The **Academy** *of*
Medical Sciences

Academic Medical Bacteriology in the 21st Century

July 2001

The Academy of Medical Sciences

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Summary and recommendations

The Council of the Academy of Medical Sciences set up a working group in 1999 to undertake an inquiry into academic bacteriology. The Academy wished to see academic bacteriology in the UK develop as a research discipline and to encourage departments of medical microbiology to become involved in addressing the many exciting challenges facing the discipline.

This report sets out the working group's findings and makes recommendations for action. The report was endorsed by the Council of the Academy of Medical Sciences at its meeting in June 2001.

The group took evidence in person from opinion leaders and from clinical microbiologists in training. In February 2001 the group circulated a discussion paper for consultation to all university faculty deans in medicine, dentistry and veterinary medicine and to heads of university medical microbiology and other relevant departments.

The main findings of this inquiry are:

- There remain major problems with the diagnosis, treatment, and prevention of infectious disease with clinical relevance for the UK and elsewhere
- Bacteriology research has undergone a major transformation over the last decade with many exciting new technical developments and the introduction of genome-based approaches
- These new approaches have made the study of bacterial pathogens and infection a vibrant and exciting discipline, with great clinical relevance, but medical microbiology departments in the UK, with a few exceptions, are in a state of torpor and are not able to meet the challenges and excitement of the discipline.

Several key areas have been identified where action can help remedy the current situation. The key areas are:

- Undergraduate education
- Joint specialty training
- Funding initiatives
- Involvement of industry
- Centres of excellence
- Clinical scientists
- The Public Health Laboratory Service
- Microbiological societies and associations.

Recommendations for action

Undergraduate education

Bacteriology as part of medical microbiology is no longer taught as a separate discipline. The Academy believes that it is necessary to continue to teach bacteriology and infection in an integrated manner as a vibrant and important aspect of medicine and veterinary science.

The Academy recommends that:

- every undergraduate medical, dental and veterinary curriculum should continue to include learning about micro-organisms and their effects on people and animals
- emphasis in teaching should be given to modern aspects of bacteriology that, for example, emphasise the relationships between pathogens and the host response
- maximum effort should be put into developing and encouraging the uptake of intercalated BSc courses, as well as other forms of in-depth study, and opportunities for students to participate in high quality bacteriology and infection research
- deans of faculties should be asked to evaluate critically the learning opportunities in modern approaches to microbiology and infection (including bacteriology) available to their students.

Joint specialty training

The Academy believes joint specialty training in microbiology and infectious disease will become the norm and recommends that the RCPath/RCP joint training committee in microbiology and infectious diseases should

- keep its training requirements as flexible as possible
- evaluate the success of joint training, particularly in terms of the length of training, the academic achievements of trainees and their career outcomes

- seek ways to promote the academic component and research opportunities available during the training period
- publish its findings.

The Academy recommends that appropriate royal college and faculty committees consider how joint training in microbiology (or infectious disease) and public health medicine can be taken forward.

Funding initiatives

There is no shortage of research funding for internationally competitive research into modern bacteriology. The Academy recommends that the Wellcome Trust, Medical Research Council and other major funders consider new ways in which they can help to support the resurgence of academic medical bacteriology in the UK as an internationally competitive discipline.

The Academy recommends that the opportunities afforded by its own tenure-track clinician scientist scheme should be made widely known within academic medical bacteriology.

Involvement of industry

The Academy believes that industry can play an important part in providing research training opportunities.

The Academy recommends that the research training opportunities in vibrant areas of microbiology and infection, for example, cellular microbiology, vaccinology and genomics, afforded by pharmaceutical and biotechnology companies in the UK and abroad should be explored further. Heads of the proposed centres of excellence may be in the best position to seek out these opportunities.

Centres of excellence

Effective research in bacteriology requires integration of classical microbiology techniques with modern cellular and molecular biology.

The Academy recommends that there should be an effort to establish a small number of UK 'centres of excellence' in microbiology and infection with multidisciplinary teams comprising basic and clinical bacteriology researchers working with cell biologists, immunologists and epidemiologists and infectious disease clinicians.

The Academy recommends that the concept of 'centres of excellence' in microbiology and infection should extend, where appropriate, to high quality multidisciplinary research in mycology or virology and might in some cases extend to veterinary microbiology or parasitology.

The Academy recommends that, where local circumstances are favourable, the disciplines of clinical microbiology and infectious disease should be merged to strengthen the clinical research base.

The Academy recommends that universities and their medical, dental and veterinary schools make a commitment to support and underpin initiatives that bring first rate laboratory scientists and clinical academics together within 'centres of excellence'.

The Academy recommends that the research and teaching expertise available in the new centres should be made available through outreach arrangements to other hospitals and their laboratories. Their staff and students should be encouraged and supported to undertake their own research and collaborative research with the centres.

Clinical scientists

The Academy considers that the career structure of clinical scientists has been weak in the past and is still not optimally organised.

The Academy recommends that more attention needs to be paid to ensuring a career structure and succession planning for clinical scientists, particularly for some of the nationally essential but almost single-handed posts.

The Academy recommends that appropriate training programmes are established for NHS and PHLS clinical scientists linked to the centres of excellence and reference laboratories.

The Public Health Laboratory Service

The PHLS is a major player in medical microbiology in the England and Wales and any recommendations

for change must include this organisation.

The Academy recommends that, where possible, future PHLS reference laboratories outside Colindale should be within a centre of excellence in microbiology/infectious disease.

Should there be any change in the location of PHLS peripheral laboratories in England and Wales, the Academy recommends that these laboratories should be located within strong academic environments and, if possible, within centres of excellence.

The Academy further recommends that the Scottish Executive Health Department should consider, where appropriate, following similar policies with regard to its reference laboratories and specialist services.

The Academy recommends that the Northern Ireland Department of Health, Social Services and Public Safety should consider adopting similar policies. The Academy recommends that there should be close links between the Northern Ireland Public Health Laboratory and the academic activities at the Queen's University, Belfast.

The PHLS has already funded chairs within university clinical microbiology departments and the Academy recommends that the PHLS might consider further developing links with academic research in universities and medical schools through funding posts within centres of excellence.

Microbiological societies and associations

The Academy sees no advantage in the proliferation of societies covering medical microbiology and infectious disease and would welcome greater unity. It welcomes the formation of the clinical microbiology group within the Society for General Microbiology as this society has the greatest potential for providing a major meeting place for clinically-qualified and basic microbiologists.

The Academy recommends that all the microbiology societies and associations dedicate themselves to organising meetings with the strongest possible scientific content that will attract colleagues from Europe and North America and provide UK trainees with opportunities to hear presentations and discussions of the very best, internationally competitive, scientific work.

Section One - *Scope of the inquiry and method of working*

1 The Council of the Academy of Medical Sciences convened a working group in 1999 to undertake an inquiry into academic bacteriology. A number of key issues had been identified by the Academy, which were suggested as a basis of the working group's initial discussions. The Academy felt that a number of factors may be holding back the development of academic bacteriology including:

- A weak academic base overall
- Inadequate or insufficient opportunities for undergraduates to learn about the exciting challenges facing microbiology
- An image of medical microbiology that does not encourage academic high flyers to enter and stay in the discipline
- Lack of centres of excellence where people can be trained in modern approaches to molecular microbiology applied to pathogens
- Difficulties faced by departments who wish to develop a research programme
- Problems that arise at the interface between training in microbiology and infectious diseases.

2 The Academy wished to see academic bacteriology in the UK develop as a research discipline and to encourage departments of medical microbiology to become involved in addressing the many exciting challenges that were being faced.

3 The members of the working group are:

Professor Brian Spratt (chairman of the working group), *Professor of Molecular Microbiology and Wellcome Trust Principal Research Fellow,* Imperial College, London

Dr Derrick Crook, *Consultant Microbiologist and Infectious Diseases Physician,* Oxford Radcliffe NHS Trust and University of Oxford

Professor Brian Duerden, *Professor of Medical Microbiology,* University of Wales College of Medicine, Cardiff, and Deputy Director of Service and Medical Director, PHLS

Professor George Griffin, *Professor of Infectious Diseases and Medicine,* Head of Department of Infectious Diseases, St George's Hospital Medical School, London

Professor Tony Hart, *Professor of Medical Microbiology and Genito-Urinary Medicine,* Medical School, University of Liverpool, Honorary Consultant Microbiologist to the Royal Liverpool and Royal Liverpool Children's Hospital Trusts

Professor Peter Lachmann, *President,* Academy of Medical Sciences

Professor Duncan Maskell, *Marks and Spencer Professor of Farm Animal Health,* Department of Clinical Veterinary Medicine, University of Cambridge

Professor Noreen Murray, *Professor of Molecular Genetics,* Institute of Cell and Molecular Biology, University of Edinburgh

Professor Hugh Pennington, *Professor of Bacteriology,* Department of Medical Microbiology, University of Aberdeen

Dr Richard Slack, *Senior Lecturer in Microbiology,* University of Nottingham, Consultant in Communicable Diseases Control, Nottingham Health Authority

Professor Douglas Young, *Fleming Professor of Medical Microbiology,* Imperial College, London

Dr Jolyon Oxley, *secretary of the group and report editor*

Method of working

4 The group held eight meetings. It took evidence from opinion leaders and from clinical microbiologists in training, and those who have recently completed their training (see Annex 1). A themes and issues paper was developed meeting by meeting, reflecting the opinions expressed by the experts and the group's discussion of their evidence. Participants validated their contributions to the paper.

5 In February 2001 the group circulated a discussion paper for consultation to all university faculty deans in medicine, dentistry and veterinary medicine and to heads of university medical microbiology and other relevant departments. A summary of the replies is given in Annex 2. The group sent the discussion paper for information to the UK Chief Medical Officers, the government's Chief Scientific Advisors, the Director of Research and Development at the Department of Health and to the presidents of the Royal College of Physicians, London and Royal College of Pathologists.

6 The group also circulated a proforma asking for data from heads of departments on research inputs and outputs. It also contacted the major funders of research including the Medical Research Council (MRC), the Wellcome Trust, the Biotechnology and Biological Sciences Research Council (BBSRC) and the Association of Medical Research Charities, asking for information about funding of bacteriology research in the UK. The group also made inquiries about the findings of the last Research Assessment Exercise (RAE).

7 The working group presented its report to the Council of the Academy of Medical Sciences in June 2001. The Council endorsed the findings and recommendations.

How this report is structured

8 The main body of this document comprises the report submitted by the working group to the Council of the Academy of Medical Sciences. The next section sets out the current challenges and opportunities in bacteriology in terms of the public health need and the excitement in bacterial research. Section 3 highlights in contrast the current situation in medical bacteriology in the UK. Section 4 draws attention to the many problems facing academic medical bacteriology and makes recommendations for action in key areas. The three annexes give details of the experts who gave evidence in person, provide a summary of the responses to the consultation and give further details of the careers of clinical scientists.

Section Two - *Challenges and opportunities*

The public health need

9 The major successes of the last century in the prevention and treatment of bacterial infection encouraged a belief that the essential problems had been solved and that infectious disease would largely be eliminated as a public health problem.

10 It is now widely appreciated that this optimism was misplaced. There is a long list of items of unfinished bacteriological business with clinical relevance in the UK and elsewhere. Familiar pathogens like *Mycobacterium tuberculosis* have not gone away, recent outbreaks showing how little we know about the routes of spread of the organism globally or even within the UK. New pathogens like *Escherichia coli* O157:H7 appear without warning and highlight the danger of spread of disease between farm animals and human populations. The development of multiple antibiotic resistance has transformed relatively benign infections into life-threatening diseases, particularly in the context of hospital acquired infections. Microbiological food poisoning has been unequivocally identified as a growing public health problem. Many of these issues have been the subject of investigations by parliamentary select committees and government audit bodies that have published critical reports[1].

11 The routine laboratory diagnosis of infections also requires new approaches. The commonest single outcome of microbiological investigation of cases of gastrointestinal infectious disease and community-acquired pneumonia is the failure to find a pathogen.

12 By themselves these represent exciting scientific challenges for medicine; and it is certain that research into these problems will bring major health improvements to benefit us all. There is concern, however, that academic medical micro biology departments in the UK, with a few exceptions, are not meeting these challenges.

Current excitement in bacterial research

13 Bacteriology research has undergone a major transformation over the last decade with the introduction of genome-based technologies. Traditional approaches to the study of bacterial pathogens relying exclusively on *in vitro* cultures have been superseded by molecular genetic techniques that allow fundamental insights into the mechanisms of disease. The complete genome sequences of all the major bacterial pathogens are now available, or will shortly be available, together with an increasing armoury of methods for understanding the function and expression of novel genes. Molecular genetic tools offer the potential for the development of more sensitive diagnostic tests and better ways of tracking the spread of micro-organisms. These can provide an accurate understanding of disease transmission that is essential for rational infection control.

14 It is now clear that the transfer of genes between different bacteria has been much more extensive during evolution than was previously believed, with virulence genes, and genes involved in antibiotic resistance, shared widely among unrelated species. In many cases these acquisitions were probably responsible for converting isolates of previously harmless species into pathogens with enhanced virulence or the ability to colonise new ecological niches. There is also a growing awareness of the amount of diversity within a single species. For example, analysis of the genome of *E. coli* O157:H7, responsible for a series of recent fatal food poisoning outbreaks, has shown that over 1300 of its genes are absent from the genome of the *E. coli* K12 laboratory strain[2]. These findings generate a very different perspective on the population and evolutionary biology of bacterial pathogens. This perspective is crucial to our understanding of why bacteria have been so successful in combating the introduction of antibiotics and in planning how we should move forward in the continuing battle against infectious diseases.

15 The ability to alter the genetic makeup of bacteria in the laboratory has been a key factor in allowing us to understand the nature of microbial diseases. By deleting particular genetic loci or by moving

them between bacteria, it has been possible to identify the molecules that mediate the interactions between bacteria and host cells that are ultimately responsible for the signs and symptoms of disease. Genetic approaches have allowed researchers to progress from studying bacteria growing in test tubes or on agar plates to a direct analysis of their behaviour in cell culture and experimental animals. Such studies have uncovered a highly complex series of interactions often involving sophisticated adaptive responses on the part of both host and pathogen.

16 With increasing knowledge of these processes, it is possible to uncover novel strategies to prevent and treat disease. Whereas most current antibiotics simply kill or inhibit the growth of bacteria without affecting the host, it is now possible to envisage new classes of drugs designed to block specific steps in the disease process. Knowledge of the evolutionary forces that have limited the effectiveness of current drugs can be used to ensure that new antibiotics are targeted in a way that minimises the development of resistance.

17 Similarly, increased knowledge of the extent and origins of the diversity within bacterial species aids the design of vaccines against antigenically-variable pathogens. Traditional vaccines have comprised killed whole bacterial cells, sub-units of those bacteria, inactivated toxins, or spontaneously attenuated live bacteria. These have been successful in controlling many infections but there is considerable scope for improvement. The ability to clone the genes encoding those antigens of a pathogen that can provide protection against disease, and the ability to generate mutants of pathogens that lack specific genes allow the generation of a wide range of new vaccine candidates. New vaccines that can be given orally and which provide protection against additional diseases are two examples of where developments are needed.

18 In addition to contributing to the rational design of new drugs and vaccines, understanding the molecular basis of bacterial infections provides fundamental insights into human biology. The immune system has evolved primarily to deal with the threat of infection. Understanding the selective pressures that have shaped this evolution, and the mechanisms by which pathogens evade or interfere with the response, will undoubtedly help us design strategies to combat autoimmune diseases and harness the power of the immune system in the fight against infection and cancer.

19 Exploitation of the exciting opportunities offered by the genomics revolution will depend on a new generation of bacteriology researchers, with technical expertise and scientific perspective driven by the insights from modern molecular genetics, evolutionary, population and cellular biology. The impact of genomics on research in academic, clinical and diagnostic microbiology will be profound.

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2. Perna et al. 2001 Nature. 2001.409:529-533

Section Three - *The current situation in the UK*

20 In striking contrast to the magnitude of the threat to human health, and the exciting research opportunities outlined in the previous section, the group has been told by almost all the experts it consulted that academic medical (and veterinary) bacteriology is in a state of torpor in the UK. There are a number of strong UK groups who work with bacterial pathogens but these are typically not within medical microbiology departments and are mostly outside medical schools or hospitals.

21 This is shown by the following observations, given to the group in evidence:

a) persistent problems have been encountered in identifying medical bacteriologists with international research reputations as candidates for departmental chairs of medical microbiology

b) funding applications to research councils and the Wellcome Trust from academic medical bacteriologists within medical microbiology departments are largely uncompetitive in peer-review; specific calls for proposals by the Wellcome Trust and the MRC elicited only very few high-quality responses

c) undergraduate medical students rank microbiology among the least attractive career options

d) university departments with historically strong programmes in bacteriology research are suffering from decline, with a limited intake of top students

e) major pharmaceutical companies have relocated their bacteriology research programmes outside the UK.

22 The disappointing status of medical bacteriology in the UK is further highlighted by the contrasting vibrancy of bacteriology research in the USA. Among the European countries, France has a particularly strong molecular bacteriology research programme, based primarily at the Pasteur Institute.

23 In an attempt to describe the performance of UK medical microbiology departments more accurately, the group sent a proforma to all heads of medical microbiology departments in the UK. It requested data on research inputs and outputs, in terms of grant income received from all funders, personnel in the department and numbers of publications over the last five years. The data returned were incomplete. Sixteen responses were received. In medical schools the number of staff (medical and science) on HEFCE contracts ranged from 2 to 19 with most having 5 to 8 staff members. In non-medical school or hospital attached departments, the numbers were much smaller. All but one of the medical school departments had a per capita income of over £100,000 for the five-year period (range £75.7k - £823k). Two departments had no Research Council funding and three had no Wellcome Trust funding. For 4 of the 11 medical school departments over 10 per cent of their research income came from industry (range 12-25 per cent). For the non-medical school departments, industrial support played a major role.

24 All but two departments had published ten or more full papers per member of academic staff (mean 17.8, range 2.4 - 29) over the five year period. The non-medical school departments produced close to the mean output for the medical school departments. One medical school department trained no MPhil/PhD students; for the rest the numbers ranged from 3 to 27 for PhD, and 1 to 6 for MPhil. The number of medically trained candidates obtaining MD degrees was much smaller (range 0 - 7), with none from 3 of the medical school departments. All departments reported one or more of their staff giving input to governmental, Research Council or learned study committees.

25 The group concluded it is clear that some departments are performing well and others not. Unfortunately there is no way to determine how well this compares to other disciplines.

Barriers

26 In reviewing this alarming situation and with the help of the expert evidence, the working group has identified a series of barriers that contributes

to the absence of an effective culture of academic medical bacteriology research in the UK.

a) the low prestige afforded to medical microbiology over several decades has resulted in a lack of inspiring individuals with international reputations at the top of the profession capable of acting as role models for new students and young doctors, dentists and veterinary surgeons.

b) requirements imposed by various regulatory bodies have resulted in a prolonged training period for medically qualified and basic scientists aspiring to a career in medical microbiology research; this problem is exacerbated by the limited number of positions available for physicians trained in infectious disease.

c) priorities in NHS funding have resulted in a very heavy service load for medical microbiologists, leaving little or no time for research.

d) failure to integrate the activities of basic and medically qualified scientists has restricted opportunities to move new research ideas forward into the clinical domain; this lack of cohesion is exemplified by the proliferation of professional societies representing UK microbiologists, in contrast to the single American Society for Microbiology (ASM).

e) the reduction of job opportunities in the pharmaceutical industry has diminished the attraction of microbiology as a career path for basic scientists.

27 Despite the unique advantages that a service role gives for applying modern laboratory methods to the study of bacteria and the way they interact with patients, departments of medical microbiology are failing to provide the lead role in developing and introducing major innovations into everyday clinical practice. Patients and the NHS are ultimately the losers.

Section Four - *Problems and solutions*

28 This section discusses further some of the problems that the group has identified. The group believes that these have led to the decline of some aspects of bacteriology in the UK as an internationally competitive research discipline, particularly in medical and veterinary bacteriology. If they are not tackled this decline will continue. The group puts forward some recommendations to remedy the current situation.

29 The first part of this section deals with problems facing medical students and doctors. Later parts cover the need for a multidisciplinary approach to modern bacteriology research, the development of centres of excellence, the career development of clinical scientists - people who have achieved a scientific rather than a medical training but who work in medical environments, the important role of the PHLS and the microbiological societies and associations. The working group proposes solutions to the problems identified.

Developments in medical education

30 Bacteriology, as part of microbiology, has traditionally been an important part of the undergraduate medical, dental and veterinary curricula. In most medical schools the microbial part of the course was taught by members of the microbiology department and tended to be classical bacteriology and virology. The way that microbes affect patients was taught as part of the clinical course and it featured in teaching about diseases affecting most organ systems. Although the separation of the basic science from clinical aspects was thought to be unsatisfactory, at least all students had a good grounding in bacteriology and some were enthused to return to it at a later time as part of an academic career.

31 Undergraduate curricula are now mostly based around the study of organ systems and their diseases, or adopt a problem-based learning approach. As a result, the teaching of microbiology and microbial diseases has become highly fragmented. At a time when there is huge progress in our understanding of many aspects of pathogenesis, epidemiology and disease control, and at a time when problems with infectious diseases remain so evident, bacteriology has almost disappeared as an identifiably separate discipline as far as students are concerned.

32 The group has concluded that many students are being denied educational opportunities in one of the most exciting and rapidly moving areas in medical and veterinary science. The working group feels very strongly that the quality of teaching and course structure is fundamental to stimulating undergraduates and instilling the concept of microbiology and infectious diseases as vibrant growing disciplines. An integrated rather than a fragmented approach is required.

33 To address, at least in part, the current shortcomings in undergraduate education, the group considers that intercalated BSc courses should be promoted as a good way of enthusing some students about bacteriology. However, their lack of previous exposure to the subject in any depth and the small number of students likely to take up this option are considerable drawbacks to the longer term resurgence of academic medical bacteriology.

The group therefore recommends that:

- **every undergraduate medical, dental and veterinary curriculum should continue to include learning about micro-organisms and their effects on people and animals**
- **emphasis in teaching should be given to modern aspects of bacteriology that, for example, emphasise the relationships between pathogens and the host response**
- **maximum effort should be put into developing and encouraging the uptake of intercalated BSc courses, as well as other forms of in-depth study, and opportunities for students to participate in high quality bacteriology and infection research**
- **deans of faculties should be asked to evaluate critically the learning opportunities in modern approaches to microbiology and infection (including bacteriology) available to their students.**

Developments in postgraduate medical training

34 Postgraduate clinical training in microbiology has recently undergone important changes in line with other clinical disciplines. Briefly, the five-year higher training curriculum in medical microbiology was put forward by the Royal College of Pathologists and approved by the Specialist Training Authority (STA). Under the auspices of the postgraduate dean, local microbiology training committees organise rotations aimed at providing broad-based clinical training and delivering the agreed curriculum to appropriate standards. The training committees assess the specialist registrars (SpRs) annually through local and deanery assessment systems. Successful completion of the programme results in the recommendation for the award of a Certificate of Completion of Specialist Training (CCST) in medical microbiology by the Specialist Training Authority. This enables the successful doctor to be entered on the General Medical Council's specialist register.

35 There is an alternative way of being eligible for the specialist register - the academic exemption route. Doctors who have a strong academic track record in addition to sufficient clinical training (even though the requirements of specialist training have not been met in full) can be placed on the specialist register without having a CCST. Being on the specialist register is an absolute requirement for an NHS consultant appointment but many NHS trusts will not appoint unless the person holds a relevant CCST. The academic exemption route is not normally recommended as it may limit the doctor's career opportunities.

36 It is possible for SpRs to have time out of the training programme (out-of-programme experience) in order to carry out research towards a higher degree. However the full clinical curriculum of SpR training must be completed on return to the programme. Thus, in order to gain a CCST in microbiology and also carry out research to PhD level, a minimum of seven years is required. Additional research experience (the equivalent of post-doctoral experience for basic scientists) would further prolong the training period.

37 There has been a recent advance in training opportunities for microbiologists and infectious disease doctors in that the Royal College of Pathologists (RCPath) and the Royal College of Physicians (RCP) have approved a joint training scheme in medical microbiology and infectious diseases. In this six year scheme trainees are required to hold the MRCP(UK) at entry and during the training programme they must obtain the MRCPath examination. At the end of the programme a dual CCST in medical microbiology and infectious diseases will be awarded. Such a CCST will allow progression to either discipline or a fusion of disciplines as a career option. However since there are few centres approved for training in clinical infection the number of places where joint training can take place is limited (Bristol, Cambridge, Cardiff, Hammersmith/Imperial, Nottingham, Oxford, St. George's, Sheffield). In addition, while this scheme is clearly an excellent way forward it prolongs clinical training and the addition of research experience prolongs the whole training period even further.

38 Despite these concerns, the group strongly supports the move towards joint training in microbiology and infectious diseases and envisages that it will become the norm in due course. It is likely that this will lead to cohesion and fusion of these two disciplines, which the group also strongly supports. As, in general terms, academic clinical infectious diseases, despite its small size, is perceived as being strong both academically and clinically and academic medical microbiology is perceived as being weak, these developments should prove beneficial to academic medical bacteriology. However, because of its concern about the possible length of training that may be needed to meet both clinical and academic requirements, **the group recommends that the RCPath/RCP joint training committee in microbiology and infectious diseases should**

- **keep its training requirements as flexible as possible**
- **evaluate the success of joint training, particularly in terms of the length of training, the academic achievements of trainees and their career outcomes**
- **seek ways to promote the academic component and research opportunities available during the training period**
- **publish its findings.**

39 The group also sees considerable merit in increasing further the flexibility of training in the area of microbiology and infection to allow joint training in microbiology (or infectious disease) and public health medicine. **The group therefore recommends that appropriate royal college and faculty committees consider how this can be taken forward.**

Research training in medical microbiology

40 The group sought evidence on the success of an important initiative taken by the Wellcome Trust in 1994. In recognition of the poor state of academic medical bacteriology, the Trust introduced a special scheme that funded a number of medical microbiology fellowships, which were designed to improve the research experience of some medical microbiologists. The medical microbiology fellowships were intended to help a cadre of bright and motivated medical microbiologists undertake high quality research in important areas of, for example, molecular or cellular microbiology. The fellowships were designed primarily for clinically qualified microbiologists who had completed Part 1 of the MRCPath examination, although they were also open to individuals at a slightly more senior level. In 1995 the fellowships were made available to non-medical basic scientists committed to a career within a medical microbiology department.

41 The fellowships have provided excellent opportunities for a small number of young medical microbiologists to obtain research experience in leading laboratories, but the scheme has not been successful in alleviating the deep-seated problems of medical bacteriology. One initial problem, which was symptomatic of the lack of innovation and excellence in research within medical microbiology departments, was a lack of boldness in the applications. Candidates often proposed to work within their existing departments on projects that were not internationally competitive. Subsequently, the Wellcome Trust made clear to applicants that these fellowships should be taken up in the very best laboratories, which in most cases are outside the department in which they trained, and in many cases are in the USA. A representative of the Trust told the group 'From our experience, there has been consistently poor interest from the target group (junior clinicians); hence it is unlikely that a lack of research funding and training opportunities is holding back capacity in the field.'

42 The Wellcome Trust medical microbiology fellows themselves have also expressed substantial concerns. These include the difficulty in maintaining high quality research activity at the end of the fellowship, in building up a research group, and the lack of a clear career structure to help the best of the fellows to develop and become established as leaders of high quality independent research groups. These problems are not unique to medical microbiology but there is a clear gap between obtaining a PhD at the end of a fellowship and being competitive for an independent career development fellowship or a senior research fellowship. This problem does not arise to such an extent for basic scientists, who start their PhD at a much younger age, and can afford to undertake several years of further supervised research as a postdoctoral scientist, before applying for a lectureship or an independent research fellowship. Fellows who have been successful in the medical microbiology scheme are often at an advantage, in terms of research experience and high quality publications, compared to other medical microbiologists of their age. They may be offered senior academic positions in medical departments, including professorial appointments, that may involve them in much teaching and administration before they have become able to develop a strong body of independent original research. This rarely occurs in appointments to senior non-clinical faculty posts in strong research universities.

43 The group considered whether there should be a further scheme to allow the most talented of the medical microbiology fellows to carry out a further period of three to five year's full time research within a high quality research group. There may, however, be conflicts with time required to complete clinical training to obtain the CCST. This further research training could be designed to allow the fellows to develop their research independence and to build their own research group. After this further research experience they would be in a much stronger position to compete for senior research fellowships, or to maintain high quality research after taking senior academic positions. However, the group's discussions with the Wellcome Trust

indicated there is very little chance of a dedicated postdoctoral fellowship scheme for medical microbiologists. Indeed it seems likely that the present medical microbiology fellowship initiative will end. The group regrets that the Wellcome Trust medical microbiology fellowship scheme has not been more successful. It takes this as further evidence of the low state of the research base in medical bacteriology and microbiology.

44 The Medical Research Council does not offer any fellowships earmarked for clinical microbiologists. However they are eligible to apply in open competition for other MRC schemes, such as Clinical Training Fellowships, Career Development Awards and Senior Clinical Scientist Schemes. In recent years few appear to have been awarded to medical bacteriologists although some have been awarded to infectious disease clinicians. Recently the MRC has introduced a fellowship scheme specifically for joint infectious diseases/clinical microbiology trainees.

45 The group therefore recommends that the Wellcome Trust, Medical Research Council and other major funders consider new ways in which they can help to support the resurgence of academic medical bacteriology in the UK as an internationally competitive discipline. Such help might include medical fellowships at post-doctoral level in the proposed centres of excellence [see para 47]. However the longer-term solution is to improve the quality of research in clinical bacteriology overall. The group also recommends that the opportunities afforded by Academy's own tenure-track clinician scientist scheme[3], should be made widely known within academic medical bacteriology.

46 The group also took evidence from representatives of one major pharmaceutical company. It is likely that the move of the pharmaceutical industry's bacteriology research effort out of the UK is irreversible, at least in the short term. However, the group was pleased to note that industry is willing to co-operate with research training through appropriate rotations and that major pharmaceutical companies are likely to continue to work with specialised bio-technology companies in the UK which may also provide further research training and career opportunities. **The group therefore recommends that the research training opportunities in vibrant areas of microbiology and infection, for example, cellular microbiology, vaccinology and genomics, afforded by pharmaceutical and biotechnology companies in the UK and abroad should be explored further. Heads of the proposed centres of excellence may be in the best position to seek out these opportunities.**

The need for a multidisciplinary approach: the creation of centres of excellence

47 Effective research in bacteriology requires integration of classical microbiology techniques with modern molecular biology, including genomics and bio-informatics, population and evolutionary biology and cellular biology, within a clinical framework that extends from individual patients to epidemiology and health services research. Specialised departments restricted to bacteriology or medical microbiology are generally unable to provide the appropriate expertise and infrastructure for such research.

48 To become internationally competitive in this area, **the group recommends that there should be an effort to establish a small number of UK 'centres of excellence' in microbiology and infection with multidisciplinary teams comprising basic and clinical bacteriology researchers working with cell biologists, immunologists and epidemiologists and infectious disease clinicians.** Research quality is paramount if centres of excellence are to attract the very best researchers, particularly academic 'high-fliers' who are currently not attracted to work within a traditional department of medical microbiology.

49 The group was told that the problems in clinical virology and mycology are just as serious as those in bacteriology; therefore it recommends that the concept of 'centres of excellence' in microbiology

3. Academy of Medical Sciences. The tenure-track clinician scientist: a new career pathway to promote recruitment in clinical academic medicine. March 2000. http://www.acmedsci.ac.uk/Clinic.pdf

and infection is envisaged as extending, where appropriate, to high quality multidisciplinary research in mycology or virology and might in some cases extend to veterinary microbiology or parasitology.

50 In addition to their major research output, it is anticipated that the centres of excellence will provide a 'seed bed' for developing and training a new generation of researchers capable of establishing their own independent high quality research laboratories over the next decade. Universities, funding agencies and the PHLS should be encouraged to recognise and institute mechanisms for support of such mid-career individuals.

51 One of the key components of such centres is a coalescence of laboratory research scientists with clinically trained academics. The group considers that bringing these two types of investigator together creates synergy and a more powerful research platform than the sum of the separate parts. To achieve this, the working group envisages that other elements and characteristics of these centres would ideally include:

- a collaborative structure that draws together clinical and laboratory investigators
- a management structure based on innovative and dynamic leadership by a scientist or clinician, thereby ensuring the establishment of clear role models
- clinical laboratories that are juxtaposed with basic science laboratories
- academic clinicians, preferably jointly trained in infectious disease and clinical microbiology, carrying out research in medically-related areas alongside basic scientists and clinical researchers in related disciplines
- access to state-of-the-art equipment and associated technical expertise required for multidisciplinary research
- all researchers striving for the highest levels of excellence, undertaking exciting and innovative cutting edge research, probably in several areas, including as many of the following as possible - immunology, molecular and cellular microbiology, genomics and post genomics, bioinformatics, molecular epidemiology and public health, population and evolutionary biology and vaccinology
- a scheme within such a unit that provides rigorous research training for both scientists and clinicians
- scientists and clinicians with equal status, and terms and conditions of employment that ensure equity of pay for seniority and responsibility.

52 The group certainly does not envisage the proposed centres of excellence will represent the exclusive location for academic medical bacteriology in the UK. While providing a benchmark for quality research and a source of trained personnel, the centres of excellence would foster related activities in associated laboratories and departments by outreach and other mechanisms. Care must also be taken to ensure that the important service work carried out by medical microbiology departments is not prejudiced by the development of the new centres.

How to bring this model into being

53 The group considers that the historical separation between clinical microbiology and infectious diseases does not enhance the development of strong academic research in bacteriology. **The group therefore recommends that, where local circumstances are favourable, the disciplines of clinical microbiology and infectious disease should be merged to strengthen the clinical research base.**

54 Excellence in research often arises when talented and motivated individuals with similar interests, but complementary experience and skills, come together within the same research environment. As the group sees academic quality as paramount to re-vitalise academic medical bacteriology, it is envisaged that few institutions would be in a position to develop a centre of excellence without recruiting additional scientists of the highest international standing. Some vision is therefore required from heads of universities and medical schools to grasp the opportunities provided by the advances in microbiology and infection. They will need to invest in this exciting and crucial area, to

create the structures needed to bring groups together and establish a collaborative structure involving laboratory scientists and clinicians. **The group therefore recommends that universities and their medical, dental and veterinary schools make a commitment to support and underpin initiatives that bring laboratory scientists and clinical academics together.**

55 Concern was expressed in the responses to the paper for consultation (see Annex 2) that the creation of centres of excellence would exclude other researchers and make their work more difficult, partly because major funders will favour research carried out at the centres. The point was also made that students at universities that do not have a centre of excellence in bacteriology/ microbiology will be considerably disadvantaged. **The group therefore recommends that the research and teaching expertise available in the new centres should be made available through outreach arrangements to other hospitals and their laboratories. Their staff and students should be encouraged and supported to undertake their own research and collaborative research with the centres.**

The role of clinical scientists

56 'Clinical scientist' is an NHS term that describes scientists who work in clinical NHS laboratories but who are not medically qualified. They play an essential role in the delivery of clinical microbiology services in the NHS and Public Health Laboratory Service (PHLS) and in the research and development that underpins those services. Further details about their current career structure are given in Annex 3.

57 Evidence given to the group suggested that the career structure of clinical scientists has been weak in the past and is still not optimally organised. There are some Grade A posts with specific training programmes over three years, including an MSc course, but accreditation now requires at least five years and there is an expectation that it will be linked to the need for a PhD for progression to senior posts. Clinical scientists are at the interface of service provision and the research and development activities, particularly in reference laboratories, that are closely aligned with academic activity in medical school developments. **The group recommends that more attention needs to be paid to ensuring a career structure and succession planning, particularly for some of the nationally essential but almost single-handed posts.**

58 The importance of a multidisciplinary approach has been emphasised previously and clinical scientists are part of the necessary team whose recruitment and training in medical microbiology have suffered in a similar way to those of medical graduates. **The group recommends that appropriate training programmes are established for NHS and PHLS clinical scientists linked to the centres of excellence and reference laboratories.**

The role of the Public Health Laboratory Service

59 The PHLS is a major player in medical microbiology in the England and Wales and any recommendations for change must include this organisation. The group envisages that the PHLS, as a leader in public health epidemiology, would have a most important role in the proposed centres of excellence. The group understands that the future shape of the PHLS is likely to be considered as part of the Chief Medical Officer's communicable diseases' review. The group urges that the PHLS should be associated as far as possible with universities or medical schools with major strengths in modern microbiology and should participate fully in interdisciplinary collaboration. **The group recommends that, where possible, future PHLS reference laboratories outside Colindale should be within a centre of excellence in microbiology/infectious disease.**

60 Should there be any change in the location of PHLS peripheral laboratories, **the group recommends that these laboratories should be located within strong academic environments and, if possible, within centres of excellence.**

61 Arrangements are different in Scotland and Northern Ireland. **The group therefore recommends that the Scottish Executive Health Department should consider, where**

appropriate, following similar policies with regard to its reference laboratories and specialist services.

62 The Academy recommends that the Northern Ireland Department of Health, Social Services and Public Safety should consider adopting similar policies. The Academy recommends that there should be close links between the Northern Ireland Public Health Laboratory and the academic activities at the Queen's University, Belfast.

63 The PHLS has already funded chairs within university clinical microbiology departments and **the group recommends that the PHLS might consider further developing links with academic research in universities and medical schools through funding posts within centres of excellence.**

The microbiology societies and associations

64 In the UK there has historically been a split between the predominately 'scientific' societies such as the Society for General Microbiology (SGM) and Society of Applied Bacteriology (SAB) and the mainly 'medical' ones. Before the foundation of the Royal College of Pathologists laboratory-based clinicians with an interest in infection were either members of the Pathological Society of Great Britain and Ireland or the Association of Clinical Pathologists. Many medical microbiologists were unhappy with the perceived dominance of histopathologists both in the Royal College of Pathologists and other groups and so many specialist societies were founded in the 1970s and 1980s. These largely have a specific remit e.g. antibiotics - the British Society for Antimicrobial Chemotherapy (BSAC), and hospital infection - the Hospital Infection Society (HIS) etc. The Association of Medical Microbiologists (AMM) has a greater interest in fostering the interests of medically-qualified microbiologists including those in academic posts. Infectious disease physicians were usually members of the British Society for the Study of Infection (BSSI) which has joined with the Clinical Infection Society to form the British Infection Society (BIS).

65 There is much cross membership of these groups and it was felt that more joint meetings should be encouraged. This led to the foundation of the Federation of Infection Societies (FIS) which has run a successful annual meeting in Manchester for the past seven years but has been unable to capitalise on other joint ventures. The Microbiology Group in the Pathological Society has decided to merge with the Clinical Microbiology Interest Group in the SGM. The former Association of Professors of Medical Microbiology has re-emerged as the more broadly based Association of Academic Bacteriologists and Virologists.

66 The group regrets the continuing fragmentation of the microbiological societies and can see few advantages to academic medical bacteriology in there being so many different societies and associations. The group applauds efforts to bring about greater unity. In particular, the group notes and strongly supports the creation of a clinical microbiology interest group within the SGM and welcomes the broadening of the interests of this major society. The group considers that this is probably the only organisation in the UK that could take on the role that is played by the ASM in the USA of bringing together medical and non-medical microbiologists interested in infectious disease.

67 The group recommends that all the microbiology societies and associations dedicate themselves to organising meetings with a strong scientific content that will attract colleagues from Europe and North America and provide UK trainees with opportunities to hear presentations and discussions of the very best, internationally competitive scientific work.

Annex 1. Experts who gave evidence to the group in person

Prof Peter Borriello
Director
Central Public Health Laboratory, Colindale, London

Prof Sir Leszek Borysiewicz
Principal
Imperial College School of Medicine, London

Prof Anthony Coates
Chairman
Association of Academic Bacteriologists and Virologists
St George's Hospital Medical School, London

Prof Jonathan Cohen
Chair
Department of Infectious Diseases and Microbiology
Imperial College, London

Prof Mike Curtis
Professor of Microbiology
MRC Molecular Pathogenesis Group
Department of Microbiology
St Bartholomew's and the Royal London
School of Medicine and Dentistry, London

Prof Stephen Gillespie
Professor of Microbiology
Department of Medical Microbiology
Royal Free and University College Medical School
University College, London

Dr Peter Goodfellow
Senior Vice President
Discovery Research
GlaxoSmithKline

Dr Pat Goodwin
Scientific programme manager
Infection and Immunity
The Wellcome Trust, London

Prof Christopher Higgins
Director
MRC Clinical Sciences Centre
Imperial College School of Medicine, London

Prof Richard Moxon
Action Research Professor of Paediatrics
Department of Paediatrics
University of Oxford

Dr David Payne
Head of Microbial Genetics
GlaxoSmithKline, Collegeville, PA, USA

Prof Mark Pallen
Professor of Microbiology
Department of Microbiology & Immunology
Queen's University, Belfast

Dr Sharon Peacock
Lecturer
Medical Microbiology Department
University of Oxford

Dr Jim Poupard
Head, Microbiology Strategy
AMHD CDPS GlaxoSmithKline
Collegeville, PA, USA

Dr Nigel Saunders
Research Fellow
Dunn School of Pathology, University of Oxford

Dr Richard Slack
Chair
Association of Medical Microbiologists

Prof Lord Turnberg
Chair
Public Health Laboratory Service

Dr David Wareham
Specialist registrar
Department of Medical Microbiology
St Bartholomew's and the Royal London
School of Medicine and Dentistry, London

Dr Anne Wood
Scientific progamme officer
Infection and Immunity
The Wellcome Trust
London

A letter in evidence was received from Dr Peter Greenaway, Department of Health.

Annex 2. Summary of the responses to the January 2001 discussion paper for consultation Academic Bacteriology in the 21st Century

A discussion paper entitled *Academic Bacteriology in the 21st Century* was produced by the working group and distributed for consultation in January 2001. The group found it difficult to find objective and reliable data on the decline of medical academic bacteriology and so this discussion paper, based on evidence give in person by opinion leaders, was sent out for consultation to test the group's preliminary findings and conclusions. It was distributed as 'work in progress' and it was stressed that the views expressed did not represent the final views of the group or of the Academy of Medical Sciences.

The discussion paper was sent to heads of medical microbiology departments and deans of faculties of medicine, veterinary medicine and dentistry with a request that it should be forwarded to those involved with bacteriology research.

Respondents were asked to indicate whether they agreed or disagreed with the statements made, to make suggestions how to effect change and to give reasons for any disagreements. Respondents were also asked to indicate if there were any important areas not covered by the paper. A list of respondents to the consultation is given at the end of this summary. Heads of departments were also asked to complete and return a proforma showing their research input and output data.

The working group considered a full collation of the responses received by the closing date. The group found the responses to the discussion paper immensely helpful in preparing its final report. This summary of the responses, prepared by the working group secretary, was based on all the responses received.

General comments on the group's January 2001 discussion paper.

In general, this discussion paper was greatly welcomed and was found to be comprehensive:

> 'I consider this working paper to be an excellent summary of the problems confronting academic bacteriology and I am relieved that, at last, a distinguished body like the Academy has taken the initiative to try to do something about this very worrying state of affairs. I think that the document has identified the main problems and has proposed some eminently sensible suggestions for trying to rectify the situation.'

> 'Your excellent paper is very important and timely. I hope that it recognised as such.'
> 'This is a considered and balanced summary of the current situation and the conclusions are generally correct in terms of recognition of the foundation with which we are currently faced and the available solutions.'

Only one respondent was critical, calling the paper 'most disappointing', largely because it failed to take a robust stand on the differential salaries and pension arrangements for medically-qualified and basic microbiologists.

The main points from the respondents are summarised under the sections of the original paper. Not all respondents commented on each section; some referred directly to the paragraphs in the original paper but others did not. Most responses were from individuals; some indicated they had discussed the paper with colleagues. Four responses were submitted on behalf of an organisation or one of its committees - the Society for General Microbiology, the microbiology specialty advisory committee of the Royal College of Pathologists and the Association of Academic Clinical Bacteriologists and Virologists.

Many respondents referred to the scope of the inquiry, the title of the paper and the terminology employed. In making their comments, respondents raised important issues about the distinction between medical and other bacteriological disciplines and whether other microbiological disciplines, such as virology, should have been included in the inquiry.

For example one respondent wrote:

> 'The title has "bacteriology", the body of the text

"microbiology"; which is meant? What is the definition of "medical microbiologist"? This is totally unclear.'

Another wrote

' "Academic Bacteriology" is a misleading title. In some areas of bacteriology, particular environmental, the UK is strong. Since the main focus of the document is bacteriology related to human infection, "Academic Medical Bacteriology" might be a better title.

Others mentioned strengths in bacteriology outside medical bacteriology.

'Academic Microbiology and Bacteriology are practised in medical schools, dental schools, and veterinary colleges and also in non-clinical universities. I believe that the document is primarily referring to the parlous state of academic input in medical microbiology but it has not referred to or commented on the strength of microbiology in universities in general.'

'...bearing in mind that bacterial genetics is a vibrant and constantly evolving field, we are struck by the current strengths in bacterial molecular genetics and genomics in the UK, which, encouragingly, is spread over many university departments and institutes, reflecting the value placed on such studies by diverse academic institutions. It includes very strong groups using genetic approaches to understand and combat bacterial pathogenesis.'

'...in part it is the context of strength within "non-medical" bacteriology research, and research on pathogenic bacteria by non-medically qualified investigators that provides an environment that makes the prospect of building up this discipline a practical reality. "Academic bacteriology" is not in a "state of torpor in the UK" as stated in paragraph 4, medical bacteriology is.'

The need to look at all microbiology disciplines was emphasised by some respondents:

'The term "bacteriology" is increasingly used interchangeably with microbiology, and indeed throughout this paper the terms are switched. Academic microbiology should be seen as including mycology, parasitology and virology as well as bacteriology. In practice both the SGM and the ASM treat all these areas as part of "microbiology". The artificial distinctions between these disciplines serve only to hinder the under standing of microbiology and its role in the world of science. Similarly, such demarcations provide a barrier to integration of the Infectious Diseases community.'

It is unwise to look at bacteriology in isolation as other components such as virology, parasitology and mycology face similar problems. In many centres of excellence, these specialities have embraced the post-genomic era with enthusiasm. The multidisciplinary approach is essential as modern microbiology research tools transcend traditional boundaries.'

A dental respondent wrote:

' The paper is entitled Academic Bacteriology but refers mainly to medical microbiology. Most departments of med microbiology also handle fungal pathogens, such as candida and indeed this is a major area of research in many medical schools.'

And another respondent stated:

'We question the narrow remit of considering only Academic Bacteriology. It seems to be rather restrictive not to include viruses and fungi as well, as there are similar problems in these disciplines, and thus the report should be entitled "Academic Microbiology in the 21st Century"'

Two virologist respondents emphasised the current needs of this specialty, described by one as:

'a small specialty currently in crisis, paradoxically because of its success in embracing the revolution in molecular technology.'

The second virologist respondent wrote:

'the situation in academic clinical virology is if anything worse than in bacteriology.' and '.... the solutions recommended by your paper to the problems faced by academic clinical bacteriology are apposite to academic clinical virology. In particular, the concentration of clinical academics and basic scientists in centres of excellence would be very welcome.'

An epidemiologist referring to the creation of centres of excellence commented:

'Although the intention is to strengthen bacteriology it would seem counter-productive to

exclude virology from the range of disciplines covered by centres of excellence for the following reasons: - Virology has a comparatively strong research base and distancing bacteriologists from virologists may serve to further weaken academic structures; many of the molecular techniques used to study bacteria and viruses are similar; when patients present clinically it may be unclear whether they have bacterial or viral infection therefore clinical research needs to encompass both possibilities; the skills of infectious disease epidemiologists, economists and others can equally well be applied to viruses as to bacteria.

The first virologist, however, concluded that:

'traditionally, virology has been considered along with medical microbiology but, in my view, is better handled as a distinct specialty.'

Both virologists provided data about the decline in the discipline, particularly in academic clinical virology.

Detailed comments on the discussion paper

The text of the original discussion paper is presented in text boxes under its original headings and with the original paragraph numbering. A summary of the comments on each section follows.

Extract from the January 2001 discussion paper

Opportunities

1 It is now widely recognised that the predicted conquest of microbial infection following the introduction of antibiotics in the second half of the 20th century was overoptimistic and dangerously misleading. Common bacterial infections have returned in more virulent drug-resistant forms, and new pathogens have emerged to exploit environmental changes. Bacterial diseases account for a significant percentage of all deaths worldwide, and over 5,000 people died from hospital-acquired infections in the UK last year. There is an urgent need for new tools to combat the increasing public health risk posed by bacterial infections.

2 In parallel with these changing health priorities, the genomics revolution has opened a new era in microbiology research. Genome sequencing projects have generated an unprecedented flow of information about the fundamental structure and physiology of the major bacterial pathogens, high lighting novel drug targets and vaccine candidates. Powerful new genetic tools have allowed microbiologists to progress from studying bacteria in the test tube to a detailed molecular analysis of their interactions with mammalian cells during infection.

3 Modern molecular microbiology has the exciting potential of generating fundamental insights into host-pathogen biology whilst addressing a major public health need and benefiting patients.

Consultation responses

Overall support was expressed for these statements; for example:

'It is clearly the case that an unprecedented opportunity currently exists in this field. There are individuals with the experience and training to take advantage of these opportunities given the appropriate frameworks.'

'I agree wholeheartedly that there are opportunities for academic bacteriology, faced as we are with a myriad of public health issues that involve micro-organisms and infection risk thereof.'

Qualifying remarks included:

'Other areas (for example environmental microbiology) have developed important approaches and techniques that are not always appreciated in clinical microbiology.'

'broader academic microbiology departments produce most of the graduates who later move into medical (and veterinary!) microbiology, and some of the biggest ideas in host-pathogen relationships are coming not from microbiologists (who appear to be taking an increasingly reductionist approach to understanding disease) but from ecologists and evolutionary biologists.'

Another respondent did not support the emphasis given to genomics:

> 'this section is offering genomes and molecular biology as the answer to the public health risks posed by bacterial infection. This is clearly only part of the story. Increased understanding of epidemiology and health service organisational strategies will in the short term probably offer more. It needs to be recognised that in terms of improving public health, altering behaviour is likely to be just as powerful a tool as molecular biology.'

Another respondent stressed the role of epidemiology:

> 'In addition the important opportunities that are stressed in the paper we would also emphasise the following:
>
> - Investigation of the possible links between bacterial infections and chronic diseases
> - Redefining the basic epidemiology of common infections using population-based studies that utilise modern diagnostic and subtyping techniques
> - Evaluating how advances in prevention, diagnosis and treatment can be used to improve patient outcomes and to control infections.'

Current situation in the UK

4 In striking contrast to the magnitude of the threat to human health and these exciting research opportunities, academic bacteriology - with the exception of a handful of internationally competitive groups - is in a state of torpor in the UK. This is evidenced by a series of observations.

a) persistent problems have been encountered in identifying candidates for chairs of medical microbiology

b) funding applications from medical microbiology departments are largely uncompetitive in peer-review; specific calls for proposals by the Wellcome Trust and the MRC elicited only very few high-quality responses

c) undergraduate medical students rank microbiology among the least attractive career options

d) university departments with historically strong programmes in bacteriology research are suffering from decline, with a limited intake of top students

e) major pharmaceutical companies have relocated their bacteriology research programmes outside the UK.

5 The disappointing status of medical bacteriology in the UK is further highlighted by the contrasting vibrancy of bacteriology research in the US. Among the European countries, France has a particularly strong molecular microbiology research programme based primarily on activities at the Pasteur Institute.

Consultation responses

There was overall strong support for these statements:

> 'the academic disciplines of microbiology/ bacteriology relating to infection in the UK are in dire straits and have been so for some time. The deficiency is now particularly serious and visible given the immensity of the public health issues relating to infection (heightened awareness of the problem) and the extraordinary advances in scientific methodologies that make the prospect of progress in the control of infections at a global level so exciting and tractable.'

> 'For the past several months (too) much of my time has been spent trying to ensure the survival of Medical Microbiology ..... I therefore support everything that is stated in the paper, almost with out exception. Perhaps if anything I would have been even more critical of the current state of play.'

A similar view was expressed from a veterinary perspective:

> 'Academic veterinary bacteriology appears to have been in decline for many years despite the re-emergence of bovine tuberculosis and the increasingly high profile of zoonotic organisms such as campylobacter, verocytotoxigenic Escherichia coli (VTEC) and antimicrobial resistance.'

'If you think you have a problem in medicine, you should look at the situation with veterinary microbiology. Given how many public health issues currently involve zoonoses, the situation is quite scandalous.'

'Within the Veterinary sphere it has been difficult to attract the best bacteriologists, especially the molecular trained ones and offer them some lasting career structure. We have great difficulty in getting good quality PhD candidates as they do not perceive it as a worthwhile career area.'

Two respondents mentioned the long timescale of decline and recovery:

'The decline of academic clinical microbiology has occurred over a number of years and any upturn in fortune is not going to occur overnight.'

'The decline in academic excellence began in the 1970s and there are now very few capable individuals in the UK. It will be slow to reverse this decline and some investment is required.'

Only one respondent called for more evidence of the state of academic bacteriology:

'I suggest that more detailed evidence needs to be given. These are basically unsupported statements at present. Negative changes over time could be usefully documented.'

However another suggested as evidence:

'There can have been few times when top multidisciplinary journals such as Nature devoted so many column inches to microbiology. One can not escape the conclusion that this is one of the most exciting times for Microbiology. It is also apparent that the UK is being left behind in this new Microbiology.'

Explanations of the causes of the decline in the discipline varied and included comments on funding policies:

'.....though antibiotics increasingly fail to kill bacteria, they have effectively killed the profession of medical microbiology. Apart from the reasons outlined in the paper, a good deal of the blame lies with educational policies that have been pushed by the GMC. More emphasis is now placed on the teaching of social and psychological aspects than on the solid sciences. Under this pressure the teaching of medical microbiology is in retreat.'

'It is clear to me that for many years the Wellcome Trust or MRC were not interested in addressing the kind of research questions that are clinically important. In recent times, this has partly changed. However, clinical research is still somewhat underrated compared to basic science. The reasons for this have little to do with the excellence of proposals but more to do with the more difficult nature of patient based research.'

'an unhealthy degree of isolationism and factionalism in microbiology. Medical microbiology in many centres became an NHS-dominated subject with most emphasis on diagnostic microbiology and molecular typing whilst the quest for basic understanding of microbial pathogenicity declined. This was further exacerbated by apparent conflict within some parts of the NHS between Medical Microbiologists and those specialising in Infectious Disease. At the same time, there was separation between Pathology departments and Microbiology at a time when our understanding of mechanisms of microbial damage of human tissue could have been developing rapidly.'

Whether the decline is a result of, or has caused, a shortage of suitable qualified people was disputed:

'the alarming attrition of academic chairs through cost-savings and non-clinical appointments has been responsible for the very poor morale in many clinical academic units.'

'It seems to me that we are no longer in a position where we can appoint Chairs in Bacteriology because of the lack of suitably trained investigators. This is one of the many specialties in British medicine which has suffered badly from the lack of career structure for bright academics. I would certainly see the training of a new generation of research individuals as a prerequisite for the recovery, in five to ten years time, of British academic bacteriology.'

.

'I disagree that there is a shortage of people qualified to fill established Chairs; alternative explanations are that such qualified persons do not wish to apply, or, more likely, that there is overwhelming pressure from University administrators to transfer established Chairs from

> the relatively unglamorous discipline of Medical Microbiology (or similar) to high-profile (in the public eye) subjects such as Paediatric Oncology or Adolescent Psychiatry (to take two examples at random). I think the Committee would find if they looked that the numbers of promotions to Personal Chairs in Medical Microbiology (and similar) are running at an all time high; it can be argued that it is more difficult to gain such promotion than to acquire an established Chair.'

Four respondents mentioned the PHLS. All felt the PHLS had an important role to play:

> 'this organisation has been rather too inward looking and would do well to link in with Research Centres, say in the University Hospitals, or elsewhere, e.g. MRC, also encourage links with developing countries.'

> 'I have been impressed by the range and complexity of the work done in the PHLS reference laboratories, but disappointed that the work is not given more recognition and wider application. The laboratories are often inundated with 'reference' material, with insufficient supporting clinical information to allow this to be a resource for research. The PHLS (who, of course, have their own budgetary problems) should be part of the solution, but as an active, not passive, partner.'

The discussion paper's comment on the healthier situation to be found abroad was mentioned by several respondents:

> 'Some of this is unfair comparison, of course. I'm not sure that I would want to go too far down the road of centralization that gives undoubted critical mass to many continental and N American labs.'

> 'It is noticeable that my collaborators in the USA seem far better off than we are.'

> 'the links with immunology and cellular biology in Europe and USA which have led to productive research collaborations should be mentioned, i.e. justifying the need to foster multidisciplinary collaborative environments in the UK.'

One respondent who had worked at the Institut Pasteur commented:

> 'The Institut Pasteur is an interesting model, a self governing "private institution of recognised public utility" which has a variable amount of direct state funding, commercial income from patents and licences, research grants and charity money. They perform some functions belonging to the CPHL and CDSC in this country as well as basic research. They were relatively late into genome sequencing and have a much smaller unit than the Sanger pathogen sequencing unit. They do not award degrees and have no direct academic status (many people have chairs elsewhere). It would be good if UK politicians could be persuaded that this represented a third way to do research.'

The strengths of some UK-led research work abroad was highlighted by another respondent:

> 'The MRC in the Gambia is doing some first class research and the Tropical Medicine Department in Oxford is doing the same with links in various parts of the world, including the Far East (Vietnam and Thailand), parts of Sub-Saharan Africa, and I believe Latin America. Such opportunities would provide a spur to recruiting high quality trainees and encourage a broader perspective of microbiology than is usually the case in the UK.'

Barriers

6 In reviewing this alarming situation, the working group identified a series of barriers that contribute to the absence of an effective culture of academic bacteriology research in the UK.

a) the low prestige afforded to medical microbiology over several decades has resulted in a lack of inspiring individuals at the top of the profession capable of acting as role models for new students and young doctors, dentists and vets

b) requirements imposed by various professional bodies result in an inordinately prolonged training period for clinician scientists aspiring to a career in microbiology research; this problem is exacerbated by the limited number of positions available for physicians trained in infectious disease

c) priorities in NHS funding have resulted in a very heavy service load for medical microbiologists, leaving little or no time for research

d) failure to integrate the activities of basic and clinical scientists has restricted opportunities to move new research ideas forward into the clinical domain; this lack of cohesion is exemplified by the proliferation of professional societies representing UK microbiologists, in contrast to the single American Society for Microbiology

e) the reduction of job opportunities in the pharmaceutical industry has diminished the attraction of microbiology as a career path for basic scientists.

Consultation responses

One respondent suggested:

> 'As to the barriers to progress in the UK, we have witnessed a 'sea change' in how microbiology is perceived as a research discipline. Now micro-organisms are perceived as tools for molecular techniques and not as biological agents causing disease. This has meant the microbiology graduates have become molecular biologists and in that role have scooped resources from grant-awarding bodies. Research grant applications which do not have a 'molecular bias' are viewed unfavourably by funding bodies. Our universities have fostered this trend in their desire to gain maximal reward from successive RAEs.'

The role of the pharmaceutical industry was highlighted by two respondents:

> 'With the emergence of antibiotic resistance, pharmaceutical companies provided ready access to bacteriologists for 'research' money, together with support for attendance at meetings, which therefore decreased the need for colleagues to test their ideas through the peer-reviewed grant process. The pharmaceutical companies should now be part of the solution to current problems; for example, by entering into strategic partnerships with academic bacteriology centres to investigate novel gene loci with the ultimate objective of identifying novel anti-microbials.'

> 'Academic bacteriology, perhaps better referred to as medical microbiology, has suffered greatly in the UK because many of our senior clinical colleagues within the discipline (probably through a lack of central funding, and the relative ease of getting money from the major pharmaceuticals) have promoted little more than surveying resistance to antimicrobial agents (or MIC-ology) and perhaps a little diagnostic technology.'

Funding policies were cited:

> 'My personal bias to the reasons for lack of progress is the narrow attitude of only funding work of apparent "biomedical importance". Thus any organisms not directly exerting a disease burden are not fundable. This is of course turning our back on the vast majority of micro-organisms and indeed the largest potential reservoir of new drugs and antibiotics. It is also particularly striking in view of current initiatives in Biodiversity by several funding bodies. I would call for a broadening of funding attitudes from bodies in the UK, this would be a good start and could help the UK consolidate the strengths that we do have.'

'....some funding policies have played a role: essentially no funding for antimicrobial research, regarding it as best left to drug companies (this is not my field of research but I know colleagues that have struggled). Applications by medical microbiology departments in their own right can easily be made uncompetitive in peer review if the assessment criteria require extremely basic science (BBSRC/MRC/Wellcome) or extremely clinical patient based research (MRC/Wellcome).

To put it crudely - if you have the patient base you can recruit the scientists and if you have an excellent science base you can find clinical collaborators. Medical microbiologists tend to fall in the middle, with the success stories those who have a flair for collaboration as well as science.'

Other factors which act as barrier to progress suggested by respondents included:

'it is unlikely the current training programme for clinical microbiologists provide the appropriate knowledge of research base for them to indulge in cutting-edge research and subsequent career advancement in an academic environment. This, of course, stifles recruitment into academic microbiology no matter how 'inspiring' are the existing academic staff. This problem has also led to failure to integrate the activities of basic and clinical scientists.'

'epidemiologists and health services research scientists [whose activities] have not been well integrated with microbiology. This limits the public health relevance of research perhaps making it less attractive to research funders. Other barriers to the development of academic bacteriology may be that academic bacteriology has often been subsumed into larger academic medical departments. Also, the PHLS with its own vigorous research and training programme provides a secure career structure that may have an adverse impact on recruitment to research in university settings.'

Respondents' comments about the length of training, the proliferation of microbiological societies and issues about NHS workloads are covered later in this summary.

Solutions

7 To address the problems outlined above, the working group has made some preliminary recommendations for initiatives in the following areas.

Multidisciplinary teams

8 Effective research in bacteriology requires integration of classical microbiology techniques with modern molecular and cell biology within a clinical framework that extends from individual patients to epidemiology and health services research. Specialised departments restricted to bacteriology or medical microbiology are generally unable to provide the appropriate expertise and infrastructure for such research. To become internationally competitive in this area, it is recommended that there should be a focus on the establishment of a limited number of UK 'centres of excellence' in microbiology and infection with multidisciplinary teams comprising basic and clinical bacteriology researchers working with cell biologists, immunologists and epidemiologists.

A new generation of researchers

9 In addition to their major research output, it is anticipated that the centres of excellence will provide a 'seed bed' for developing and training a new generation of researchers capable of establishing their own independent high quality research laboratories over the next decade. Universities and funding agencies should be encouraged to recognise, and institute mechanisms for support of, such mid-career individuals.

Consultation responses

There were a large number of supportive responses to this section of the discussion paper that included proposals for the creation of centres of excellence and multidisciplinary teams. Some respondents felt that this was the only way forward and an inevitable development. Others warned about the

disadvantages of centres of excellence feeling that they are exclusive and harmful to those outside.

Supportive comments for centres of excellence included:

> 'I am in complete agreement with the proposal to create centres of excellence in the UK and would like to see one for the Veterinary area.'

> 'I strongly agree that high quality, world-class research is best performed in dedicated centres which adopt a multidisciplinary approach and that this requires expertise from a variety of backgrounds.'

> '[one of the keys to] progress lies in: Creation of several centres of excellence. It is imperative to identify and reinforce the existing strengths in the UK.'

> 'We agree that in order to be internationally competitive microbiology has to be carried out in "Centres of Excellence" with multidisciplinary teams.'

> 'I wholeheartedly support the importance of multidisciplinary teams, centres of excellence and strategic alliances to ensure that the most appropriate medical, veterinary and scientific expertise is brought together in a co-ordinated way to solve particular scientific problems.'

> 'We agree strongly with the proposal to establish multidisciplinary teams situated in a limited number of centres of excellence in microbiology. Such centres of excellence would be valuable training centres and raise the profile of veterinary public health to our veterinary students.'

Qualifiying comments included:

> 'The establishment of the centres of excellence which then feed out to the other academic institutions is a good strategy, however issues of flexibility of movement between clinical specialist training directorates will need to be addressed so that these opportunities are not restricted to a very small proportion of specialist trainees.'

> 'I do subscribe to the 'critical mass' view of research in which for work to progress you really need a critical mass of scientists. However, I am concerned that the proposed centres of excellence will act as draw for funds and the best microbiologists, leaving other institutions floundering.'

> 'We consider that "centres of excellence" are best arrived at by natural evolution rather than being contrived and such centres should not be at the expense of other clinical microbiologists who provide essential contributions to teaching and valuable contributions to research.'

Other respondents did not support the proposal for centres of excellence:

> 'Your recommendation that there should be a focus on the establishment of a limited number of U.K. centres of excellence in microbiology is not logical. Who will decide which centres of excellence are promoted, and what criteria will be used? The downstream consequence of this could be the obliteration of promising foci within universities that are not deemed to be centres of excellence. This would be counter-productive. A better approach might be for funding bodies and the Department to reward universities for identifying and encouraging multidisciplinary teams capable of internationally-competitive activity within the discipline of academic bacteriology.'

> 'I am depressed by the suggestions being made about centres of excellence. Experience shows that where they have been established they have only local effects. They have always been a self-fulfilling 'prophesy'. It would be no different for medical microbiology.'

> 'I am always concerned when I hear mention of 'a limited number of centres of excellence' when it comes to research. Research is for all and should not be the exclusive domain of a few larger centres. In my opinion, research is fundamental to the practice of medicine and not some luxury confined to only those who attract large grants. Research must be integrated with educational developments and professional advancement, and not just seen as a means to professional promotion. Yes, larger centres may co-ordinate research strategies, but to deprive others of developing ideas and trying to bring them to fruition, is a form of intellectual apartheid. I feel very strongly about this.'

> 'I have considerable doubts as to the "centres of excellence" approach. The problems of

bacteriology are not restricted to the clinically qualified but also occur among basic scientists.'

Most respondents supported the concept of multidisciplinary working very strongly. The link with centres of excellence was highlighted:

'The idea of establishing centres of excellence in microbiology and infection is potentially powerful mechanism for encouraging multidisciplinary working.'

'This multidisciplinary approach has been very successful in allowing us to attract grant funding and pursue a varied portfolio of activity around our main research themes. I, therefore, believe [this] section of the document is of paramount importance. The development of 'centres of excellence' is a good way of achieving this in a structured fashion, but much can be achieved locally in the shorter term through local contacts.'

Respondents added to the list of disciplines that should be included:

'The links with immunology and cellular biology in Europe and USA which have led to productive research collaborations should be mentioned, i.e. justifying the need to foster multidisciplinary collaborative environments in the UK.'

'Multidisciplinary teams and networks are clearly the way forward, they need to involve primary care academics, statisticians as well as those active in "health services" research.'

'We agree that multiple scientific disciplines can contribute to academic bacteriology, though this list should also include information technology, genomics, comparative genomics and proteomics. In fact, it is likely that many of the academic centres in the U.K. already have collaborating groups of apparently unrelated scientists that we would recognise as forming an interest group in academic bacteriology. Universities should be encouraged to bring together such individuals to form themes.'

'I firmly believe that the future of microbiology must be part of a multidisciplinary research environment. The post genomic era allows a dissection of mechanisms of pathogenicity from the perspective of both the micro-organism and the host. The best of the new generation of researchers will not be limited by the boundaries of the old. Although centres of excellence are needed, it must be in a framework of excellence in all areas of "pathology".'

'Please don't forget environmental and veterinary microbiologists in this, and note that ecologists have an almost parallel literature to that of epidemiologists, with little dialogue between the approaches!'

'and include mathematical modellers.'

One respondent suggested that the value of a multidisciplinary approach should not be taken as a given and requires more understanding:

'We agree absolutely with the need for much better multidisciplinary working but think that the document could be strengthened by expanding the explanation of the rationale for multidisciplinary teams. One could use the example of tackling antibiotic resistance as a paradigm for the multiple disciplines that are needed...'

Another warned about the costs:

'Point 8 is excellent and warrants support at both governmental and University level - but where is the money coming from to set things going? Organisations such as the PHLS should be included in such programmes.'

Several respondents gave details of the development of their own centres and multidisciplinary teams. One concluded:

'This is an exciting development that is already resulting in cross-fertilization, new ideas and collaborative research.'

Medical microbiology and infectious diseases

10 Individuals who would not be classified as 'medical microbiologists' currently carry out the majority of the top quality clinical microbiology research in academic institutions in the UK. In recognition of this fact, it is recommended that recruitment to medical microbiology appointments should be broadened to include applicants from alternative training programmes such as infectious diseases and to non-clinical molecular and cellular microbiologists.

Consultation responses

This section of the discussion paper stimulated comments on roles, responsibilities, training needs and career prospects of people both from medical and scientific backgrounds:

> 'I wholeheartedly subscribe to the view that academic microbiology should be a multidiscipline activity. Indeed as the document suggests a multidisciplinary approach is essential for the microbiological community to address the challenges of the future. With this in mind I feel that it is important to distinguish between medically qualified microbiologists and scientifically qualified microbiologists in terms of training. Their needs are different and nurturing of good candidates from each group presents different issues.'

> 'Recruitment of infectious diseases and non-clinical staff to posts previously occupied by medical microbiologists may be justifiable in terms of basic science research excellence but ignores the potential that academics have for providing leadership and innovation within the NHS through exemplar sites and training. Medical Microbiologists are best placed to do this as they are the most important group in this area.'

> 'As a non-clinical microbiologist I have some sympathy with the view that appointment panels should choose from a broad spectrum of candidates.'

One respondent warned about the effect of non-medical appointments on doctors:

> 'Non medical appointments to Chairs of Medical Microbiology are already fairly standard and offer a good way of reinforcing the basic science strengths of medical microbiology departments. It has to be recognised that a dilution of medically trained people in academic departments increases the teaching burden on medically qualified staff and some allowance has to be made for this.'

Referring to a point made earlier in the discussion paper, another respondent wrote:

> 'The suggestion that NHS pressures make life difficult for academic medical microbiologists is fatuous. I heard my colleagues say this for my 15 years in the Association of Professors of Medical Microbiology. They counted the number of specimens they had to test rather than the ideas they or their juniors had that might be worthy of grant support.'

The need to keep departments fully integrated was emphasised by another:

> 'I strongly support the concept of integrated academic and clinical departments. It is clear that trainees in microbiology must be exposed to an academic environment but conversely that non-clinical microbiologists benefit from the input of clinically related material.... The merger of medical schools has resulted in departments which are theoretically quite large and with a large service commitment. It would be difficult to see the benefits of removing the academic components from the service components in these instances.'

Others felt that responsibilities within departments had to be clearly defined:

> '[there is] a major contrasting difference between the UK and the successful centres described in the US and some strong European centres (as referred to in paragraph 5). Even good academic medical bacteriologists cannot do good work without a significant portion (or even all of) their time to invest in this area. In the US clinically

qualified individuals leading successful research programmes are frequently largely or completely freed from other responsibilities. This contrasts dramatically with the UK. The mixed activity clinician scientist is largely a mythological creature, in addition to the fact that clinical services are under staffed, it is increasingly the case that it is not possible to be a competitive international standing researcher and a highly contributing 'state of the art' clinician.'

As a solution, this respondent suggested:

'Where staffing will allow, some individuals manage the mixed activity and others are more suited to a predominantly or exclusive clinical or academic role. Asking each individual in a group to be a master of all trades is generally a mistake - the mixture within the groups is more realistically achieved by employing a group of individuals with mixed skills who interact and inter-relate.'

Three respondents mentioned additional barriers to successful integration:

'I would add one additional factor to the barriers identified in the report. Basic science training and research in microbiology is, in many places, of very high quality. Many of our most distinguished biochemists and cell biologists began as under graduate microbiology students. The high quality of basic science research in this subject is, I believe, inhibiting to medically-qualified individuals who might consider a career in this subject.'

'It is astonishing that the Report does not touch upon the matter of salaries and conditions of service in academic posts. This has a crucial bearing as to whether bright sparks decide to take up a certain career path.'

'It is easier and more rewarding both financially and personally for a clinically qualified microbiologist to work in the NHS. They will be eligible for a consultant contract long before they would be eligible for a comparable university post and have available a clear well understood training programme. There is little if any encouragement for the clinically qualified microbiologist to obtain research expertise outside service related areas e.g. antibiotic sensitivity. If a clinically qualified microbiologist undertakes research training it is likely to diminish their eligibility for clinical post and will at best delay a consultant appointment.'

The suggestion that heads of medical microbiology departments could be recruited from other medical disciplines such as infectious diseases drew one response:

'You have perhaps been less radical than was possible. I would suggest that we de-classify medical microbiologists and fuse this specialty with infectious diseases. This would be a controversial recommendation as there are considerable vested interests in maintaining the status quo. However, if we were to follow the American model of infectious diseases which incorporates some components of UK medical microbiology and some components of UK infectious diseases, I feel confident we would attract much higher quality graduates into training programmes and improve the quality of research, and be more able to compete with the Americans on their own terms.'

In contrast, another felt that medical microbiologists would continue to have their own role:

'In paragraph 10, the emphasis is on infectious disease clinicians, yet they will need a laboratory with a strong director able to maintain quality and meet the requirements of quality control, quality assurance and external accreditation. These components, traditionally provided by the MRCPath training programme, should be given more emphasis here. The broadening of criteria to include non-medical microbiologists is welcome, and could lead to the establishment of a small number of Centres of Excellence able to train the next generation of medically qualified microbiologists.'

Education, specialty training and career development

11 Ways need to be found of giving at least some medical, dental and veterinary students the opportunity to experience the excitement afforded by new challenges and techniques in bacteriology. The provision and uptake of intercalated BScs in bacteriology needs to be promoted.

12 The full benefits of the new Royal College joint training programmes in infectious diseases and microbiology have yet to be seen but the quality of candidates applying for these posts is high. It is important that the training arrangements remain as flexible as possible.

13 The career development pathways for clinical scientists wishing to work in medical microbiology should be reviewed and rationalised within the framework recommended by the Academy of Medical Sciences' report *The tenure-track clinician scientist: a new career pathway to promote recruitment into clinical academic medicine* (the Savill report).

Consultation responses

This section of the discussion paper included preliminary recommendations on both undergraduate education for medical, dental and veterinary students and postgraduate opportunities for registered practitioners and scientists. It stimulated many comments.

The importance of undergraduates learning about bacteriology was emphasised by one respondent:

> 'The two major dental diseases are caries and periodontal disease and both are caused by bacteria. It is essential that dental undergraduates have a thorough training in Microbiology with a particular emphasis on Oral Microbiology. To achieve this, every Dental School should have a dedicated teacher in this discipline that is based within the School as opposed to a Department of Medical Microbiology.'

Changes in the undergraduate curricula were criticised by several respondents:

> 'The ongoing revolution in the medical curriculum means that medical students will not rate microbiology as an unattractive option - they will simply be unaware that it exists as a specialty. Patient-centred learning effectively means that no teaching labelled pathology is left in any UK curriculum that I know of. This is a complete contrast to US medical curricula e.g. Harvard.'

> 'I am greatly concerned by the continuing erosion of microbiology teaching to undergraduate medical and dental students in the new style curricula. Not only does this mean that high calibre undergraduate students are not likely to be attracted to the discipline as a career, but also potentially reduces the ability of the next generation of clinicians to deal effectively with the huge problems currently posed by infection. In my view, infection should be regarded as a significant part of the core curriculum and not offered mainly as SSMs [special study modules].'

> '"Tomorrow's Doctors" and its implementation in different universities has affected the provision of teaching in medical microbiology. Infection is not now recognisable as medical microbiology and as such does not suggest future career opportunities.'

> 'Most vet students want to be practising clinicians and do not see bacteriology never mind research as an option. The modern clinical bacteriologist will have to have to be very well informed about molecular bacteriology and some emphasis on this at the teaching stage would be beneficial.'

Many respondents supported the wider uptake by students of intercalated BScs:

> 'I agree more intercalated BSc courses in bacteriology would provide a useful way in which academic practice could be promoted.'

> 'A Final Honours School (FHS) option in medical microbiology would I think be popular with the students and should be set up as a matter of high priority. Only through this route will we be able to excite the next potential generation of medical bacteriologists with our science, and attract them to build careers in this area.'

Such courses were not thought to be the whole answer or without problems:

> 'We agree that provision and uptake of intercalated BScs in bacteriology is one way of raising the profile of microbiology to students, but another way would be to encourage uptake of MD/Ph.D. programmes in infection/clinical microbiology. Also, you have probably noticed that undergraduate teaching in microbiology is in a very poor state of health, as our cohort of available teachers has been depleted by the need for the universities to compete effectively in the RAE.'

> 'Intercalated BScs require a large academic and financial commitment by students. Medical students are already the most in debt. Special study modules offer a means of introducing the subject to medical students without prolonging the course: ours has certainly been popular. Alternatively a truly modular American style medical degree with course credits would bring us a way back in.'

One respondent was doubtful about the attractiveness of a research career in veterinary medicine.

> 'The Selbourne report highlighted the lack of veterinary qualified researchers and suggested some solutions which have either failed to be implemented or are still to have an effect. I think it is unlikely that a career in research is any more attractive now than it was then.'

Most respondents who commented on postgraduate training supported the recent moves towards joint training in microbiology and infectious diseases:

> 'We need to develop more of these joint training programmes and indeed if my earlier point is to be taken up, we need to actually make this the standard training for infection specialists in the United Kingdom.'

> 'I warmly support the joint training programmes in infectious disease and microbiology that are under consideration and development. When I was an undergraduate, and early in my clinical career, the best medical microbiologists were those who understood the disease in the patient, as well as the organism in culture.'

> 'This initiative is now attracting some of the high flyers and hopefully will result in the production of future leaders in the profession which will include those with an interest and research back ground in Academic Bacteriology.'

One respondent said that its success should not be taken for granted:

> 'I support the initiative of establishing joint training programmes in microbiology and virology as an interesting experiment. However, the comments in paragraph 12 appear to assume that the programme will be successful, i.e. ' The full benefits .....'. While it is hoped that there will be benefits, this should not be assumed at this stage.'

Another warned:

> 'The Academy needs to take on board, ensuring that there are a sufficient number of senior posts available for such persons when they have completed their training.'

Not all respondents supported joint training unreservedly, one believed that it might harm academic bacteriology.

> 'This situation reflects the decline in academic training and the dominance of service related training. The move to a joint programme in Medical Microbiology and infectious diseases is another example of this. It might be remarked that at the time the greatest contribution of UK medical microbiologists to bacterial genetics there were no infectious disease physicians in the UK, it is in the US that that group contributed. I could continue to talk of the problems but the message is clear. More MSc level training is needed by both medical and non-medical microbiologist to enable the potential benefits of molecular biology to be realised.'

Respondents supported clearer career pathways for scientists and academic clinicians.

> 'The career pathway for clinical scientists needs to be more clearly defined and available. A massive expansion in the number of posts is necessary. Many individuals working in non-clinical academic departments are unaware of the role of the clinical scientist or the opportunities that exist.'

The problems of marrying clinical and academic

training and career development were particularly highlighted.

> 'The career pathway for budding academic clinical microbiologists is fraught with problems. The rationalisation described in Section 13 of the document should, in my view, be seen as a priority, if the discipline is to be re-built.'

> 'My former students include a number of those who have been appointed to chairs in medical microbiology and infectious disease and to PHLS directorships and I am aware of the problems they have faced in following this path.'

> 'Training in medical microbiology now takes five years, this is much shorter than previously. The compression of training however has made it much more difficult to give SpRs a research training unless they step out of training schemes. This in itself can produce problems.'

> 'Professional standards of postgraduate training are designed to ensure the highest standards of clinical practice. The relatively new concept of revalidation has been introduced to maintain these standards and encourage excellence in all aspects of clinical practice. Although an argument can be made for streamlining the training of clinicians wishing to pursue academic careers, is there not a risk that this will ultimately compromise their clinical skills, adversely affecting their role within a service department?'

Solutions offered by respondents included:

> 'Concerted efforts to provide structured, long-term career support for both clinical and non-clinical scientists who are committed to the study of pathogens. (This must be linked to centres of excellence and the influence of appropriate role models.)'

> 'We need well trained and experienced academics who are fully qualified and ready to take on the roles that are needed, not prematurely promoted individuals who then fail to fulfil their potential due to a lack of experience. It is not the length of this process that needs to be addressed - it is stable career progression that does not require those committed to this path to accept lower salaries or accept much greater career insecurity in order to become the investigators that the profession needs. These represent important barriers to entry and pursuit of academic careers in general, especially when the age and family responsibilities of mature medical trainees are considered.'

> 'The college [Royal College of Pathologists] has recently formed a new research committee, the purpose of which is to encourage academic research in pathology by seeking funding for research training. This training will occur at all levels and includes bursaries for elective students to work in pathology laboratories and for intercalated BScs in pathology. For pathology trainees, the college is developing a series of collaborative ventures with a number of groups including international specialist journals, and the Medical Research Council. Approaches to other groups will be made in the future.'

The need to address the discrepancy in salaries was advocated vociferously by one respondent:

> 'It is astonishing that the Report does not touch upon the matter of salaries and conditions of service in academic posts. This has a crucial bearing as to whether bright sparks decide to take up a certain career path. I address the subject from the viewpoint of non-clinical academic medical microbiologists (medically qualified academic staff have a well established link with equivalent NHS grades, and once they reach Consultant level have access to merit awards etc, giving the possibility of salaries as high as £80K - even at the Senior Lecturer level; very unfairly, no such link exists between non-clinical academics and their equivalent PHLS grades e.g. Professor should be equivalent to Clinical Scientist C, but is not).'

Microbiology societies

14 The broad range of professional societies representing clinical and basic microbiologists in the UK should be encouraged to organise joint meetings of the highest quality. They should aim to speak with one voice, expressing a coherent political and strategic view on the future of microbiology and infectious disease research

Consultation responses

This section attracted a large number of responses. The proposals in the discussion paper were broadly supported as follows:

> 'I agree wholeheartedly with the comments on the need for one overarching Microbiology society to represent UK microbiologists.'
>
> 'The "fragmentation" of Microbiology is also clearly demonstrated by the broad range of societies representing clinical and basic microbiologists. It is my view that they should be encouraged to become one, rather than be encouraged to organise joint meetings occasionally. A useful model must be the way that the Biochemical Society covers almost all branches of that vast subject. The subject can only speak with one voice if it truly has one voice. If it is to compete with other disciplines, it must do so.'
>
> 'Concerted action to unite and co-ordinate activities in microbiology/infection in what is currently a fragmented academic community. The Society for General Microbiology would be the obvious body, but its attitude needs to change.'
>
> 'The need for an umbrella organisation analogous to the ASM [American Society of Microbiology] is clear. Attempts to bring this about through the formation of the Federation of Infection Societies (FIS) have been only partially successful. This is in part due to the pressure from some of the larger Societies who perceive that a single body may limit their individual sphere of influence.'

Other respondents were more cautious:

> 'I agree with the first line, but worry about the second - surely debate and a variety of views are good things.'
>
> 'I also agree that microbiological societies need to speak with one voice and presumably FEMS is important here. I have heard it suggested that the USA has a single ASM and that explains its success. In fact there are other US societies dealing for example with infectious disease and with anaerobic bacteria. I think different societies are OK but, yes, they need a single voice to have any effect.'
>
> 'I'm unclear as to whether the number of professional societies in the UK is a functional barrier to basic science - clinical co-operation. In my own research area, the BSAC incorporates basic science, industrial science and clinicians. This is an excellent mix. The issue of cohesion of the professional societies is a slightly different once. Given the recent problems with expanding the role of the Federation of Infectious Societies (FIS), it is very likely that amalgamation of societies will proceed in the short term.'

Respondents reported that action is already being taken. Respondents from the Society of General Microbiology gave details of recent initiatives, the merit of which was echoed by others.

> '[This] is being addressed by the formation of FIS (as already discussed) and by the formation of the clinical microbiology group of the SGM with its first meeting next month. Also the opening up of the PHLS Annual Conference to 'outsiders' might help to integrate UK clinical microbiology.'
>
> 'The Society for General Microbiology has begun an interesting initiative with a division devoted to clinical microbiologists, but the majority of clinical microbiologists and infection physicians in the U.K. belong to one or more societies such as the AMM, BSAC, HIS and BIS. It is an appalling mess.'
>
> 'The recent formation of a Clinical Microbiology Group by the Society for General Microbiology is a welcome development. Indeed, attendances at SGM meetings in general are currently extremely healthy.'

A respondent representing the Association of Academic Clinical Bacteriologists and Virologists gave an outline of its remit:

> 'The purpose of the Association is to be the authoritative voice of Academic Clinical Bacteriologists, Virologists, Parasitologists and Mycologists in the United Kingdom. The Association will be a principal source for informed opinion and advice on matters concerning medical education and research in Medical Schools in the United Kingdom. It will work to improve and maintain quality in medical education, specialist training, and medical research and will encourage clinical innovation and leadership in bacteriology, virology, parasitology and mycology. In addition it will promote medical education and research through collaborations with the National Health Service, Government Departments, the Academy of Medical Royal Colleges, the General Medical Council, the Research Councils and other organisations. It will encourage recruitment into academic clinical bacteriology, virology, parasitology and mycology. It will serve as a point of reference for the media.'

However one respondent was unsure of the likely outcome of current developments:

> 'The profession is attempting to resolve these issues, the success of these attempts cannot be predicted at present.'

Basic bacteriology

15 Efforts should be made to re-establish the traditional core UK expertise in bacterial genetics, including linkage with proposed centres of excellence. In addition to its fundamental scientific value, basic bacteriology research provides an essential underpinning for investigation of pathogenesis. In the absence of major pharma, potential career opportunities for basic microbiologists in the small and intermediate biotech sector should be encouraged.

Consultation responses

This section of the discussion paper was not strongly supported. Respondents commented:

> 'The final point (# 15) is not really appropriate to this document. The UK already is close to the leading edge of molecular genetics. What is needed is the integration of molecular microbiology with clinical experimental microbiology whereby the pathogenesis of microbial disease can be properly addressed.'

> ' Surely this is just one area of bacteriology - why has it been picked out for special attention?'

> 'Good quality research does not necessarily equate to genomics and studies on molecular pathogenesis (even though these are my own areas of research!).'

> 'I strongly endorse the importance of basic science and bacterial genetics but what about epidemiology, primary care, statistics, sociology and behaviour modification, and healthcare organisation researchers.'

> 'In paragraph 15, which concentrates on Basic bacteriology, mention is made of re-establishing the traditional core UK expertise in bacterial genetics. We are not convinced that there would be much support for this. With genome sequences being available for more and more of the major pathogens, functional genomics that includes the determination of phenotypes resulting from gene knockouts is a more than adequate replacement for the golden days of bacterial genetics.'

Other respondents considered that traditional skills are being lost and that the proposed remedy may not be sound:

> 'There is a danger that the skills involved in isolating, identifying and characterising bacterial species are disappearing fast. It is no surprise that the collections of isolates and strains are more difficult to maintain and curate as those people with basic bacteriological skills move on. However it will never be an attractive research area on its own and there will need to be a molecular understanding to overlay this.

Molecular techniques have demonstrated that phenotypic and genotypic plasticity does occur frequently and the latter is only detectable with molecular techniques.'

'One of the main reasons why the traditional core U.K. expertise in bacterial genetics has waned is because it has not been a priority for the Research Councils and it needs their support. If you mean by linkage of proposed centres of excellence that Research Council funding should be exclusively focused on centres of excellence, then we believe that this may be counterproductive for the reasons outlined above. The Biotech sector is subject to market forces and will only invest in basic bacteriology if the market exists. Preservation of the discipline can only be achieved if all the universities in the U.K. are encouraged to identify multidisciplinary teams and focus them as outlined above.'

Other comments

Two respondents stressed the need to disseminate the group's findings widely and effectively:

'Finally, we are microbiologists because we find the subject fascinating; we must communicate that better to the public, colleagues, students and both medical and science postgraduates.'

'I hope these points are taken seriously and that the Working Party endeavours to highlight the plight of medical microbiology to government, HEFC and the funding agencies.'

One respondent pointed out some omissions:

'your paper ignores the role of industry as a support for academic practice. Clearly this has its problems, especially in the area of clinical trials, and the role of regulatory authorities in this area needs to be considered. There is little about teaching which is central to improving practice.'

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Annex 3. **Clinical scientists**

The career posts for clinical scientists are in three grades (A B C), from Grade A Trainees to Grade C posts that are equivalent in seniority and in levels of responsibility to medical consultants.

Roles

a) Some of the most senior Grade 3 Clinical Scientists work in partnership with their Medical Consultant colleagues in delivering the frontline clinical microbiology services at consultant level and serve as Heads/Directors of laboratories. This is analogous to the situation in chemical pathology/clinical biochemistry where many clinical service laboratories are headed by a non-medical clinical biochemist. This situation is less common in medical microbiology currently. It is likely to increase.

b) The Clinical Scientists often take the lead, and are expected to do so, in the research and development programmes that are essential for development, progression and improvement of the services (NHS/PHLS).

c) At the more specialised level, Clinical Scientists often head specialist units (e.g. molecular diagnostics, mycology, virology) in large peripheral/regional laboratories and in those attached to Medical Schools.

d) Clinical Scientists provide the essential core of expertise in most National Reference Laboratories (at the Central Public Health Laboratory and elsewhere in the PHLS). These laboratories have a small number of medical consultants but the reference microbiology services and the research and development programmes necessary to keep reference services at the forefront of scientific development are provided by Clinical Scientists.

Qualifications

The initial qualification is an Honours Degree in Microbiology or an allied science. Grade A Trainee Scientists are required to undertake MSc (if in general training) or MPhil degrees in the early years and most are then expected to progress to PhD. A PhD level is essential for the more senior posts. Many also aim to achieve the MRCPath by examination (if in more general clinical microbiology posts) or by published works (if in specialised/ reference laboratories). Clinical Scientists now have to be accredited through the Council for the Professions Supplementary to Medicine. This requires completion of a recognised training programme, appropriate higher qualification and participation in a continued professional development (CPD) programme.

Career structure

This has been weak in the past and is still not as well organised as it should be. Clinical scientists are key members of staff on which medical microbiology services, and in particular the research and development to underpin those services, depends. There are some Grade A posts with specific training programmes over three years, including an MSc course, but accreditation now requires at least five years and there is an expectation that it will be linked to the need for a PhD for progression to senior posts. They are at the interface of service provision and the research and development activities that are closely aligned with academic activity in medical school developments. More attention needs to be paid to ensuring a career structure and succession planning, particularly for some of the nationally essential but almost single-handed posts.