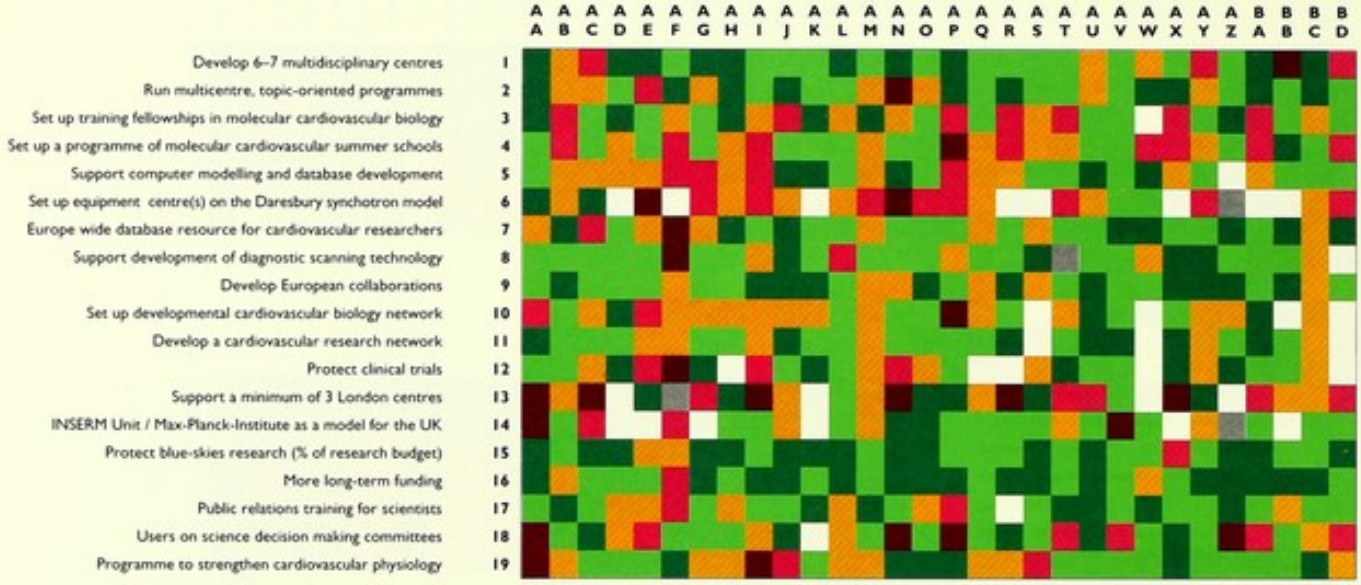
Bottom: **This is the processed image of the same data. The blocks for each item have been aggregated by colour and the items have been ranked from those seen most positively (most green, least red) at the top to those seen least positively (least green, most red) at the bottom.**

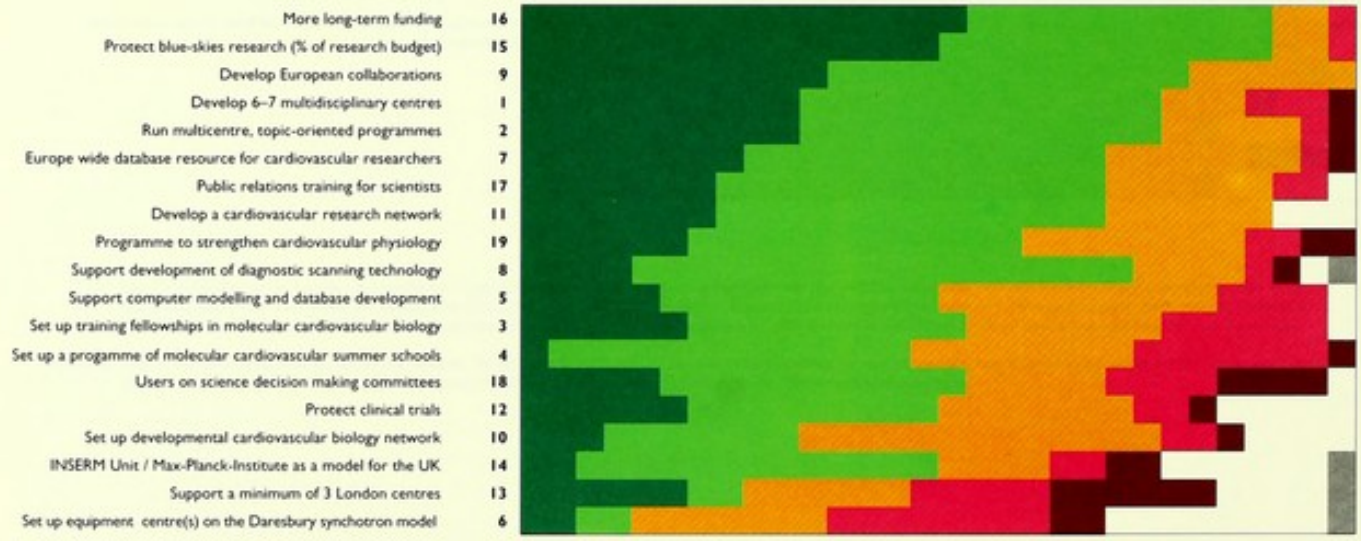
Figure 15(a)

Workshop outcomes

Infrastructure: 1st vote

Participants' views on the suggestions listed below for priority topics for strengthening the infrastructure for cardiovascular research





Top: **Each two-letter code on the horizontal axis represents a participant and the numbers on the vertical axis refer to each item on the voting sheet. The views of the participants on each item are represented as a block of colour. Dark green represents a strongly positive view by the participant; dark red represents a strongly negative view with other colours representing shades of opinion in between. White represents 'can't answer' and black represents 'won't answer'.**

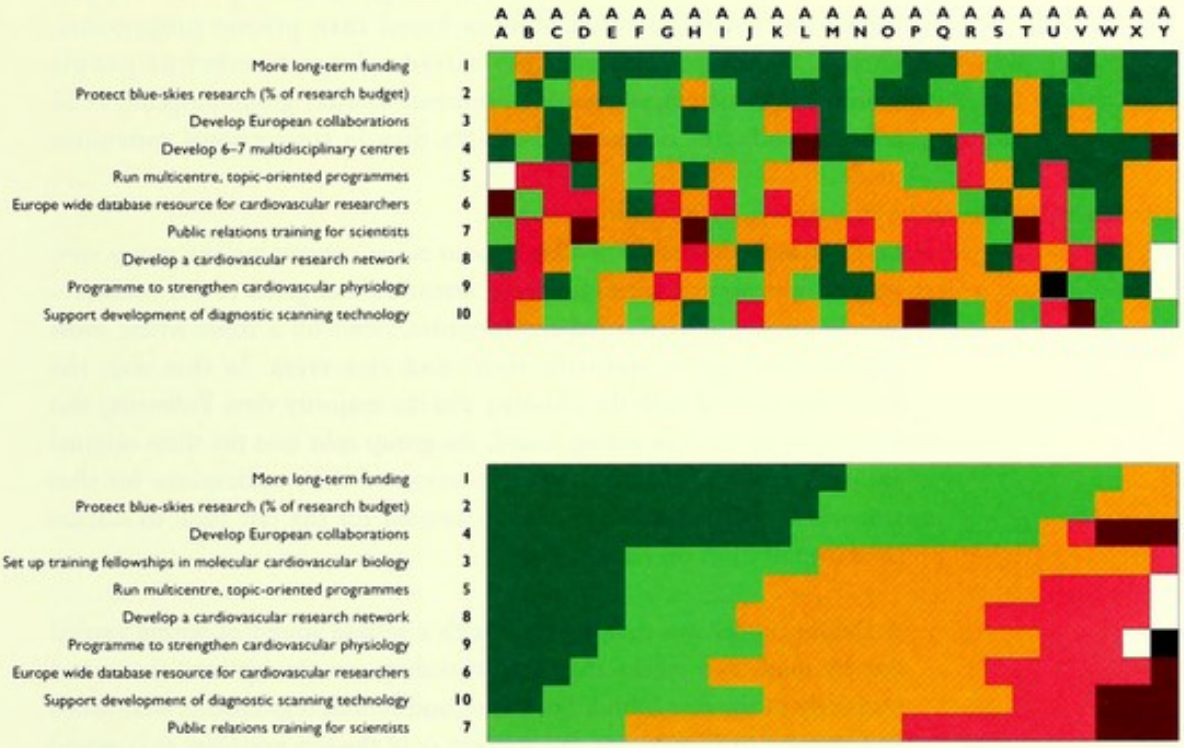
Bottom: **This is the processed image of the same data. The blocks for each item have been aggregated by colour and the items have been ranked from those seen most positively (most green, least red) at the top to those seen least positively (least green, most red) at the bottom.**

Figure 15(b)

Workshop outcomes

Infrastructure: 2nd vote

Participants' views on the suggestions listed below for priority topics for strengthening the infrastructure for cardiovascular research



Top: **Each two-letter code on the horizontal axis represents a participant and the numbers on the vertical axis refer to each item on the voting sheet. The views of the participants on each item are represented as a block of colour. Dark green represents a strongly positive view by the participant; dark red represents a strongly negative view with other colours representing shades of opinion in between. White represents 'can't answer' and black represents 'won't answer'.**

Bottom: **This is the processed image of the same data. The blocks for each item have been aggregated by colour and the items have been ranked from those seen most positively (most green, least red) at the top to those seen least positively (least green, most red) at the bottom.**

The purpose of using colours, rather than numbers to vote was that it provided an immediate visual guide to group opinion. The amount of 'greeness' (positiveness) or 'redness' (negativity) on an issue was reflected in a simple pictorial way that was more appropriate in an interactive workshop environment than a hard percentage figure. Responses on topics were expected to be more opinion-based than precise judgements. Crucially, the process also permitted a large number of people representing a heterogeneous set of interests to make group judgements on a large number of issues more speedily than in conventional committee mode.

During projection of the results, various issues concerning the group view on priorities were discussed. Special attention was given to the outliers – i.e. those people who voted red (negative view) on a topic where most people voted green (positive view) and vice versa. In this way, the workshop covered both the minority and the majority view. Following this discussion on the first voting round, the group split into the three original scenario subgroups for further discussion of the implications for that scenario. Finally, the subgroups reconvened for the last time to discuss their overall views on priorities.

A Delphi model was than adopted with a second round of voting carried out by mail, two weeks after the workshop, on the options seen most positively in the first round. For the second round, respondents were asked to constrain their opinions and support only the top priorities as it would be impossible to support all of the options seen favourably in the first round.

5.2 Workshop outcomes

Figure 14 shows the pattern of responses by participants to the priority scientific topics presented after the first and second rounds of colour voting. Figure 15 shows the most favoured options for development of research infrastructure, again after the first and second rounds of voting.

Topic priorities

The views emerging from the workshop follow closely those of the opinion survey respondents. Three molecular and cellular topics dominated the list of priorities – vascular endothelium, molecular genetics of cardiovascular disease risks and atherogenesis. All the participants agreed with the option of strengthening research on the vascular endothelium and more than 80 per cent strongly supported development of research in this area.

Infrastructure priorities

Of the ten suggestions given highest priority for strengthening the infrastructure in the first round of colour voting, a shift towards long-term funding, protection of blue-skies research and the development of a small number of multidisciplinary centres were seen as the top priorities in the second round. On infrastructure, there was also support for the development of research networks.

5.3 Key discussion points raised

- There were perceived opportunities for increased funding at the university/industry interface of cardiovascular research and the establishment of a funded network may facilitate collaboration between researchers from both sectors.

- Multidisciplinary research groups should not be just conglomerates. Bricks and mortar were not necessarily essential but strong leadership, sufficient size and incorporation of both basic and clinical research were important.

- Multidisciplinary groups should be university-based rather than self-contained to allow the option of teaching and greater career flexibility.

Drawing together the various aspects of the project, it is possible to identify a number of policy issues for consideration by funding bodies when planning future priorities for cardiovascular research. It must be emphasized that the findings have been drawn from very large scale collection and analysis of cardiovascular research data and consultation with both users and a large sample of the relevant scientific community.

The first point to make is that the study has produced good evidence that cardiovascular research does not stand out as a prominent area in the UK's national research portfolio. Despite the significance of the disease burden and the priority given to this field in targets for the Government's health strategy, the volume of research activity (as measured by research publications) is not correspondingly high. The picture in other countries, notably Japan and Germany, is different and cardiovascular research there has had some prominence in the national research portfolios for several years. There may well be a case, therefore, for strengthening support for cardiovascular research in the UK.

Against this background, a number of scientific opportunities have been identified that are good candidates for special support. In addition, the views on a number of promising areas of disease intervention have been gathered, which may be of interest to planners in industry and the health service. Finally, a number of practical policy options have been identified for strengthening the infrastructure and skills base for the field. Each of these options is laid out below:

6.1 Scientific opportunities

Although cardiovascular research is a multidisciplinary field and questionnaire respondents showed a range of research expertise, there was broad agreement on the scientific opportunities over the next 5–10 years in the development of cellular and molecular topics. The views of the respondents were endorsed by the workshop participants (both researchers and users) who identified these topics as priorities for strengthening the field.

6.2 Opportunities for improving disease interventions

The development of novel drugs with potential for treatment and prevention was widely anticipated over the coming five years. In addition more effective use of present treatments and knowledge, through the development of enhanced methods of evaluation, was widely perceived as a present opportunity for the field. The value of strengthening and broadening the base for audit of new treatments was also strongly supported by the researchers consulted.

6.3 Skills needed

An analysis of skills needed by respondents suggested that molecular and cellular technologies have failed adequately to penetrate cardiovascular research. There appears to be substantial gaps in molecular biology and genetics expertise that may be limiting research in more established fields such as epidemiology and physiology.[1] Additional engineering (mostly

imaging and scanning) skills were also identified for respondents' future research plans. The development of training schemes in these skill areas is one policy option but in the short term, funding for research collaborations and networks involving people presently with these skills could strengthen the field.

6.4 Infrastructural support

Current activity in cardiovascular research nationally appears to be heavily concentrated in London. Sixty-nine of the 100 most 'visible' cardiovascular researchers were based at addresses in London as revealed by analysis of more than 14 000 cardiovascular papers published by UK authors between 1988 and 1991. This dominance of London contrasts with non-clinical biomedical fields which tend to be less concentrated in the capital. The proximity of a large number of active groups in London may be noteworthy in any consideration of options for strengthening the field.

Against this background, there was a clear signal from the research community against further concentration of cardiovascular research, for example, by creating a new national institute. Although it is possible that this finding was caused by functional responses (or self-interest) from the majority of researchers who were not likely to benefit from a national institute, interviews with users (industrial R & D managers and Health Service managers) also revealed doubts about the need for such an initiative.

There was instead strong support for the development of multidisciplinary centres or networks as the most appropriate means of strengthening the field. An attraction of centres or networks was flexibility, but strong leadership was seen to be essential. Workshop participants believed that such centres should maintain strong links with universities to enhance career options.

7.1 Achievements of the foresight process

Although the focus of this study was on cardiovascular research, some of the findings and recommendations (particularly regarding infrastructure) may also be of relevance to other fields of research. In addition, the lessons learned from running this foresight programme at the level of a single research field may be of relevance to other funding agencies considering introducing foresight techniques to their forward planning processes.

One of the central goals of foresight is to foster communication between people with a broad range of interests in a field of research, including users, to discuss strengths and weaknesses of the field, and identify research opportunities of common interest. The specific processes developed in this project may have wider application in reaching for this goal, because they provided:

A vehicle for partnership

The foresight project provided a platform for partnership at a number of levels – between researchers from widely different scientific disciplines, between researchers and users, and between research administrators from a number of different funding agencies. The latter partnership was formalized in the shape of a steering committee to oversee the project. The three funding bodies represented (MRC, BHF and the Wellcome Trust) met regularly over a two-year period, and through a process of analysis and systematic study agreed the boundaries of the field under study, identified the most important questions for survey, and regularly helped interpret the findings as these emerged. The focus on study and analysis was crucial for placing discussions on a factual basis, and helped the three bodies collectively take a longer-term view of the future, while maintaining their independence to pursue their own policies subsequently.

A mechanism for identifying and consulting with researchers and users

The combination of structured interviews with users, postal survey of a large cross-section of the research community, and an interactive workshop bringing the two groups together proved to be an effective mechanism for opening the priority-setting process to a wider range of inputs than has traditionally been the case in science funding.

A means of assessing various options for infrastructural reform

The combination of hard data on national and international patterns of research activity, reliable information on the opinions of the research community, and scenario analysis of possible future socioeconomic backgrounds for research, provided a means for taking a fresh look at options to develop the funding infrastructure.

A mechanism for agreeing actionable priorities

Overall, the process of analysis, structured consultation, and facilitated interaction between different interest groups proved to be an effective mechanism for identifying a number of priorities which enjoy widespread support. This support is important, because while it is usually easy to identify priorities for any one field by consulting a small number of leading experts, it is often much more difficult to implement a national policy for a field on the

strength of such limited input. The consultation process developed also, importantly, captured the minority (possibly maverick) viewpoints, which were explored in the foresight workshop. This is important in science for ensuring that the final consensus on priorities is robust, and not simply the 'lowest common denominator' of thinking among a mass of people.

7.2 Lessons learned for developing future foresight studies

A number of general points should be made concerning the approach and techniques employed in this project. The first point is that this was a foresight project aimed at the 'micro-level' – i.e. with a focus on one specific field of research. This level of analysis is important to funding bodies, because specific subject priorities are usually developed through the Boards or Committees concerned with a subject area, and it is through these routes that foresight is likely to be operationalized. The second point is that the approach was developed to introduce foresight concepts to organizations concerned with supporting the UK science-base. Related, but modified techniques are required for organizations concerned with supporting research less closely linked to the science base in the national innovation network.

With this focus on micro-level, science-base foresight, a number of points may be made concerning the tools and techniques used, which may be of value for future studies:

Initiate foresight process through structured consultation with users

The distance between academic researchers and users is often great. In the early stage of a foresight project, it is therefore difficult to involve both communities simultaneously in the consultation process. For example, there is little merit in sending an identical questionnaire to both groups – different questions are necessary. Users cannot be expected to answer questions on scientific feasibility, and researchers are not always best placed to answer questions on the application of their results. An effective approach is, therefore, to start by identifying key user groups, and consulting them on their needs through structured interviews. The 'seven question' approach adopted in this project was helpful in this respect. Once the key areas of user need have been identified, it is then possible to mount a survey of the research community on areas of science likely to underpin these needs.

Survey spread of scientific opinion, as well as consensus

When surveying opinion on likely developments in the advance of basic scientific knowledge, it is crucial to give attention to the spread of opinion. Many researchers doubt that science advances through a consensus view of the future; and such doubts are strengthened by the many examples, which exist, of serendipitous discoveries by researchers outside the mainstream which have transformed understanding. It is, therefore, important to identify outliers, or maverick opinions where they exist. Developments in particular areas of science thus identified can then be included in a workshop to be debated by both researchers and users. The workshop, if

structured appropriately, can serve as the second stage of a Delphi exercise, and a process like colour voting can ensure that workshop participants and postal survey respondents explore the same issues.

This highlights an important feature of the Delphi process that is often overlooked in foresight studies. In the second stage, respondents must be provided not only with aggregated opinion data from the first round, they must also have the opportunity to explore arguments for and against the opinions expressed. This is important when considering the future of academic science, and it is a requirement more readily achieved in a workshop setting rather than in a second round of a postal survey.

Emphasize non-scientific and infrastructural priorities

Traditional peer-review committees of scientists, if composed well, can be very effective at identifying hot areas of science, and foresight appears to have little to add to their work in promoting promising areas of science. One of the real strengths of foresight in the science-base appears to be in investigating infrastructural changes that need to be made today, to strengthen the field tomorrow – e.g. in identifying skills needs, or institutional reforms needed to bring scientists and users into closer contact.

However, one possible criticism of using a questionnaire survey to explore future options for infrastructure development or skills training, is that researchers may respond functionally. For example, when an expensive, centralized development is proposed (e.g. a national institute), it is possible that the majority opinion will be negative more for reasons of self-interest, than for what is good for the field. This potential criticism needs further exploration, and it is one reason why foresight studies should not rely too heavily on questionnaire surveys alone.

Drive process with hard data, and reliable evidence

Foresight analysis is made up of two components: hard facts about the past and present, and opinions on future developments. Opinions can be influenced heavily by anecdote and personal experience, and it is crucial, therefore, that some basic facts are established about the field under review at the outset. Ideally, it is important to have some hard facts about a field – e.g. funding levels, research outputs and productivity – and evidence on the utilization of research results. Such 'benchmarking' data can reduce polemic in policy debate, and provide a common ground for dialogue between users and researchers. One of the goals of foresight should be a move towards evidence-based policy making.

Use objective and transparent methods

Those responsible for conducting foresight studies must use methods that are acceptable to scientists in the field under review. In opinion surveys, this means being open about the approach used to identify the survey questions, and objective in drawing the sample of respondents. It also means publicizing the criteria that were used to identify priorities, and the decision-making process within which these criteria were applied.

A transparent, objective and reproducible methodology enhances the credibility of the study, and encourages acceptance of the results.

Employ innovative techniques for facilitating dialogue between users and researchers

Time constraints mean that it is often difficult to bring together senior figures from the user and researcher communities for more than a short period in workshops. It is vital, therefore, in a one-day workshop, carefully to structure the event, so that creative debate is encouraged, and clear policy options emerge. Introducing the workshop with benchmark and opinion data is valuable for setting the scene, while scenario analysis and voting on policy options can help focus thinking on the future.

Importance of the process

It is important to emphasize that the process of analysis, may be as significant as the outcome. The ability of foresight exercises to generate 'ownership' and permit input to the policy process from a diverse range of stakeholders should not be underestimated. At the outset of this project, the concept of research 'users' and the notion that they should have a role to play in the development of research policy, was relatively new and controversial. However, by the end of this project, a good deal of common ground had been identified between users and researchers (e.g. on disease interventions likely to be of most impact in the next five years), and a greater appreciation gained of user perspectives among the scientific policy-makers connected with the project.

Improving the process in future projects

A cost of the process is the time required: this project took two years elapsed time (three and a half person years of research time) to complete. For foresight exercises to become more widespread in policy-making, it will be necessary to reduce their time-span. One option would be to reduce the extent of the formal opinion survey stage which was less valuable than expected. Although the survey results were a useful starting point for the workshop, the consensus identified on hot scientific topics was largely unsurprising to scientists at the workshop. In addition some of the findings concerning options for reforming the infrastructure suffered from the potential criticism that they may have resulted from self-interest on the part of respondents. For these reasons, in future foresight exercises, it may be worth placing more emphasis on events, such as workshops, which develop direct dialogue between researchers and users. In other words, an improvement on the present project would be to adopt an approach that is more 'process-intensive' than 'analysis intensive'. The exact balance between these approaches will clearly depend on the time available and the needs of the policy-making customers for the study.

Transferability of the process

It is possible that the methods described in this project should be transferable to foresight studies in other fields of academic science (biomedical or otherwise), and it is hoped that such techniques may provide a more robust, convincing basis on which to develop priorities than has traditionally been the case in science.

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APPENDICES

APPENDIX 1

Project steering committee

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APPENDIX 2

Japan: The thirty-year technology foresight exercise

This survey, first carried out in 1971, stimulated much subsequent interest in foresight activities in Japan. Its origins lay in the recommendations made in 1968 by the Future Research Operational Group that 'studied technological forecasting and the development of creative power as a means of shifting Japanese technological development from reliance on imported technology to a self-reliant approach'.[6] It has been repeated on a quinquennial basis, with the most recent survey carried out in 1991.

Unlike many of the other foresight studies carried out within the Japanese agencies, this exercise is not targeted at a specific audience or policy process. The aim is to make available a comprehensive overview of trends in technological innovation 'so as to contribute to the planning and formulation of the government policies on science and technology and to provide private enterprises with guidelines for activities in science and technology'.[6]

The 1986 exercise [15] included questions on cardiovascular research. It involved a questionnaire survey of more than 3000 researchers on a range of more than 1000 topics. A two-stage 'Delphi' technique was used in which respondents were invited to reassess their views in the light of the overall responses in the first round. If they continued to hold markedly divergent opinions they were asked to give reasons. To give further guidance, respondents were also invited to propose appropriate government initiatives to help realise the developments.

Cardiovascular research issues

The results revealed considerable optimism in the potential for advances in prevention, fetal diagnosis and artificial membranes before the end of the decade (Figure 16).

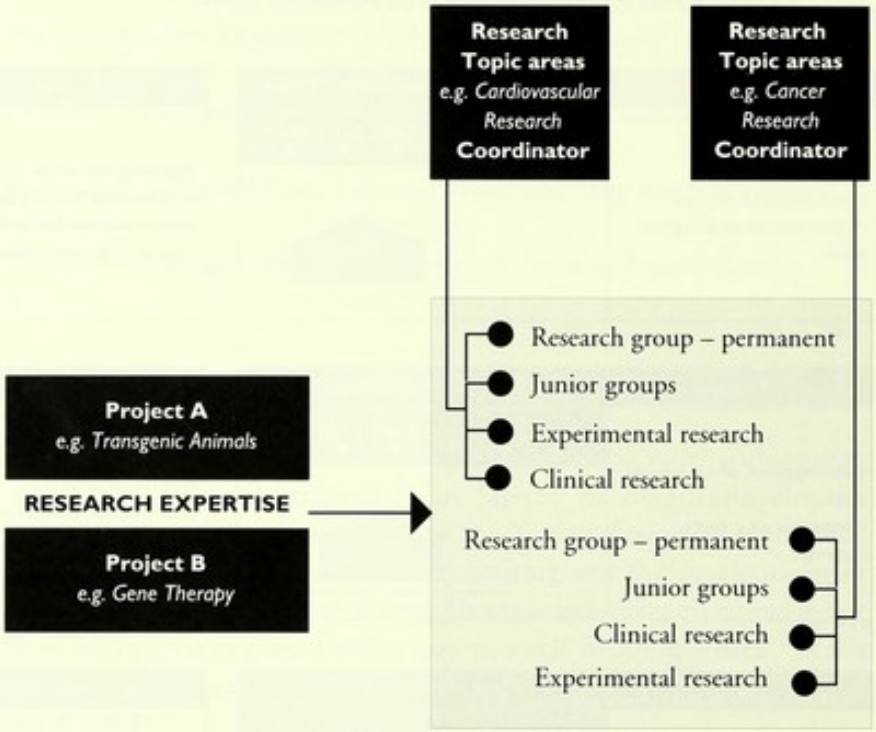
In contrast, 'realization of free conversion between smooth muscle, striated muscle and myocardium' was seen as remote. The survey also provided views on importance, constraints and suggested funding options for each item.

Figure 16 **Japan: The thirty-year technology foresight exercise**
Delphi survey responses relating to cardiovascular topics.[15]

Topic	Time of realization (Year)
Elucidation of the mechanism of cardiac malformation at the gene level.	1990 1995 2000 2005 2010 2015
Practical use of an implantable battery as power sources for artificial organs (like pacemakers).	1990 1995 2000 2005 2010 2015
Development of extremely effective drugs for treatment of arterial sclerosis.	1990 1995 2000 2005 2010 2015
Possibility of synthesizing functional artifical membranes capable of removing desired constituents from blood.	1990 1995 2000 2005 2010 2015
Realization of free conversion between smooth muscles, striated muscles, and the myocardium.	1990 1995 2000 2005 2010 2015
Fabrication of safe, high-polymer materials with haemoglobin functions.	1990 1995 2000 2005 2010 2015
Development of fetal diagnosis and, to a certain extent, treatment of congenital cardiac abnormalities.	1990 1995 2000 2005 2010 2015
Development of artificial myocardium.	1990 1995 2000 2005 2010 2015
Design and synthesis of substances capable of withstanding flexing of at least one billion times, without causing blood coagulation or calcification.	1990 1995 2000 2005 2010 2015
Development of totally implantable artificial hearts.	1990 1995 2000 2005 2010 2015

The unshaded kite represents the distribution of responses (middle quartiles) in the first round of questioning; the shaded kite represents responses in the second round in the light of the results of the first round. The upper bar shows the median, with lower and upper quartiles in the first round, the lower bar represents the same figures for the second round.

Figure 17 **Max-Delbrück Centre, Berlin**



The diagram shows the matrix organizational structure of the Max-Delbrück-Centre for Molecular Medicine in Berlin. Research groups of differing seniority and focus are organized in 'vertical' research topic areas while other groups are organized 'horizontally' around specific skills and techniques.

The Max-Delbrück-Centre for Molecular Medicine (MDC) in Berlin was established in 1992. The main work is the study of disease in the areas of the cardiovascular system, oncology, immunology and neurobiology using the methods of molecular and cell biology. But the centre's policy is to avoid orientation towards any particular disease. Instead, it seeks to combine different areas of knowledge in a broader sense so as to increase the scope of the scientific approach. Small, flexible, project-oriented research groups that interact with one another are the key organizational unit.

To support this structure, traditional departments have been avoided and instead, a matrix structure of disease areas form reasonably permanent 'vertical elements', and technique-based skills, which may be appropriate to more than one disease area, form the more flexible horizontal elements. Research groups are built around these two axis (see figure above).

The centre has around 380 staff, which includes 120 scientists. The expectation is that half the staff will be working on cardiovascular disease and cancer, 20 per cent on medical genetics and cell biology and 10 per cent on neurobiology.

The budget for 1992/93 was DM83m (approx. £35m) but this included funds for repair and rebuilding of laboratories.

List of workshop participants

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Three scenarios for 2005: Introduction

These scenarios were devised to emphasize the different ways the biomedical research environment might develop from present conditions, trends, projections and critical uncertainties. None of them were intended as a prediction or offered as a 'preferred' view. The purpose of the scenarios was to provide a framework within which potential opportunities and problems for cardiovascular research can be considered. Each participant explored only one scenario at the workshop. To assist the imagination of participants, each scenario was supported by a different edition of a mock newspaper, *Research Today*, with stories of what might have happened under that scenario.

Although the scenarios try to emphasize differences, they all have the following common features and assumptions ('drivers').

Background

Molecular developments

- Work has continued through the 1990s and early next century on the human genome project and the map and sequence of most human genes will be completed by 2005.
- The programme will have provided a vast range of data on genes and biological structures. With the sequence more or less complete, the focus of biology will once again be on cells, systems and function.
- Genome sequences will be used widely by medical and biological researchers as a tool, much like a microscope or spectroscope.
- The adjective 'molecular' will be becoming redundant in biology. 'Complexity' will be an increasing concern for many researchers.
- Gene therapy will have had some preliminary successes and show promise for further development for a number of diseases. Several genes associated with major polygenic diseases, such as cardiovascular disease, will have been identified and there will also be more details at the molecular level on the role of environmental factors.
- New drugs to halt or reverse atherosclerosis and better drugs for treatment of heart failure will be in development or under trial.

Information technology

- The second major development will be in information technology, which will be interlinked with genetic developments to provide researchers with good access to molecular data.
- Fibre optic networks will allow large amounts of information to be transmitted effectively and the powerful artificial intelligence systems support the sophisticated processing and analysis of data.
- Remote teaching and research training, using the new links, from key centres will now be carried out in many fields.
- Bioinformatics will be a key research field. New information processing techniques will be under development to model genetic and biochemical data with the aim of producing 'virtual cells' in which experiments, such as gene therapy, can be tested 'in silico'. The approach will highlight the need for real data to develop the models.
- Outside the laboratory, user-friendly computers will be able to give doctors and patients access to information including diagnosis and treatment. Doctors will be

able to obtain data of sufficiently high resolution using enhanced optical links for remote diagnosis and even treatment of patients.

- There will also be new, more sensitive and effective diagnostic tools such as scanners which are used with increasingly specific molecular markers or are increasingly sensitive to physiological changes.

Other trends

- The demand for a highly skilled workforce is acknowledged and university structures will have remained relatively unchanged although sources (and amounts) of funding, and student numbers vary.
- Research, however, will have become concentrated in fewer fields and at fewer centres. Funds will also be constrained but amounts vary.
- Other likely trends include a growth in the UK gross domestic product devoted to healthcare, but new demands on the system, more expensive therapies and increased labour costs mean that resources will remain constrained.

Critical uncertainties

The three scenarios were constructed to consider the above potential scientific developments and other trends in the context of key uncertainties:

- organization and funding of healthcare,
- patient-based research,
- other economic and policy pressures.

The aim was to explore the scenarios' logic and consequences for cardiovascular research as a background to determining present priorities and options for best strengthening the field.

Scenario 1: Free market

This future maximizes the effects of market forces. Industry has an increased role in funding research in the public sector. Clinical research is dispersed among a mixed collection of competitive trust and private hospitals, universities and autonomous institutes. In it healthcare becomes increasingly privately financed and consumer driven. **See First Edition of *Research Today* (pages 58–59).**

Key elements

- Public funding of university research is low in this scenario and is clustered around fewer centres with good groups and facilities. Efforts are made to maintain first-rate research in some areas (with charity help) but some fields have been abandoned.
- Industrial needs are taken seriously in a competitive economic climate. Research is considered important but geared to the needs of industry, which funds a substantial proportion of it. Government assessment of university research takes industrial funding into account.
- Industrial collaboration with basic researchers in universities is good, although support tends to be tightly project-based. Industries support collaborators well. They can respond quickly and flexibly to perceived research needs by targeting appropriate research groups but seek collaboration in other countries when required expertise is not available in the UK.
- Health services are mixed, private and NHS. The former is the larger sector. Hospitals are mostly 'trust' run but some have become fully private. There is competition between them for patients. Consultants working within trusts will increasingly be given tasks set by administrative doctors, which hinders their involvement in research.
- Industrial collaboration with clinical researchers is good. Industrial income is highly valued by trust and private hospitals. There is a strong market for new medicines and other treatments in the private sector, and also in the public sector, if they are effective in attracting referral of patients.
- There are, however, tensions for researchers in medical schools because of the demands of the hospital trusts and limited public research funds and there has been some shift of more basic biomedical research into autonomous or semi-autonomous units. Successful research units may be subject to bids from rival trusts.
- Evaluation of treatments and audit is strong and fully integrated within trust hospitals. Dissemination of research information is not good – some results become proprietary in the competitive climate, if they increase efficiency and reduce treatment costs.
- The infrastructure tends to hinder multicentre interdisciplinary collaboration (other than on focused industrial projects) and projects requiring a large number of subjects – for example, epidemiology, human genetics and prevention trials.
- Primary care centres have developed around fund-holding mixed private/NHS GPs. There is a lot of variation in services and specialities offered.
- The market relationship between primary care and hospitals hinders research collaboration between the two levels.
- Private, home-based medical information/advice systems, in contrast, are popular with the increased private spending on health.
- Cardiovascular disease rates are highest under this scenario.

Scenario 2: Regulated market

This future maximizes government and EU-led regulations and planning. A small number of regional acute super-centres have been established where clinical research is concentrated. Coordinated use of information technology dramatically changes the delivery of healthcare and provides a rich source of population-based health data. There are new opportunities for research at the primary-care level. **See Second Edition of *Research Today* (pages 60–61).**

Key elements

- In this scenario there is more government intervention at all levels and more international regulations governing trade and environmental issues. There is a strong public infrastructure for health, education and social services. Industries in the health sector are constrained by the dominance of the government as a purchaser in the market leading to fewer opportunities in private healthcare. Substantially less is spent by individuals on health and education.
- A key feature of this scenario is the concentration of acute services at 20–25 hi-tech 'super' centres. These are geographically based and not competitive for the bulk of their work. They are fully connected to the standardized data and information systems used by the primary-care network they serve and national databases.
- The centres use standard, rigorously evaluated procedures and high technology to increase efficiency and throughput. Consultants are mostly in the NHS using audit-based guidelines. High-tech services are rationed according to well-defined criteria.
- Clinical research is well integrated into the system, with good interdisciplinary collaboration but the emphasis is on reducing costs and increasing efficiency. The role of individual consultants will be weakened because of a stronger role for administrative doctors at the centres.
- Collaborations between industry and university-based scientists are few, partly because of the public commitment to funding science and higher costs charged to industry by universities.
- There are new opportunities in sophisticated information and other technologies. An ambitious international collaborative information technology programme has grown out of the human genome project to develop 'virtual people' to model systems physiology and pathology 'in silico' although the programme is still at a very early stage.
- Enthusiasm for the computer network, SuperJANET, and its successors, have made teaching and research training much more flexible, with widespread use of remote lessons from the hi-tech centres.
- The emphasis on information exchange also supports population-based genetic and other epidemiological studies at the primary-care level but strong individual motivation for health is not widespread.
- In contrast, dissemination of research results is good because of the need for national policies and the strength of, and wide access to, information networks.
- Health status improves following higher taxes on alcohol and cigarettes and a tax on sugar products which have reduced consumption.
- The widespread availability of sophisticated medical information and diagnostic systems at primary-care centres has meant less demand for home-based health products and services.
- Medical research is seen very favourably by the public in this scenario, partly as result of widespread access to hi-tech treatments.

Scenario 3: Lifestyle concerns

This future emphasizes the effects of lifestyle changes on the population's health. Clinical research at hospital-associated units is reduced with more work at universities and primary-care centres. Primary-care centres have been greatly strengthened and their role is supported by new diagnostic and information technology developments. They also offer new opportunities for research. **See Third Edition of *Research Today* (pages 62–63).**

Key elements

- In this future, events have led to the prominence of government policies to support energy and resource efficiency, healthy lifestyles and individual responsibility.
- Industry has exploited the burgeoning fitness market and opportunities in primary healthcare with new technology, dietary products and preventive treatments. Some areas of medical research, such as psychology and nutrition, attract strong industrial interest but the complexity of biological systems is proving problematic and causing slower development of some pharmaceutical interventions than had been hoped.
- Biomedical research, in the face of this complexity, has grown around a small number of interdisciplinary groups with strong bioinformatic skills and resources.
- Primary healthcare centres have been developed and strengthened. There is substantial use of exercise/diet/fitness programmes in the treatment of hypertension, obesity, depression and a number of other common complaints. There is also considerable use of technology for diagnosis and health monitoring.
- Work on the human genome has, however, helped identify individual people's risk for a number of diseases and has also strengthened the role for primary care in treatment and research. There is considerable public interest and willingness to take part in novel dietary and other intervention trials and public health research is strong.
- There are a large number of bogus claims for 'healthy lifestyle' products and activities which have led to pressure from researchers for better trials.
- There are strong links between the centres and their patients, but the staff and information links between primary centres and hospitals are less strong.
- Health services are mixed private and NHS. The latter is the larger sector. Hospitals are mostly 'trust' run and concentrate on acute services. There is limited competition between them for patients. Local respite, geriatric and home-based care is well developed.
- There is a strengthened role for pharmacists who carry out diagnostic tests, such as measuring blood pressure, and a shift to personal prescribing by them.
- There is a large geriatric population and an increased opportunity for research in this area.

RESEARCH TODAY

FIRST EDITION No: 43,035 45P (E/U 1.20)

MONDAY DECEMBER 6 2005

Claiming that elusive 100,000th gene. But is it conclusive?

Gene landmark sparks new data row

Last week's announcement of the discovery of the 100,000th human gene in the consensus map has been challenged by managers of an independent database. An international consortium of industrial scientists and academics, SequiGen, claim to have recorded a further 300 human genes within the map by use of private data and advanced analytical software that have not be logged with the public database.

By Janet Ashworth

The 100,000th gene, a landmark stage in the mammoth 18-year human genome mapping project, was announced jointly by scientists at the public reference database at the European Bioinformatics Institute (EBI) in Cambridge, and at the US genome database at National Institutes of Health in Maryland.

The new claim, however, marks a significant increase in the number and power of private consortia working on the human genome and has led to calls from academics for further efforts to strengthen public access to basic data.

The sequence manager at the EBI said: "It's getting increasingly difficult for public and charity sectors alone to fund adequate data analysis systems and it is very frustrating to see the fruits of the genome project going into private hands."

The project, which has been funded by governments and other agencies in 34 countries, has been the flagship of biological research since the closing years of the last decade and draws on complete genetic maps of a number of other organisms including yeast, *Arabidopsis* and the nematode worm, *Caenorhabditis elegans*. The speed of the mapping and sequencing work has staggered even the most optimistic geneticists. The resulting database is proving to be almost an "embarrassment of riches" for other biologists working in the fields of dynamic systems who are struggling with the volume of potentially useful data, a leading physiologist said.

And the disputed 100,00th gene? "It's in the Uj/MAP3 family of Rek/SW kinase kinases, called DFRq/vc/r3, with more than 90 per cent predicted protein sequence similarity in two alpha-helix domains with several other key members of the family," according to the team at the Shanghai Institute of Biochemistry, which has coordinated the research at a number of the new Pacific Basin universities. "It has key features of this family of regulatory genes but its function is not known," the team leader added.

Integrated Wales model 'a success'

By Janet Ashworth

The University of Wales's bid to boost flagging student numbers and strengthen rank 1 research has been successful, according to the first University Funding Council's figures published since the radical restructuring plan was completed three years ago.

The figures show that the university has achieved one of the lowest teaching and research cost overheads for a European university, which has boosted industrial research funding. "We're not yet up with the golden LonCamOx triangle but we have achieved an increase in the amount of rank 1 research at the university," the bioscience coordinator said.

The restructure plan, which aimed to create a single non-overlapping teaching and research institution, caused uproar amongst staff when it was first proposed. The key element was the installation of a dedicated optical data link between colleges which was enthusiastically supported by hi-tech, Japanese-backed Welsh businesses, which helped ease academic opposition.

Biomedicine is concentrated at the southern sites whereas agriculture, terrestrial and marine management have been focused at the northern and western centres, the coordinator said. "The aim was for flexible, modular teaching and research, using the data links to exploit the best of our human skills and to import others as needed. The result has been to build courses using the best teachers available, live or via video link, for each module. "We are now looking at the possibility of marketing them," she added.

Pressure builds on Archie's heart

A dispute has broken out over ownership of software rights for the cardiovascular system installed in Archie, the infamous "virtual" human, who arose as an ambitious new goal for the human genome project five years ago.

Archie (active, real-time, computational, human interactive experiment), a product of more than 50 laboratories in Europe, and backed by the EU, is attracting growing interest in a number of other countries keen to develop their own human systems modelling efforts and other data processing skills. "Archie has a good set of human genes but he doesn't know what to do with most of them," a project scientist said.

But a group of cardiovascular and information scientists, attending an international conference in Berlin two years ago, announced that they had built up sufficient physiological, pathological, developmental and genetic data to simulate the first steps towards a heart and crude cardiovascular system for the bloodless Archie, which was subsequently installed.

"Input of the vast amounts of cardiovascular data has been enormously helpful in getting a key bit of his physiology established, and has proved remarkably popular with pharmaceutical companies," a project scientist said.

Archie's virtual silico-heart.

"The demand, however, has forced two of the universities involved to press for renegotiation of the software rights," she added.

The aim of the project is ultimately to build up sufficient genetic and dynamic data for Archie to be able to answer complex questions about environmental effects and is now acquiring the data needed as the first step to this goal.

Public hostility to the project, dubbed Frankenstein II by critics at the outset because of fears over the power of the human genome project and information technology in general, has mostly waned. "He's never going to get off the network," she added.

• By Robert Aldridge

The 'Gravity Experience' Dome

Hindsight plan launched

The Department of Tourism has launched a new initiative, Hindsight, to identify new national heritage themes to support the country's increasingly important specialist tourism industry. The Government's Science Office has agreed to delve into history and identify potential science and technology themes and centres, in the light of the popularity, particularly with Pacific Rim visitors, of Cambridge University's new theme park, the Gravity Experience, and the continuing success of the Royal Institution-backed Electric Avenue in London.

Clinical research publications dip

Bibliometric analysis of UK clinical research has recorded the first fall in the annual number of publications from UK addresses since studies were first carried out more than 20 years ago.

The fall reflects the growing concern among the academic community that the proprietary value of research results for competitive trusts has become so significant that it has become part of their key strategic business development. They fear that there is little that can be done to encourage researchers to publish their data.

Business needs are reflected in other surveys which, in contrast, show a small but steady growth in patents from UK clinical and industrial collaborators.

There is also some sign that the business potential of more basic university-based research is also being realised with a fall, for the first time, in the rate of increase of UK biomedical publications in the human area coupled with strengthened patenting support.

Foresight programme backs bioscience

Preliminary indications from the government's third technology foresight exercise again highlight the continuing importance and opportunities within biological science for UK industry. The exercise, the biggest ever, has polled opinions from more than 5,000 academic and industrial and business experts identified using the new National Skills database.

"Use of the new database has, for the first time, allowed creative input from those with skills in the arts, media and advertising which have been such a successful UK business sector over the previous decade and are proving increasingly important in determining new technology markets," one of the project steering committee said.

The experts were asked about a range of technologies and creative development opportunities in the UK that had been shortlisted by a pool of leading scientists and industrialists. The final list, however, provides grim reading for some researchers as perceived opportunities in many areas of materials, energy, transport and information technology, have further dwindled, confirming the continuing withdrawal of the UK from several manufacturing sectors.

Opportunities

Bioscience, however, and its application in the pharmaceutical, agricultural and marine and terrestrial management sectors came out strongly in the exercise as a key area of expansion although the advertising specialists polled still saw some of the sectors as "challenging", particularly following the row that broke out over last year's "blue trees" genetic engineering accident.

"The UK's world-leading pharmaceutical industry has maintained strong links with the country's science base, helped by government partnership programmes, and it is likely a new set will be developed when the full details of the foresight exercise are published," a spokesperson for the Government's Science Office said.

Nevertheless the explicit recognition of dwindling opportunities for industrial exploitation of several manufacturing technologies in the UK has alarmed some commentators on the exercise but is defended by officials as "realistic".

Cross-country keyhole treatment trial

An experimental gene therapy to regress atherosclerosis, under development by researchers at the South London Hospital Trust (SLHT), has been carried out remotely for the first time on a patient in Glasgow.

The operation, which uses a specialised catheter to deliver genes to cells close to the site of the damage in the artery, involves sophisticated intracellular biochemical measurements which are processed in real-time by novel software developed at the SLHT to determine a 'personalised' gene cocktail for the patient.

The procedure, which has been tested in phase II trials on more than 20 patients at the SLHT, with funds from industry and two major insurance companies, has shown promising preliminary results and the team have been looking for a new set of patients to extend the trial.

"Talks with a number of other centres have led to a strategic alliance with the Western Glasgow Hospital Trust, who have attracted funding from the Scottish Home and Health Department," one of the London researchers said.

"Distance is not a problem," he said. "The catheter is quite portable. One of our team was in Glasgow with the clinicians while the rest of the team operated the catheter from London and processed the physiological data to determine the precise gene delivery," he said.

Happy hour cocktails – 24 hour delivery – distance no object.

By Janet Ashworth

"The procedure requires extremely good optical data transmission and novel data processing but that is something we have specialised in at the SLHT in association with university collaborators and we've got a number of patents submitted," he said.

The team plan to carry out ten further operations in Glasgow and a number of European centres have declared an interest.

The potential in remote treatment could provide valuable income for the cash-pressed trust. The SLHT business manager said that remote treatment was one of the key interests of the trust and was a vigorous research priority in a number of departments.

Department faces closure threat

Molecular modellers future in jeopardy.

The department of pharmacology at the University of Middle England, in Leicester, faces closure after Nipponsys, the Japanese pharmaceutical company, announced that it would not be renewing its research contract with the department next year.

Nipponsys have pulled out because of a rival bid from Cambridge University, a company spokesman said. Cambridge, through amalgamation of a number of departments and recruitment of key scientists from the US and Europe, including one from Middle England University, have offered the company an enhanced package with state-of-the-art modelling facilities available through collaboration with the Institute of Mathematics.

The contract, worth £500,000 (ECU 2.0m) annually, supports seven staff within the department and attracts other substantial associated charity and public funds. The project, which has been running for more than eight years, has centred on the development of novel recombinant DNA technology to generate cell lines expressing hybrid cell surface receptors.

Loss of the contract is particularly disastrous for the Middle England department because, under the University Funding Council's new procedures, research quality assessment scores industrial funding as a key element in its own funding allocations.

"The concentration of university research funds at fewer centres with industrial backing presents a 'catch 22' when the company money goes," the head of the department said.

She warned that loss of the contract and a poor research assessment could lead to the end of research in the department. Teaching in the department could also be jeopardy. "Without substantial research the university might be tempted to buy-in teaching from one of the increasingly competitive 'remote' centres," she said.

Yeast Co targets muscle

The international Backo Yeast Co., which holds patents on a number of key yeast gene products and processes, has announced backing for a major project by researchers in five EU countries with the aim of identifying the molecular blocks to cardiac muscle cell differentiation. Success could transform approaches to treating ischaemic cardiac muscle damage, which have lagged behind efforts to treat atherosclerosis.

This partnership, worth £10 million (ECU40m) over five years, is fuelled by recent success in cracking the genetic "postcodes" of cells that provide the vital address information for cells and thereby the pattern of gene activation.

"It now appears feasible to change that postcode and, using the extraordinary detailed knowledge of yeast cell cycle and division, which is proving a good model for other organisms, it may be possible to persuade cardiac muscle cells to divide," the project director said. A spokesman for Backo said: "We are delighted to support this project as we have considerable in-house expertise in yeast biology".

LAST WET BIOLOGY

The Imperial Cancer Research Fund has announced plans to cease all wet biology experiments at its London headquarters site.

The Fund, which has played a key role in gathering molecular data, has decided that cell modelling and software development will be the key activities, with further expansion of the Human Epidemiology Study, the corporate plan for 2006 reveals. Wet biology will cease by 2010 and essential experiments will be funded in universities or one of the small outpost laboratories, a spokesperson said.

NEWS IN BRIEF

Data rights negotiations stall

The Accra round of negotiations on licence rights for use of genetic information derived from indigenous species has stalled once again on a definition of "unit of genetic information". The long-running battle by Southern countries to cash in on the genes of many tropical plants and microorganisms has been thwarted again by lawyers representing Northern business interests challenging the basis of genetic uniqueness.

Intellectual property values soar

The value of intellectual property, the indicator developed by the international accountancy conglomerate Burgle, Feiff and Ho, which is showing growing importance amongst the range of standard economic indicators, has risen steadily over the last three months to reach an all-time high in November, the Wall Street Watcher has announced.

Challenge to LonCamOx triangle

The favoured LonCamOx triangle, which now attracts more than 50 per cent of the UK university research and development budget, has been challenged by the Joint Monitoring Board of the Northern Universities. The board accuses the universities of producing artificially low research overheads in the national listings table for their joint bids to attract research funds. The JMB made the unprecedented public statement because of "frustration" over their efforts to get the issue investigated by the National Trading Audit Bureau, which claims a five-year backlog of work.

Wales model studied

The European Union has set up a committee to consider if the optical link system established between the colleges of the University of Wales could be used by other dispersed colleges in remote regions of the Union to develop unified, streamlined centres. The committee will be coordinated by officials based at EU offices in Iraklion in Greece.

Science backs soccer

The Committee for the Public Understanding of Science (Copus), is to sponsor next year's premier football league, with support from the Association of the British Pharmaceutical Industries.

Hospital tops efficiency league

The Newcastle Hospital Trust has come top of the national league in a basket of measures of efficiency, a new study by the insurance conglomerate Gen Pru Union, reveals. The trust plans to cut treatment and research overhead costs by 3.5 per cent next year.

RESEARCH TODAY

SECOND EDITION No: 45,035 45P (E/U 1.20)

- Genome landmark
- Network heart
- Cross-country keyhole trail

- Publication bulge
- Foresight for collaboration
- Wet biology to end

MONDAY DECEMBER 6 2005

Cambridge scientists celebrate the 100,000th gene: but are scientists hanging on to their 'pet' sequences?

Hundred thousandth human gene discovered

Researchers have announced the discovery of the 100,000th human gene - a landmark stage in the mammoth 18-year human genome mapping project. The announcement, made by scientists who recorded the gene on the consensus map held at the reference database at the European Bioinformatics Institute in Cambridge, was confirmed by researchers at the US genome database at National Institutes of Health. "Ten years ago we thought we'd be through by this stage but there a few more genes yet," a spokesperson said.

By Janet Ashworth

The project, which has been funded by government and other agencies in 34 countries, has been the flagship of biological research since the closing years of the last decade and draws on complete genetic maps of a number of other organisms including yeast, *Arabidopsis* and the nematode worm, *Caenorhabditis elegans*.

The speed of the mapping and sequencing work has staggered even the most optimistic geneticists. The resulting database is proving almost an "embarrassment of riches" for other biologists working in the fields of dynamic systems who are struggling with the volume of potentially useful data, a leading physiologist said.

And the gene in question? "It's in the Uj/MAP3 family of Rek/SW kinase kinases, called DFRq/vc/r3, with more than 90 per cent predicted protein sequence similarity in two alpha-helix domains with several other key members of the family," according to a researcher at the Shanghai Institute of Biochemistry, which has coordinated the research at a number of the new Pacific Basin universities. "It has key features of this family of regulatory genes but its function is not known," she added.

There are also doubts that its notable position in the chronological human list will endure. Researchers at the EBI in Cambsdge believe that there are many more genes to be discovered lurking within those already recorded which will emerge on full analysis of the sequence data. "There may also be a few 'pet' genes researchers have been hanging on to in their own laboratories before releasing the data," she added.

Continued on page 15

Network Archie gets first beat of a heart

Archie, the infamous "virtual" human whose plans arose as an ambitious new goal for the human genome project, is about to acquire his first coronary data.

Archie (Active, real-time, computational, human interactive experiment), a product of more than 50 laboratories in Europe, and backed by the EU, is attracting growing interest in a number of other countries keen to develop their own human systems modelling efforts and other data processing skills.

Now a consortium of European cardiovascular and information scientists, attending an international conference in Berlin, have announced that they have built up sufficient physiological, pathological, developmental and genetic data to set up the first steps towards a heart and crude cardiovascular system for the bloodless Archie.

"Archie has a good set of human genes but he doesn't know what to do with most of them," a project scientist said.

"We've got a pretty good grip on his early development with all the fabulous work that's been done on other organisms but the model weakens as we age him.

"Input of the vast amounts of cardiovascular data will be enormously helpful in getting the framework for a key bit of his physiology established and we plan to discuss with the consortium how we might unify and incorporate the data they have collated as soon as possible."

Archie: perplexed by his genes.

The aim of the project is ultimately to build up sufficient genetic and dynamic data for Archie to be able to answer specific questions about the effects of environmental and other treatment interventions.

Public hostility to the project, dubbed Frankenstein II by critics at the outset because of fears over the power of the human genome project and information technology in general, has mostly waned. "He's never going to get off the network," one of the project scientists said.

"As for anything remotely resembling a human brain, I can't see it," he added.

Welsh solution studied as EU model

The University of Wales's success in boosting flagging student numbers and increasing the amount of rank 1 research, according to the first University Funding Council's figure published since the radical restructuring plan was completed three years ago, is to be studied by a committee of the EU as a way of distributing research and teaching funds at multiple sites in the Union.

The figures show that the University has achieved one of the lowest teaching and research cost overheads for a European university, which has boosted

By Janet Ashworth

industrial research funding. "We're not yet up with the golden LonCamOx triangle but we have for the first time achieved a 1 rank for some of the biological research at the university," the bioscience coordinator said.

The restructure plan aimed to create a single non-overlapping teaching and research institution. The key element was the installation of a dedicated optical data link between colleges which was enthusiastically supported by hi-tech, Japanese-backed Welsh businesses, which helped ease academic opposition.

Biomedicine is concentrated at the southern sites whereas agriculture, terrestrial and marine management have been focused at the northern and western centres, the coordinator said.

"The aim was for flexible, modular teaching and research, using the data links to exploit the best of our human skills and to import others as needed. The result has been to build courses using the best teachers available, live or via video link, for each module," she added.

Bright light, big city, London's Electric Avenue

Hindsight plan launched

The Department of Tourism has launched a new initiative, Hindsight, to identify new national heritage themes to support the country's increasingly important specialist tourism industry.

The Government's Science Office has agreed to identify potential science and technology themes and centres, in the light of the popularity, particularly with Pacific Rim visitors, of Cambridge University's new theme park, the Gravity Experience, and the Royal Institution-backed Electric Avenue in London.

Paper peak

Bibliometric analysis of UK clinical research has recorded the largest rise in number of authors and number of addresses on a single paper since the first studies were carried out 20 years ago.

The growth marks increasing multi-centre and multidisciplinary collaboration in clinical research.

The findings also reflect the increasing complexity of biomedical research and the vast genetic information base on which projects are based.

Policy analysts believe the growing influence of the EU on biomedical project funding, with its demands for increasingly diverse collaborative structures as a requirement for funding consideration, is also a significant factor.

Support for this belief comes from a sharp increase in the number of UK clinical papers with an additional Portuguese or Greek address.

The study also records a growing number of patents in the biomedical area held by UK clinical and industrial collaborators.

Foresight programme highlights links

Preliminary indications from the government's third technology foresight exercise again highlight the continuing importance and opportunities within biological science for UK industry but stress the need for greater collaboration. The exercise, the biggest ever, has polled opinions from more than 5,000 academic and industrial and business experts identified using the new National Skills database.

"Use of the new database has, for the first time, allowed creative input from those with skills in the arts, media and advertising which have been such a successful UK business sector over the previous decade and are proving increasingly important in determining new technology markets," one of the project steering committee said.

The experts were asked about a range of technologies and creative development opportunities in the UK that had been shortlisted by a pool of leading scientists and industrialists. The final list, however, provides grim reading for some researchers as perceived opportunities in many areas of materials, energy, transport and information technology, have further dwindled, confirming the continuing withdrawal of the UK from several manufacturing sectors.

Opportunities

Bioscience, however, and its application in the pharmaceutical, agricultural and marine and terrestrial management sectors came out strongly in the exercise as a key area of expansion. But the programme has highlighted the need for unprecedented levels of collaboration over a wide range of skills in both the technology and production sectors if the main opportunities are to be realised.

"The UK's world-leading pharmaceutical industry has maintained strong links with the country's science base, helped by government partnership programmes, and it is likely a new set of collaborative proposals will be developed when the full details of the foresight exercise are published," a spokesperson for the Government's Science Office said.

Nevertheless the explicit recognition of dwindling opportunities for industrial exploitation of several manufacturing technologies in the UK has alarmed some commentators on the exercise but is defended by Government officials as "realistic".

Remote treatment programme go-ahead

An experimental gene therapy to regress atherosclerosis, under development by researchers at the South London Acute Centre (SLAC), has been carried out remotely for the first time on a patient in Glasgow.

The operation, which uses a specialised catheter to deliver genes to cells close to the site of the damage in the artery, involves sophisticated intracellular biochemical measurements which are processed in real-time by novel software developed at the SLAC to determine a "personalised" gene cocktail for the patient.

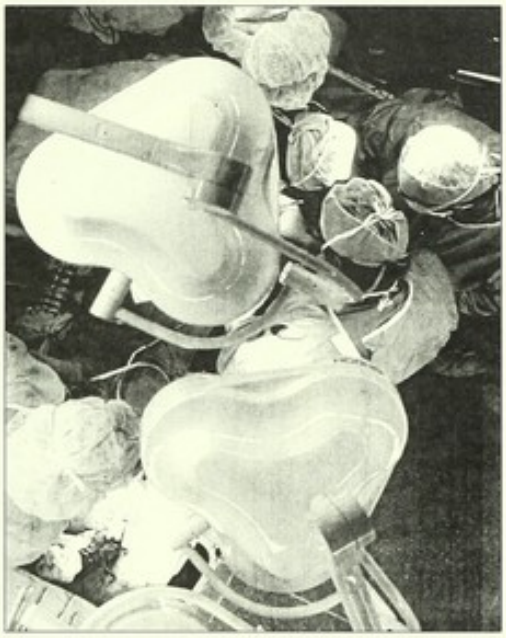
The procedure, which has been tested in phase II trials on more than 20 patients at the SLAC, with funds from industry and the central NHS development pool, has shown promising preliminary results and the team has been looking for a new set of patients to extend the trial.

"Talks with a number of other centres have led to a collaboration with the Western Glasgow Acute Centre, which has attracted funds from the Scottish health department," one of the London researchers said.

"Distance is not a problem," he said. "The catheter is quite portable. One of our team was in Glasgow with the clinicians while the rest of the team operated the catheter from London and processed the physiological data to determine the precise gene delivery," he said.

"The procedure depends on the extremely good optical data transmission between acute centres and novel data processing but that is something we have specialised in at the SLAC in collaboration with university colleagues", he said.

The team plan to carry out ten further operations in Glasgow. The procedure will then be subject to scientific audit and, if highly rated, it will face the increasingly tough NHS value audit. Fewer than 20 per cent of potential new treatments presently survive this scrutiny.



Designer gene cocktails: mixed in London, delivered in Glasgow.

By Janet Ashworth

Industry backs department deal

The department of pharmacology at the University of Middle England, in Leicester, facing closure as a result of rationalisation within the university, may be reprieved as a result of a strategic alliance with the University of Cambridge which has attracted interest from Nipponsys, the Japanese pharmaceutical company.

The company has announced interest in a research contract with the alliance beginning next year.

The contract, worth £500,000 (ECU 2.0m) annually, would support seven staff within the Middle England department and is likely to attract other substantial associated charity and public funds. Initially planned for six years, the contract centres on the development of recombinant DNA technology to generate batteries of cell lines expressing hybrid cell surface receptors together with advanced monitoring techniques and real-time analytical software.

Nipponsys have chosen the joint bid from the two universities because of the highly competitive research overhead component tendered, a company spokesman said. Cambridge, through amalgamation of a number of departments and recruitment of key scientists from the US and Europe, including one from Middle England University, have offered the company an enhanced package with state-of-the-art modelling facilities available through collaboration with the Institute of Mathematics.

The potential contract, is particularly important for Middle England University because, under the University Funding Council's new procedures, research quality assessment scores industrial funding as a key element in its own funding allocations.

"The concentration of university research funds at fewer centres with industrial backing presents a 'catch 22' when the company money goes," the head of the department said.

She stressed the need to exploit research skills through strategic alliances with the more powerful research universities if the inexorable contraction of the research base into fewer and fewer centres was to be resisted.

Teaching in the department may also be reprieved. "Without substantial research the university might be tempted to buy-in teaching from one of the increasingly competitive 'remote' centres," she said.

NEWS IN BRIEF

Brussels blamed for link failure

The European Union has come under bitter attack from academics over its failure to support efforts by NAFTA and the Pacific Rim to establish a common global standard for international data exchange specifications. Critics claim the determination to use European-based technology and software has been disastrous, particularly in the light of the flexibility of the Pacific Rim. The word "dinosaur" is now frequently heard in Brussels' more critical corridors, sources say.

Doubts over new information deal

Progress has been reached on the UN's Public Information Commitment. The commitment, which aims to protect a core of fundamental scientific data to ensure total access by all who wish it, is close to agreement but critics are increasingly concerned that the terms of inclusion for core data are contracting dramatically. The EU's enormous effort appears to have hit the buffers in a number of commercially or industrially sensitive areas, a spokesperson said. "The prospects of truly free access to data remain fragile," he added.

Intellectual property rethink

The increasing use by international economic analysts of new indicators to assess corporate intellectual property has been challenged in the European Court. The court faces claims that intellectual property is not a tradeable "product". The hearing, backed by the EU, has arisen from academics concerned that contrived indicators, rather than acknowledgement of broad-ranging intellectual capacity, had become the dominating factor in research output assessment in most union countries.

Hospital tops audit league

The West Central Acute Centre in Shrewsbury has come top of the league in a basket of measures recorded by the NHS central audit team. The measures focus on patient throughput, costings and patient questionnaire returns in an effort to monitor and compare centres. "Shrewsbury has done exceptionally well," the NHS audit minister said. "Their less strong scoring in research deserves close scrutiny and may be a lesson to other centres," she said.

Database bids sought

Bids have been sought to develop and run the first of three major databases within the NHS to track research in clinical epidemiology which requires elaboration of sophisticated extra-EU links. Bids must be lodged, on official email forms, with any local EU office before the end of the year.

Yeast clues to cardiac muscle

The largest collaborative project funded by the EU's Biomed3 programme, has announced support for a project by researchers in five EU countries with the aim of identifying molecular blocks to cardiac cell differentiation. Success could transform approaches to treating ischaemic damage, which have lagged behind efforts to treat atherosclerosis.

This project, costing £10 million (ECU40m) over five years, is fuelled by recent success in cracking the genetic 'postcodes' of cells that provide the vital address information for cells and thereby the pattern of gene activation in each cell type. "It now appears feasible to change that postcode and, using the extraordinary detailed knowledge of the genes involved in controlling the yeast cell cycle, which is proving a good model for other organisms, it may be possible to persuade cardiac muscle cells to divide," the project director said.

A spokesman for the union's DG XXII, responsible for collaborative biomedical research, said: "We are pleased to fund this imaginative and scientifically ambitious project".

LAST WET BIOLOGY

The Imperial Cancer Research Fund has announced plans to cease all wet biology experiments at its London headquarters site.

The Fund, which has played a key role in gathering molecular genetic data, has decided that cell modelling and software development will be the key activities, with further expansion of the Human Epidemiology Study, the corporate plan for 2006 reveals. Wet biology will cease by 2010 and essential experiments will be funded in universities or one of the small outpost laboratories, a spokesperson said.

RESEARCH TODAY

THIRD EDITION No: 43,035 45P (E/U 1.20)

MONDAY DECEMBER 6 2005

The numbers game: 100,000 down – how many more to go?

Complexity mars genome landmark

Researchers have announced the discovery of the 100,000th human gene - a landmark stage in the mammoth 18-year human genome mapping project - but the complexity of genetic information is hindering its application to several human diseases, a leading researcher said. The announcement, made by scientists who recorded the gene on the consensus map held at the reference database at the European Bioinformatics Institute in Cambridge, was confirmed by researchers at the US genome database at National Institutes of Health. "Ten years ago we thought we'd be through by this stage but there are a few more genes yet," a spokesperson said.

By Janet Ashworth

The project, which has been funded by government and other agencies in 34 countries, has been the flagship of biological research since the closing years of the last decade and draws on complete genetic maps of a number of other organisms including yeast, *Arabidopsis* and the nematode worm, *Caenorhabditis elegans*.

The speed of the mapping and sequencing work has staggered even the most optimistic geneticists. The resulting database is proving almost an "embarrassment of riches" for other biologists working in the fields of dynamic systems who are struggling with the volume of potentially useful data, a leading physiologist said.

And the gene in question? "It's in the Uj/MAP3 family of Rek/SW kinase kinases, called DFRq/vc/r3, with more than 90 per cent predicted protein sequence similarity in two alpha-helix domains with several other key members of the family," according to a researcher at the Shanghai Institute of Biochemistry, which has coordinated the research at a number of the new Pacific Basin universities. "It has key features of this family of regulatory genes but its function is not known," she added.

There are also doubts that its notable position in the chronological human list will endure. Researchers at the EBI in Cambridge believe that there are many more genes to be discovered lurking within those already recorded which will emerge on full analysis of the sequence data.

"There may also be a few 'pet' genes researchers have been hanging on to in their own laboratories before releasing the data," he added.

Network host seeks heart data

Archie, the infamous planned "virtual" human who arose as an ambitious new goal for the human genome project, is about to acquire his first coronary data.

Archie (Active, real-time, computational, human interactive experiment), a product of more than 50 laboratories in Europe, and backed by the EU, attracted a lot of interest from a number of other countries keen to develop their own human systems modelling efforts and other data processing skills, at the launch five years ago.

A consortium of European cardiovascular and information scientists have, since then, been collecting physiological, pathological, developmental and genetic data to simulate a heart and crude cardiovascular system for the bloodless Archie. At a conference last week in Berlin, the consortium announced plans to install the first set of data.

"Archie has a good set of human genes but he doesn't know what to do with most of them," a project scientist said.

"We've got a pretty good grip on his early development with all the fabulous work that's been done on other organisms but the model weakens as we age him.

"Input of the vast amounts of cardiovascular data will be enormously helpful in getting a key bit of his physiology established and we plan to discuss with the consortium how we might unify and incorporate further data they collate as soon as possible."

The aim of the project is ultimately to build up sufficient genetic and dynamic data for Archie to be able to answer specific questions about the effects of environmental and other treatment interventions.

But Archie still has a public relations problem. Hostility to the project, dubbed Frankenstein II by critics at the outset because of fears over human genetics and information technology, has not gone away. Even the choice of acronym has angered sectors of the public as "regionalist" and "sexist".

Heartache: will the data get Archie's heart to beat?

Wales tops 'student friendly' league

By Janet Ashworth

The University of Wales is overall winner in the new Government-backed league table of university performance as scored by their own students. The league table, the first assessment of the university since the radical restructuring plan was completed three years ago, put Wales strongly ahead on course content and community responsibility.

The university's flagship role in the creation and maintenance of the EU's biggest marine nature reserve was also highly regarded by the students.

The university's restructure plan, which aimed to create a single non-overlapping teaching and research institution, caused uproar amongst staff when it was first proposed.

The key element was the installation of a dedicated optical data link between colleges which was enthusiastically supported by hi-tech, Japanese-backed Welsh businesses, which helped ease academic opposition.

"The aim was for flexible, modular teaching and research, using the data links to exploit the best of our human skills and to import others as needed. The result has been to build courses using the best teachers available, live or via video link, for each module," she added.

Biomedicine is concentrated at the southern sites. Food ecology, terrestrial and marine resource support have been focused at the northern and western centres, the bioscience coordinator said. "But the data links mean that students may study any module at any of the centres," she added.

Strong attraction: the Gravity Experience

Hindsight plan launched

The Department of Tourism has launched a new initiative, Hindsight, to identify new national heritage themes to support the country's increasingly important specialist tourism industry.

The Government's Science Office has agreed to identify potential science and technology themes and centres, in the light of the popularity, particularly with Pacific Rim visitors, of Cambridge University's new theme park, the Gravity Experience, and the Royal Institution-backed Electric Avenue in London.

Clinical research publications dip

Bibliometric analysis of UK clinical research has recorded yet another fall in the annual number of publications from UK addresses. The fall is the fourth consecutive year of decline in this research sector since studies were first carried out more than 20 years ago, analysts said.

The fall reflects growing concern among the academic community about the widely perceived difficulties of obtaining public funding and support for collaboration between researchers at different centres.

On analysis by sector, psychology and psychiatry appear to be the only areas of research with a growing number of publications within the clinical field. Address field analysis shows a greater number of primary care centre addresses compared with the previous year. The relative role of industry in funding clinical research appears to have weakened, with a smaller proportion of papers including an industrial address than in previous years.

Foresight programme highlights lo-tech

Preliminary indications from the government's third technology foresight exercise highlight the importance of lo-tech opportunities for the country's economic development. The exercise, the biggest ever, has polled opinions from more than 5,000 academic and industrial and business experts identified using the new National Skills database.

"Use of the new database has, for the first time, allowed creative input from those with skills in the arts, media and advertising which have been such a successful UK business sector over the previous decade and are proving increasingly important in determining new technology markets," one of the project steering committee said.

The experts were asked about a range of technologies and creative development opportunities in the UK that had been shortlisted by a pool of leading scientists and industrialists. The final list, however, provides grim reading for some researchers as perceived opportunities in many areas of materials, energy, transport and information technology, have further dwindled, confirming the continuing withdrawal of the UK from several manufacturing sectors.

But lo-tech opportunities scored highly. The UK's resurgent bicycle industry based on innovative materials, design and world-leading marketing were cited as a model of collaborative effort that could be explored in other areas of technology.

Overall in bioscience the experts have perceived a narrowing of opportunities since the last foresight exercise five years ago. The upsurge in the fitness market has boosted pharmaceutical sales from health products but is putting pressure on new drug developments. "The UK's world-leading pharmaceutical industry has maintained strong links with the country's science base, helped by government partnership programmes, and it is likely a new set of collaborative proposals will be announced to help the industry exploit new markets when full details of the foresight exercise are published," a spokesperson for the Science Office said.

Nevertheless the explicit recognition of dwindling opportunities for industrial exploitation of several manufacturing technologies in the UK has alarmed some commentators on the exercise but is defended Science Office officials as "realistic".

Remote treatment tackles shortages

An experimental gene therapy to regress atherosclerosis, under development by researchers at London University South, has been carried out remotely for the first time on a patient in Glasgow as part of an effort to widen the availability of increasingly scarce clinical research skills.

The operation, which uses a specialised catheter to deliver genes to cells close to the site of the damage in the artery, involves sophisticated intracellular biochemical measurements which are processed in real-time by novel software developed at the university to determine a "personalised" gene cocktail for the patient.

The procedure, which has been tested in phase II trials on more than 20 patients in London, with funds from industry and the central NHS development pool, has shown promising preliminary results and the team have been looking for a new set of patients to extend the trial.

"Talks with a number of other centres have led to a collaboration with the Western Glasgow Hospital Units, which has attracted funds from the Scottish health department," one of the London researchers said.

"Distance is not a problem," he said. "The catheter is quite portable. One of our team was in Glasgow with the clinicians while the rest of the team operated the catheter from London

Remote control: Southern scientists need never leave the sanctuary of London. . .

By Janet Ashworth

and processed the physiological data to determine the precise gene delivery," he said.

"The procedure depends on the extremely good optical data transmission between acute centres and novel data processing but that is something we have specialised in at the university in collaboration with clinical colleagues", he said.

The team plan to carry out ten further operations in Glasgow. If successful, it will face the tough NHS resource and lifestyle audit. Fewer than 20 per cent of potential new acute treatments presently offer sufficient resource and patient lifestyle advantages to survive this scrutiny.

Pharmacology closure threat

The department of pharmacology at the University of Middle England, in Leicester, faces closure after Nipponsys, the Japanese pharmaceutical company, announced that it would not be renewing its research contract with the department next year.

The contract, worth £500,000 (ECU 2.0m) annually, supports seven staff within the department and attracts other substantial associated charity and public funds.

Nipponsys have pulled out because of a major strategic review of the company following declining demand for a number of its most profitable drugs and a smaller than expected market for a number of compounds under development.

The growth in health supplements, particulary those that include oriental formulations, has caused Nipponsys to refocus its research programme.

Analysts believe the company plans to establish research agreements with the new Chinese universities in Hong Kong and Shenzhen.

Loss of the contract is particularly disastrous for the Middle England department because, under the University Funding Council's new procedures, research quality assessment scores industrial funding as a key element in its own funding allocations.

"The concentration of university research funds at fewer centres with industrial backing presents a 'catch 22' when the company money goes," the head of the department said.

The contract, which has been running for more than eight years, centred on the development of novel recombinant DNA technology to generate cell lines expressing hybrid cell surface receptors.

The department head warned that loss of the contract and a poor research assessment could lead to the end of research in the department.

Teaching in the department could also be jeopardy. "Without substantial research the university might be tempted to buy-in teaching from one of the increasingly competitive 'remote' centres," she said.

Yeast Co. rise in profile

The international Backo Yeast Co., which holds patents on a number of key yeast gene products and processes, has announced backing for a major project by researchers in five EU countries with the aim of identifying molecular events within the cardiovascular system brought about by different exercise regimes.

This partnership, worth £10 million (ECU40m) over five years, is fuelled by recent success in cracking the genetic "postcodes" of cells that provide the vital address information for cells and thereby the pattern of gene activation.

"It now appears feasible to change that postcode and, using the extraordinary detailed knowledge of the genes involved in controlling the yeast cell cycle and division, which is proving a good model for other organisms, it may be possible to get a detailed picture of what is going on in a number of different cells and tissues," the project director said.

A spokesman for Backo said: "We are delighted to support this project as we have considerable in-house expertise in yeast genetics and the possibility of collaboration to understand details of basic human physiology would greatly enhance our public profile."

LAST WET BIOLOGY

The Imperial Cancer Research Fund has announced plans to cease all wet biology experiments at its London headquarters site.

The Fund, which has played a key role in molecular genetics, has decided that gene counselling support and public education will be the key activities, with further expansion of the Human Genome Epidemiology Study, the corporate plan for 2006 reveals.

Wet biology will cease by 2010 and essential experiments will be funded in universities or one of the small outpost laboratories, a spokesperson said.

NEWS IN BRIEF

Oriental links strengthened

The University of Oxford has announced new formal links with three Chinese universities which it hopes will strengthen research collaboration and increase the exchange of research and teaching staff. The new links, with Beijing, Shanghai, and Hong Kong, will give Oxford one of the strongest links of any Western university with the new Chinese universities.

Data talks extended

The Accra round of negotiations on licence rights for use of genetic information derived from indigenous species has stalled once again on a definition of "unit of genetic information". The long-running battle by Southern countries to cash in on the genes of many tropical plants and microorganisms has been thwarted again by lawyers representing Northern business interests challenging the basis of genetic uniqueness.

Curriculum review planned

Following the successful lobbying to get osteopathy, acupuncture and a number of other subjects included in EU undergraduate medical training, a full curriculum review is planned by a committee of the UK Royal College sector of the EU health and medicine directorate, DGIV.

Designer gym wear 'a success'

The commission of a series of gym and swim wear from a set of Europe's top fashion designers, funded by the UK association of medical and health charities, has been hugely successful, the association's secretary said. Sales of the designs, which were manufactured by a number of companies in partnership with the charities, have exceeded expectations and further similar initiatives may be planned, she said.

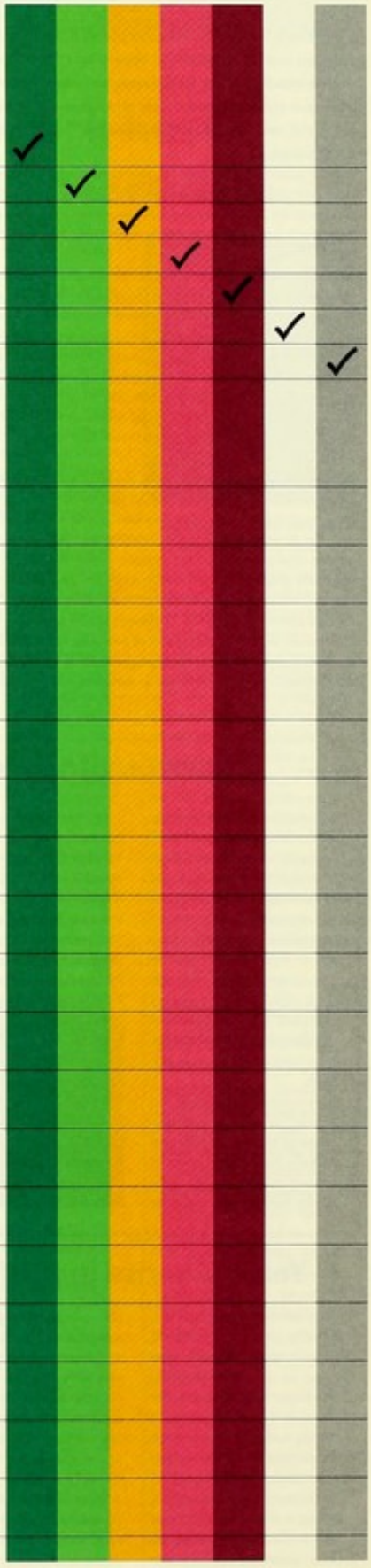
Yorkshire universities study Welsh system

A joint committee of the Yorkshire universities is studying the feasibility of a single, non-duplicating county university, on the Wales model, in an effort to cut teaching and research overhead costs.

Hospital tops audit league

The West Central Acute Centre in Shrewsbury has come top of the league in a basket of measures recorded by the NHS central audit team. The measures focus on patient throughput, costings and patient questionnaire returns in an effort to monitor and compare centres. "Shrewsbury has done exceptionally well, the NHS audit minister said. Their less strong scoring in research deserves close scrutiny and may be a lesson to other centres," she said.

Colour sheet used in the second round of voting



I strongly agree ✓
I agree ✓
I neither agree nor disagree ✓
I disagree ✓
I strongly disagree ✓
I can't answer ✓
I won't answer ✓

Please give your view on the suggestions listed below for strengthening cardiovascular research

Scientific topics

1 Vascular endothelium
2 Molecular genetics of cardiovascular disease risks
3 Gene screening
4 Non-invasive detection of early disease
5 Atherogenesis
6 Physiology/Integrated biology
7 Myocardial function

Infrastructure

1 More long-term funding
2 Protection blue-skies research
3 Develop European collaborations
4 Develop 6–7 multi-disciplinary centres
5 Run multi-centre, topic-oriented programmes
6 Set up a Europe-wide database resource
7 Public relations training for scientists
8 Develop a cardiovascular research network
9 Program to strengthen cardiovascular physiology
10 Support development of diagnostic scanning techology

PRISM report no. 3

March 1995 – £10.00

Publication details:

Unit for Policy Research in Science and Medicine
210 Euston Road
London NW1 2BE

Tel: 0171 611 8888
Fax: 0171 611 8742

ISBN: 1 869835 45 X