The findings of a series of engagement activities exploring

THE CULTURE OF SCIENTIFIC RESEARCH IN THE UK

NUFFIELD COUNCIL ON BIOETHICS

DECEMBER 2014

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Foreword

Given public investment in UK science and the potential benefits it can bring, it is vital that the culture of scientific research supports and encourages science that is high quality, ethical and valuable.

We welcome the aims of this project to gather evidence and promote debate about whether the current culture of scientific research in the UK is successful in this respect. A wealth of information has been gathered during the project from the hundreds of scientists and others who took part. It is the people engaged in scientific research who are in the best position to tell us what it is like to be a researcher, whether a post-doctoral researcher on a short-term contract, or a well-established professor.

The diverse opinions and evidence gathered during the project are not readily synthesised into a unified picture. However, the findings of the project confirm that the culture of scientific research is shaped by a wide range of interconnecting factors, each exerting their own influences and raising their own challenges. How research is assessed by funding bodies and promotions panels, for example, can affect what science is carried out and by whom. And changes in the way that science is disseminated and critiqued can influence how scientists work and behave. Debates about different features of research culture have been running for many years. Given the overlapping nature of many of these features, the culture-wide approach of this project provides a more integrated view.

By taking this broad approach, the project highlights that all those involved in the practice of scientific research play a role in shaping its culture, and therefore all should take responsibility for building a culture conducive to high quality, ethical and valuable research. This report concludes with some suggestions for those who fund, publish, host, organise and do science. As Chairs or Presidents of organisations that carry out a number of these functions, we will consider these suggestions in the context of our own communities, as well as encourage and support funding bodies, research institutions, publishers and researchers to recognise and fulfil their roles in shaping an ethical culture for scientific research.

Professor Jonathan Montgomery
Chair, Nuffield Council on Bioethics

Sir Paul Nurse
President, Royal Society

Professor Dame Jean Thomas
President, Society of Biology

Professor Dominic Tildesley
President, Royal Society of Chemistry

Professor Sir John Tooke
President, Academy of Medical Sciences

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Executive summary

BACKGROUND

In 2013, the Nuffield Council on Bioethics embarked upon a series of engagement activities that aimed to inform and advance debate about the ethical consequences of the culture of scientific research in terms of encouraging good research practice and the production of high quality science. Under the guidance of a Steering Group, the activities of the project included:

- An online survey that received 970 responses.
- Fifteen discussion events co-hosted with universities around the UK involving around 740 speakers and participants.
- Evidence-gathering meetings with funding bodies, publishers and editors of scientific research, and academics from the social sciences.

A detailed analysis of the survey responses, a summary of the discussion events, and a background paper about the culture of scientific research in the UK are available at: www.nuffieldbioethics.org/research-culture

Most of the people who took part in our activities are involved in research being undertaken at higher education institutions (HEIs). A wide range of views, perceptions and experiences about scientific research in HEIs were raised, and these are summarised in this report.

WHAT WE HEARD

What is high quality science?

When asked to pick from a list of options, high quality research was described by survey respondents as: rigorous, accurate, original, honest and transparent. In addition, collaboration, multidisciplinarity, openness and creativity were frequently raised as important components in the production of high quality science. Survey respondents are motivated in their work by improving their knowledge and understanding, making scientific discoveries for the benefit of society, and satisfying their curiosity.

Concerns about the culture of scientific research

Competition

High levels of competition for jobs and funding in scientific research are believed both to bring out the best in people and to create incentives for poor quality research practices, less collaboration, and headline chasing.

Funding of research

There are concerns about a loss of creativity and innovation in science caused by perceived funding shortages, strategically-directed funding calls, short-term funding, and trends towards funding of safer research projects and established research centres. However, support for multidisciplinary and collaborative work was praised.

Assessment of research

The perception that publishing in high impact factor journals is the most important element in assessments for funding, jobs and promotions is creating a strong pressure on scientists to publish in these journals. This is believed to be resulting in important research not being published, disincentives for multidisciplinary research, authorship issues, and a lack of recognition for non-article research outputs. The Research Excellence Framework (REF) is thought to be a key driver of the pressure to publish in high impact journals, with many unaware or untrusting of the instructions given to REF assessment panels not to make any use of journal impact factors in assessing the quality of research outputs.

Attempts to assess the societal and/or economic impact of research are welcomed by some, but others believe this is creating a culture of short-termism and is pushing aside interest in curiosity-driven research, as well as resulting in researchers exaggerating the potential application of research in grant proposals.

It was suggested that research organisations should better recognise the wider activities of researchers, such as mentoring, teaching, peer review and public engagement.

Peer review is thought to be having a positive effect on science but concerns were raised about unconstructive reviewer comments and shortages of peer reviewers. The importance of peer reviewers being given training, time and recognition for their work was emphasised.

Research integrity

Fifty-eight per cent of survey respondents are aware of scientists feeling tempted or under pressure to compromise on research integrity and standards, although evidence was not collected on any outcomes associated with this. Suggested causes include high levels of competition in science and the pressure to publish. Training in good research practice is thought to be important in creating conditions that support ethical research conduct.

Career progression and workload

Features of researcher careers, including high competition for jobs and funding and heavy workloads, are thought to be resulting in a loss of creativity and innovation in science. Suggestions for improvements include: fair and consistent recruitment processes, better provision of mentoring and career advice, tackling negative attitudes towards those who leave academic science, and good employment practices for women.

OBSERVATIONS AND SUGGESTIONS FOR ACTION

The Steering Group hopes that the findings of this project provide useful evidence that will advance future debate on the culture of scientific research in HEIs. In the context of what scientists told us motivates them in their work and what they believe to be important for the production of high quality science, the findings lead us to make some general observations:

- In some cases the culture of scientific research does not support or encourage scientists' goals and the activities that they believe to be important for the production of high quality science.
- There seem to be widespread misperceptions or mistrust among scientists about the policies of those responsible for the assessment of research.
- Among all the relevant stakeholders, concerns about the culture of research are often on matters that they think are outside their control or are someone else's responsibility.

We believe there is a collective obligation for the actors in the system to do everything they can to ensure the culture of research supports good research practice and the production of high quality science. As such, we provide a number of suggestions for action for funding bodies, research institutions, publishers and editors, professional bodies and individual researchers (see Figure 1). Key examples are:

Funders: ensure funding strategies, policies and opportunities, and information about past funding decisions, are communicated clearly to institutions and researchers; and provide training for peer reviewers to ensure they are aware of and follow assessment policies.

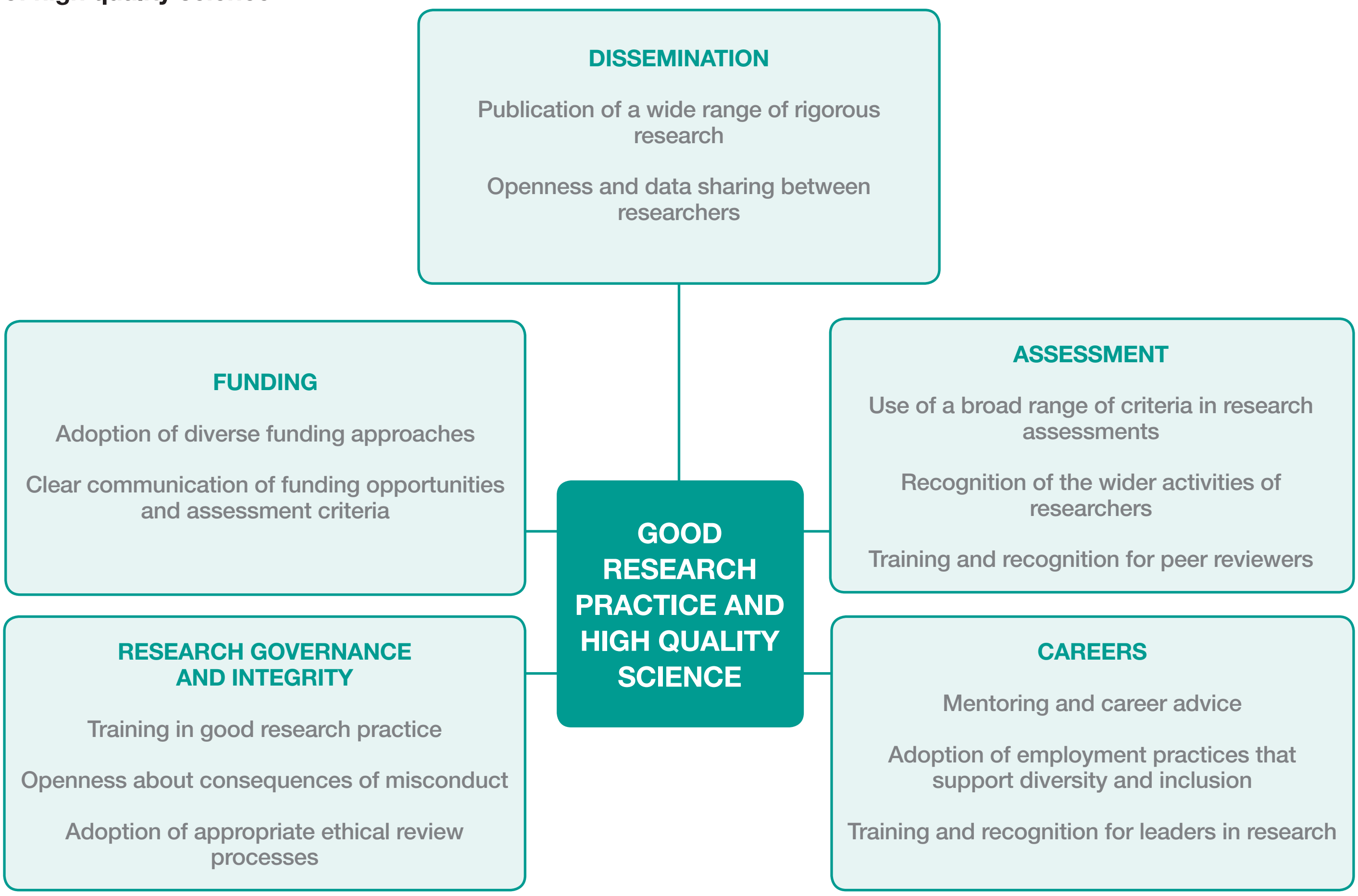
Research institutions: cultivate an environment in which ethics is seen as a positive and integral part of research; ensure that the track record of researchers is assessed broadly; and provide mentoring and career advice to researchers throughout their careers.

Publishers and editors: consider ways of ensuring that the findings of a wider range of research meeting standards of rigour can be published; consider ways of improving the peer review system; and consider further the role of publishers in tackling ethical issues in publishing and in promoting openness among scientists.

Researchers: actively contribute to the adoption of relevant codes of ethical conduct and standards for high quality research; use a broad range of criteria when assessing the track record of fellow researchers; and engage with funders, publishers and learned societies to maintain a two-way dialogue and contribute to policy-making.

Learned societies and professional bodies: promote widely the importance of ensuring the culture of research supports good research practice and the production of high quality science; and take account of the findings of this report in relation to guidelines for members on ethical conduct and professionalism.

Figure 1. Suggestions for action to support good research practice and the production of high quality science



BACKGROUND

Project origins and activities

The Nuffield Council on Bioethics carried out inquiries on the ethical issues raised by emerging biotechnologies in 2011-12, and by novel neurotechnologies in 2012-13. These inquiries brought to light concerns about the ethical consequences of the culture of scientific research in terms of its potential to affect research practices and the quality and direction of science.

These concerns were shared by organisations that work closely with the scientific community, including the Royal Society, Society of Biology, Institute of Physics, Royal Society of Chemistry and Academy of Medical Sciences. Under the guidance of a Steering Group that included members of staff from these organisations, in October 2013 the Nuffield Council on Bioethics embarked upon a series of engagement activities that aimed:

> *…to foster constructive debate among all those involved in scientific research about the culture of research in the UK and its effect on ethical conduct in science and the quality, value and accessibility of research; and to advance current debate through wide dissemination of the outcomes of these discussions.*

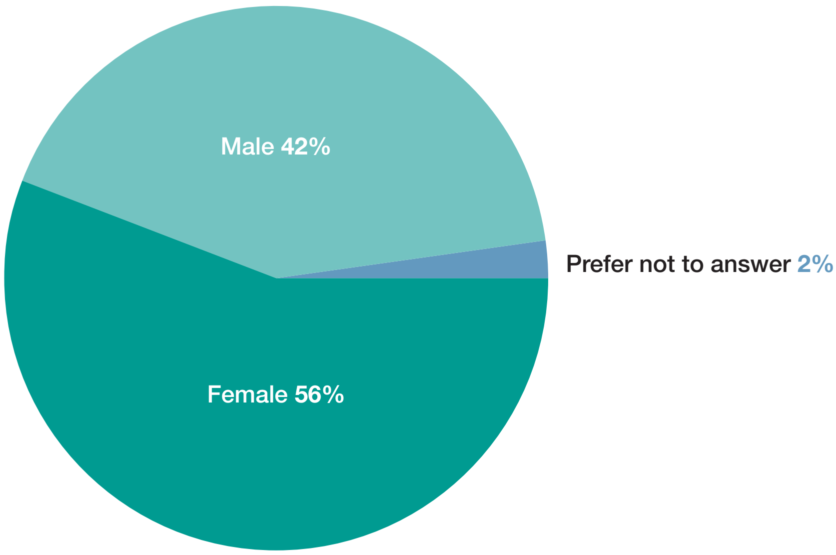
The project aimed to explore the effects of a wide range of influences on scientific research including, for example, funding mechanisms, publishing models, career structures and governance processes. 'Science' and 'scientific research' were not strictly defined in order to allow anyone involved in science or a related discipline to take part in the activities.

The activities of the project included:

Online survey

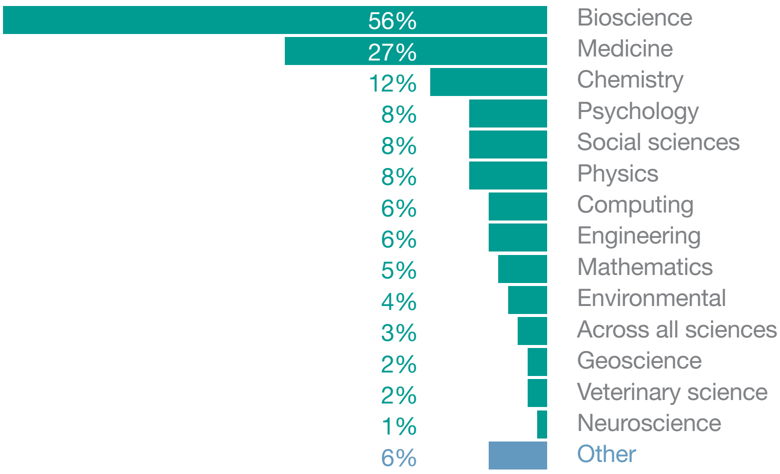
An online survey was open from March to July 2014 and received 970 responses. The survey consisted of 26 questions that asked respondents to provide their views on various aspects of the culture of scientific research. The survey included a mixture of multiple-choice questions, some with the option to add comments, and questions that allowed free text answers. A detailed analysis of the responses was carried out by Research By Design and is available at:
www.nuffieldbioethics.org/research-culture

DEMOGRAPHICS OF SURVEY RESPONDENTS

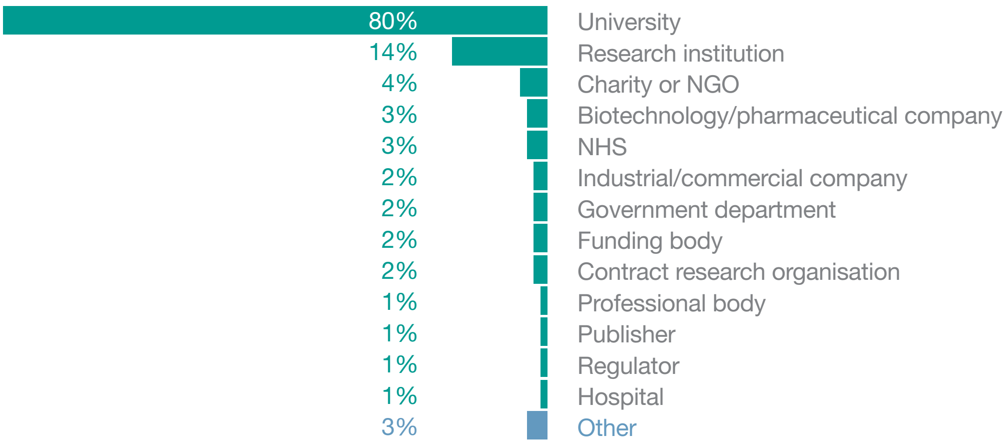


DEMOGRAPHICS OF SURVEY RESPONDENTS

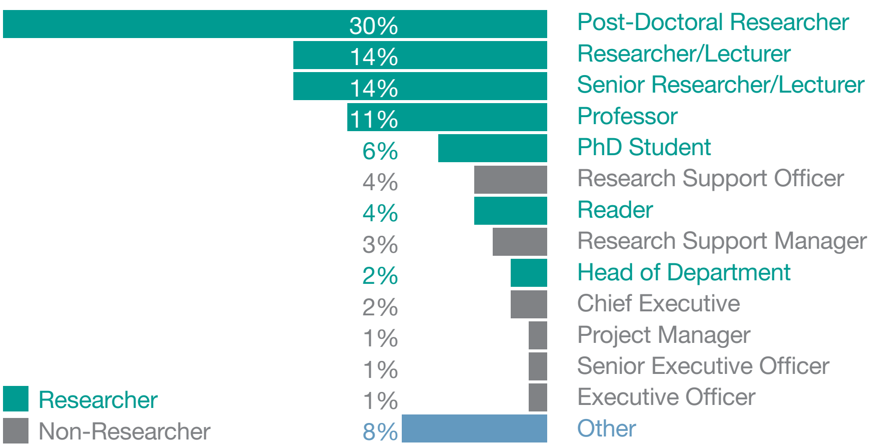
What area(s) of science do you work in?§



What type of organisation do you work for?§



Which of the following most closely matches your job title?§



§ The percentages show the proportion of the total number of respondents who provided an answer to the question. In the graphs on area of science and type of organisation, the percentages do not total 100 due to respondents being able to tick more than one answer. For all graphs, the percentages may not total 100 due to rounding of numbers.

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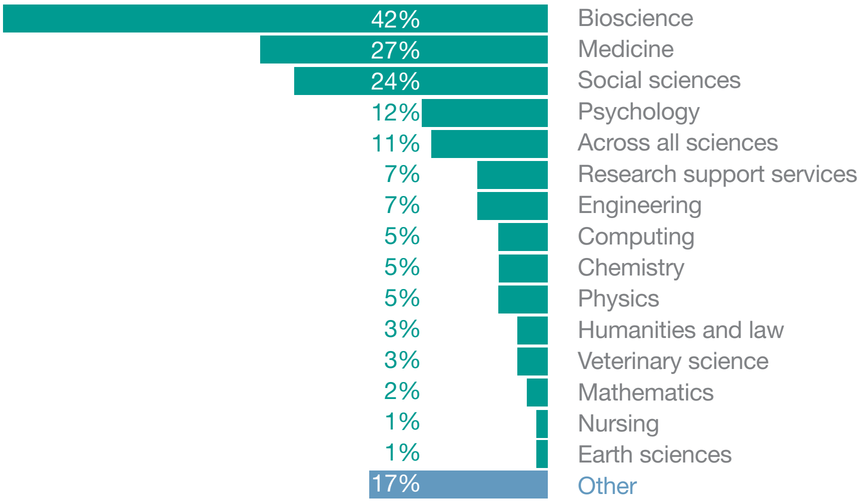
Discussion events

Fifteen discussion events were co-hosted with universities between June and September 2014. The universities were chosen to ensure a geographical spread around the UK. Most of the events took the form of a 90-minute lunchtime seminar that was free to attend and open to anyone. The events involved a total of 63 speakers and chairs, and approximately 680 people registered to attend as participants. A summary of the issues that were raised at the events is available at:
www.nuffieldbioethics.org/research-culture

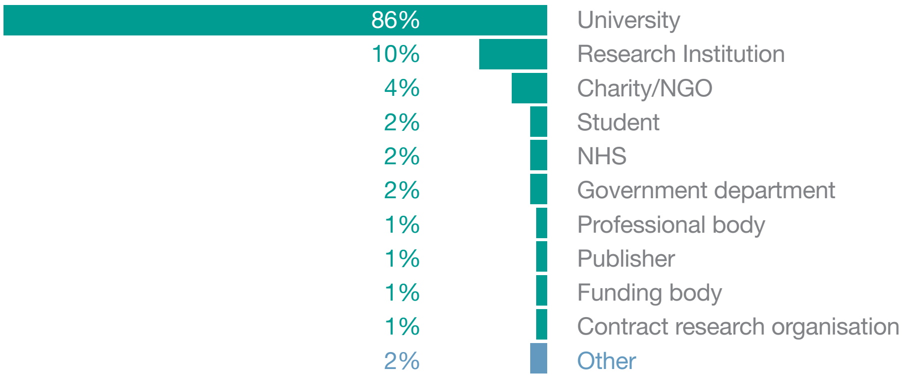
LOCATIONS OF DISCUSSION EVENTS

DEMOGRAPHICS OF PARTICIPANTS WHO REGISTERED ACROSS ALL EVENTS

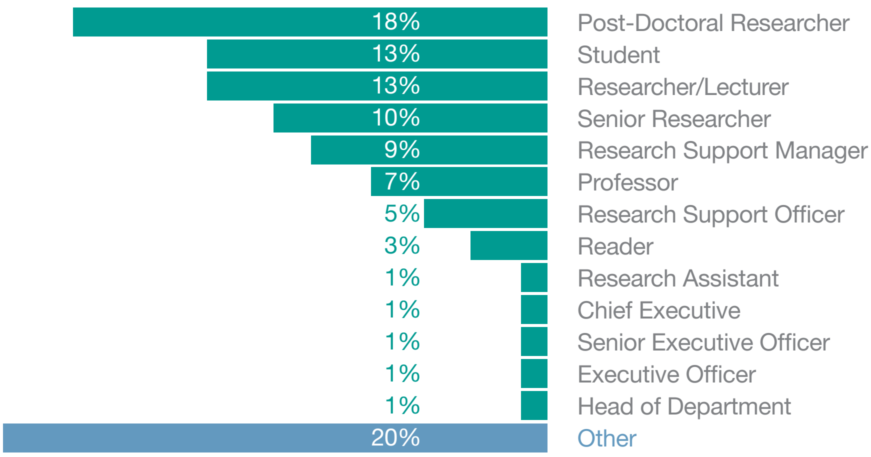
What area(s) of science do you work in, if relevant?±



What type of organisation do you work for, if relevant?±



Which of the following most closely matches your job title?±



± The percentages show the proportion of the total number of participants who provided an answer to the question on registering for an event. In the graphs on area of science and type of organisation, the percentages do not total 100 due to participants being able to tick more than one answer. For all graphs, the percentages may not total 100 due to rounding of numbers.

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Evidence gathering meetings

Three closed meetings were held between June and September 2014 to engage with: 1) representatives of organisations that fund scientific research; 2) publishers and editors of scientific research; and 3) academics from the social sciences with expertise in the practice and culture of scientific research.

REPORTING ON THE DATA

The people who took part in the survey and discussion events were self-selecting participants and cannot be assumed to be representative of the wider researcher population. Most of those who took part in our activities are involved or interested in research being undertaken by higher education institutions (HEIs), which carry out around a quarter of UK research and development. A large proportion of the survey respondents and event participants work in either bioscience or medicine and are early-career researchers, which is reflective of the demographics of the HEI research community.

Not all the survey respondents answered every question. Where percentages of survey respondents are used in this report, this refers to the percentage of respondents who answered that particular question.

Taking into account the limitations of the data, we believe some important themes and ideas emerged during the project. These are summarised in this report and illustrated with data from the survey and with views and evidence raised during the discussion events and evidence gathering meetings. The report aims to inform and advance debate about the ethical consequences of the culture of scientific research in terms of encouraging good research practice and the production of high quality science. Although the focus of the project was scientific research, the issues being considered are likely to be relevant to many other areas of academic research.

The Steering Group

A Steering Group was set up in October 2013 to oversee the design and implementation of the project and to provide connections with the scientific community. The contributions of members of the Steering Group were based on their personal expertise and experience. They were not formally representing the views of their organisations but did regularly consult with their organisations and members to help inform the project and raise awareness of activities.

MEMBERS

Ottoline Leyser (Chair)
Professor of Plant Development and Director, The Sainsbury Laboratory, University of Cambridge; Deputy Chair, Nuffield Council on Bioethics

Laura Bellingan
Director of Science Policy, Society of Biology

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Ann Gallagher
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James Hutchinson (until June 2014)
Senior Programme Manager, Life Sciences, Royal Society of Chemistry

Peter Main
Director of Education and Science (until May 2014, now Education Advisor), Institute of Physics

Peter Mills
Assistant Director, Nuffield Council on Bioethics

Jonathan Montgomery
Professor of Health Care Law, University College London; Chair, Nuffield Council on Bioethics

Rachel Quinn
Director of Policy, Academy of Medical Sciences

Introduction to scientific research in HEIs in the UK

A detailed background paper which provides more information about the culture of scientific research in the UK is available at: ***www.nuffieldbioethics.org/research-culture***

Scientific research has led to advances in knowledge that have improved our health, well-being and understanding of the world, and to innovations and technologies that have had a major impact on the way we live and on economic growth. The UK regularly tops international lists ranking countries by research productivity and quality when numbers of researchers and levels of R&D expenditure are taken into consideration.

FUNDING OF RESEARCH IN HEIS

Annual research and development (R&D) expenditure across all sectors and disciplines in the UK has increased from around £17 billion in the 1980s to £27 billion in 2012, with the higher education sector carrying out £7.2 billion of R&D.[1]

Core (or block) funding is allocated annually by the UK higher education funding bodies to HEIs. This funding supports research infrastructure and gives institutions freedom to undertake research in keeping with their own objectives. The amount of funding awarded to each institution is determined by the number of researchers, the costs of different types of research and an assessment of the quality of research carried out every five or six years.

In addition to core funding, grants for specific research projects or programmes are awarded by a wide range of bodies, including the seven Research Councils, government departments, businesses, charities, foundations, and overseas sources such as the European Commission. This kind of funding is offered through a mixture of research grants, fellowships, studentships, training and other programmes, and supports a wide range of research, including basic research which aims to advance knowledge of the world, and applied research which is directed towards the development of particular applications or products.

Funding bodies tend to provide a combination of short and long-term grants. Some Research Council funding is directed towards providing long-term support for large-scale projects at institutes or research centres, such as the Biotechnology and Biological Sciences Research Council (BBSRC)-supported John Innes Centre. Alongside such projects, funding bodies may award large project grants such as the Engineering and Physical Sciences Research Council's (EPSRC) Research Capacity grants. Other funding streams are designed to support medium and short-term work, such as the EPSRC's Mathematical Sciences Small Grants or the Natural Environment Research Council's (NERC) Urgency Grants.

Some funding bodies have introduced initiatives to support 'high risk' science. For example, the EPSRC has a number of grant programmes that aim to stimulate creativity, adventure and lateral thinking in research, and NERC's Discovery Science funding stream aims to support curiosity-led science and encourages adventurous research.

Most funders have schemes targeted at supporting early career researchers. The Medical Research Council's (MRC) New

1 Office for National Statistics (2014) *UK Gross Domestic Expenditure on Research and Development, 2012*, available at: **www.ons.gov.uk/ons/dcp171778_355583.pdf**. Prices have been adjusted for inflation.

Investigator Grant, for example, is aimed at researchers with between three and ten years of post-doctoral experience and the Wellcome Trust's New Investigator Awards are intended to support researchers in the first five years of their research careers.

DISSEMINATION OF RESEARCH

The findings of research are typically disseminated via peer-reviewed journals. Papers are assessed by journals through a process of peer review to determine whether or not they should be published. Peer review typically includes assessment of the rigour of the science and of the contribution it makes to the field. Acceptance of a paper in a prominent journal typically requires that the work is of high technical quality and that the findings represent a major, and possibly newsworthy, advance in knowledge. Some journals, however, such as the open access journal PLOS ONE, have removed 'scientific importance' from its acceptance criteria.

The traditional publishing model relies on researchers writing and reviewing papers, journals publishing them, and institutions paying subscriptions fees to view the published papers. There is support from policy makers, funders and others for a move to open access publishing, where peer-reviewed journals allow free access to their articles, paid for by article processing charges (often referred to as 'Gold' open access), or where published research is placed in a separate public repository for anyone to see after an agreed period of time (often referred to as 'Green' open access). Many research funders now require or encourage their grant holders to ensure free, online access to their published work, and most universities have publicly accessible research repositories for their researchers to use. Discipline-specific repositories also exist, such as arXiv.org, where pre-prints of papers in the fields of physics and mathematics are self-archived by authors.

The findings presented in journal papers may be reported in the media if they come to the attention of journalists and are deemed to be of interest to the wider public. Research institutions, funding bodies and a range of other organisations, including journal publishers, support researchers in engaging the public with science through the media and in other ways, for example, by taking part in public events and festivals.

ASSESSMENT OF RESEARCH

Peer review is the process by which academic work is assessed by other experts in the field. It is the mainstay of most research assessment processes, including those carried out by journals to assess which work to publish, by funding bodies to determine which proposals to fund or how much core funding to allocate, and by institutions to decide who to appoint or promote to academic positions. Peer reviewers are typically, but not always, unpaid.

In science disciplines, the peer review process is usually 'single-blind', where the identity of the reviewer is hidden from the author or applicant, and takes place prior to publication. However, open and post-publication peer review are gaining prominence. For example, many of the journals published by Biomed Central make reviews available alongside the final articles, and websites such as PubPeer and PubMed Commons allow researchers to post public comments about articles following publication. In addition, some science journals are experimenting with double-blind reviews where the identity of both the author and the reviewer are hidden, which is common practice among social science journals.

As a key indicator of research quality, publication in peer-reviewed journals is highly sought after by researchers, particularly journals with the highest 'impact factors'. High impact factor journals are widely read, often leading to work receiving a high number of citations by other academics. Although this varies across disciplines, the impact factor of the journal in which a paper is published is therefore often used as an indicator of the quality and impact of published work. Despite their prevalent use, it is widely agreed that journal impact factors have serious limitations. The San Francisco Declaration on Research Assessment (DORA) recognises that research should be assessed on its own merits rather than on the basis of the journal in which the research is published, and has now been signed by over 12,000 individuals and 500 organisations.

One method for assessing the significance of individual papers is to use the number of times the paper has been cited in other peer-reviewed papers, which can be adjusted to account for article type, time since publication and differences in citation practices across disciplines. There is also growing interest in 'altmetrics' – metrics proposed as alternatives to journal impact factors and paper citation numbers for assessing the quality and reach of all kinds of published research. Altmetrics include download and bookmark numbers, blog and social media mentions, and expert recommendations. Altmetrics are beginning to be explored and adopted by publishers, funders, institutions (for example, through the Snowball Metrics Initiative) and researchers. However, there is also wide recognition that research is very difficult to assess using metrics alone, and that qualitative assessments are an essential component. The Higher Education Funding Council for England (HEFCE) is currently undertaking an independent review of the role of metrics in the assessment of research.

In an attempt to undertake a fuller assessment of the value of research and the contributions of researchers, some funding bodies are taking into consideration the impact of future or previous research beyond academia. For example, Research Councils require researchers to set out how they are going to explore opportunities for their research to have an impact on society in the 'Pathways to impact' section of grant applications. In addition, in 2013, the UK higher education funding bodies undertook a new process for assessing research quality, the Research Excellence Framework (REF), to inform the allocation of core funding to HEIs from 2015. The process involved peer review of each institution on the basis of 1) the outputs of research (such as journal publications, datasets and patents), 2) the impact of past research on the economy, society and culture, and 3) the vitality and sustainability of the research environment. The REF assessment panels were instructed not to make any use of journal impact factors in assessing the quality of research outputs. The results are due to be announced in December 2014. HEFCE is currently undertaking research to evaluate the strengths and weaknesses of the REF process.

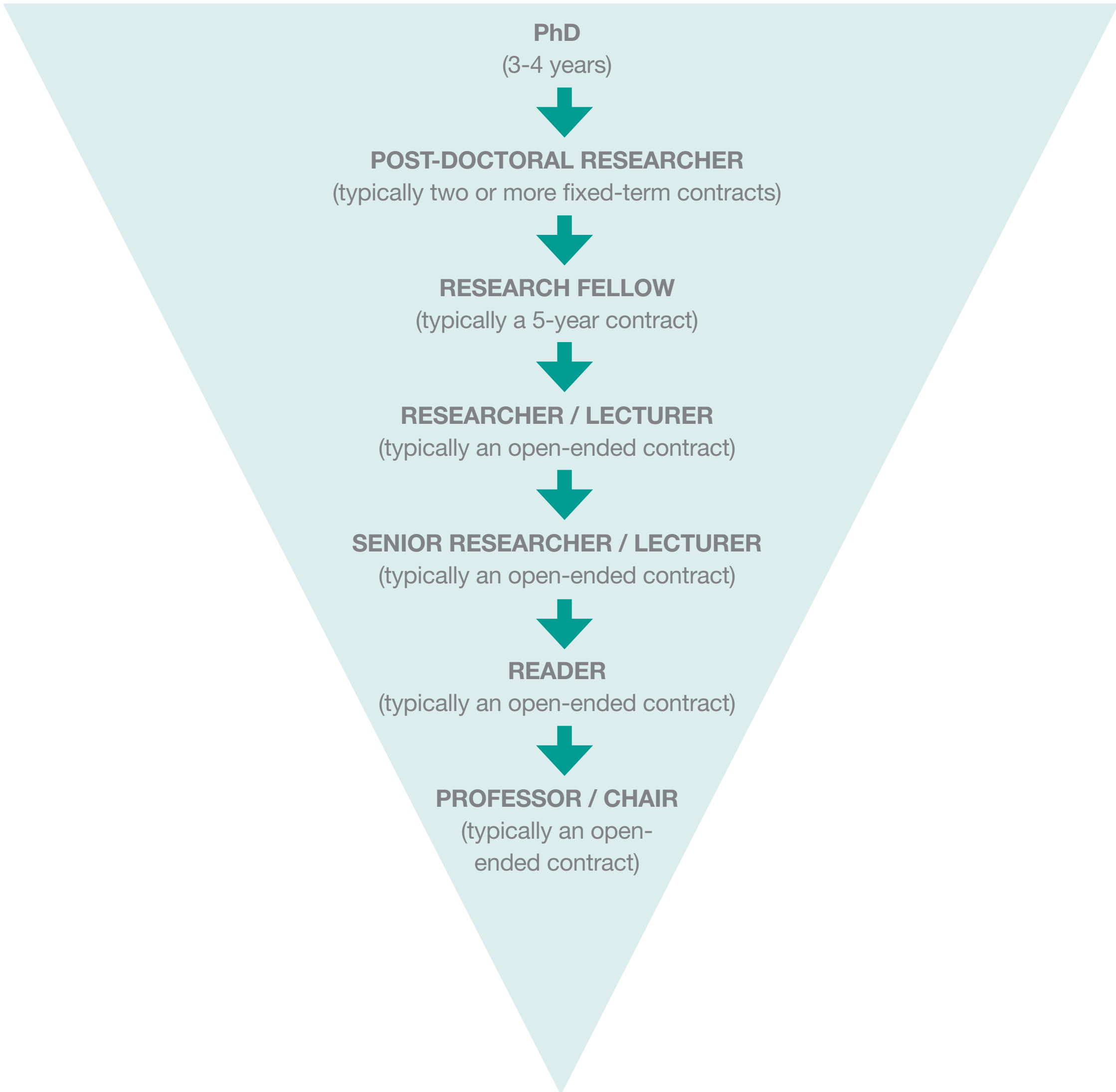
CAREER PROGRESSION

The number of academic staff across all disciplines employed in English HEIs has risen from around 105,000 in 2003-04 to around 126,000 in 2012-13.[2] Around 30 per cent of science PhD graduates go on to post-doctoral research positions, and around four per cent of science PhD graduates proceed to permanent academic posts with a significant research component.[3] Many overseas researchers are recruited into the UK system at different career points, and UK researchers take up positions in other countries.

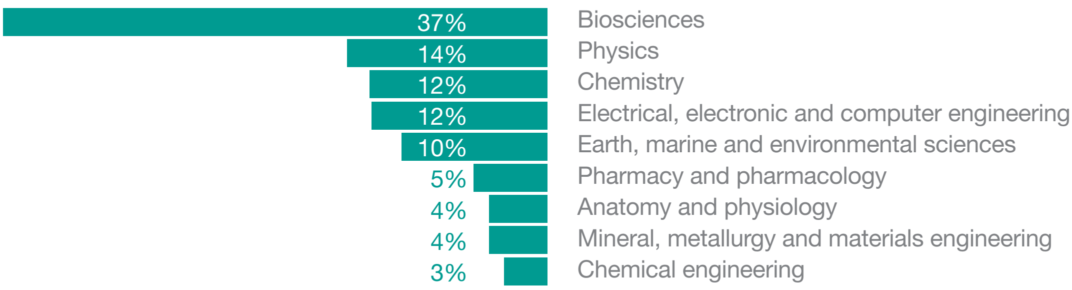
Researchers are assessed for promotions or jobs by panels of senior members of staff on the basis of a range of relevant criteria, such as their performance in research, teaching, leadership and outreach activities.

2 Higher Education Funding Council for England (2014) *A briefing on: Staff employed at HEFCE-funded HEIs: Trends and profiles*, available at: **www.hefce.ac.uk/whatwedo/lgm/workforce/staff/overall/**
3 The Royal Society (2010) *The Scientific Century: securing our future prosperity*, available at: **https://royalsociety.org/~/media/Royal_Society_Content/policy/publications/2010/4294970126.pdf**

Typical career path for a scientist in an HEI



Percentages of staff employed in research roles in UK HEIs in 2011/12 in selected scientific disciplines[4]



4 Data supplied by HESA Services Ltd. The percentages do not total 100 due to rounding of numbers

RESEARCH GOVERNANCE AND ETHICS

Research in HEIs is not overseen by a dedicated regulatory body, but most institutions have their own policies on good research practice, systems for the ethical approval of projects, and procedures for handling misconduct.[5] Certain types of research have additional oversight processes that are governed by bodies outside the HEI system, such as animal research, clinical trials and research involving genetically modified organisms.

There is a wide range of activities that could be considered to constitute research misconduct or poor quality research practice. This includes data fraud, poor experimental design, corner-cutting in research methods, inadequate replication of research, 'cherry picking' results, inappropriately slicing up data to create several papers, authorship issues, plagiarism, over-claiming the significance of work in grant proposals and papers, and carrying out poor quality peer review, for example by failing to declare a conflict of interest. The scale of research misconduct or poor quality research practice is hard to assess since it is likely that much goes on undetected. The Committee on Publication Ethics (COPE) identifies authorship issues as one of the most common concerns raised by its journal members.

The first sector-wide research guidance for universities, *The Concordat to Support Research Integrity*, was published in 2012.[6] Institutions funded by the UK higher education funding councils are required to comply with the concordat, which sets out a number of commitments. These include maintaining the highest standards of rigour and integrity in all aspects of research, and supporting a research environment that is underpinned by a culture of integrity and based on good governance, best practice and support for the development of researchers.

This section has provided an introduction to the wide range of factors that influences the culture of research in the UK, including what kind of funding is available and how it is allocated, the governance of research, the way in which research is disseminated, the composition of the workforce, and how researchers progress in their careers. The next section presents evidence collected during this project about how scientists and other key stakeholders experience the culture of research and the factors that they believe are having positive or negative effects on science.

5 For instance, see the University of Birmingham's *Code of Practice for Research 2013-14*, available at: **www.birmingham.ac.uk/Documents/university/legal/research.pdf**

6 Universities UK (2012) *The Concordat to Support Research Integrity*, available at: **www.universitiesuk.ac.uk/highereducation/Pages/Theconcordattosupportresearchintegrity.aspx**

WHAT WE HEARD

Over the course of the project, we heard a wide range of views, perceptions and experiences related to the ethical consequences of the culture of scientific research in terms of encouraging good research practice and the production of high quality science. These are summarised in this section.

What is high quality science?

When survey respondents were asked to select five words from a list that best describe their understanding of high quality research, the five most frequently selected words were:

1. Rigorous
2. Accurate
3. Original
4. Honest
5. Transparent

'Rigorous' was the top choice across all disciplines. Respondents working in medicine, engineering, psychology, social science and computing included 'ethical' in their top five, and 'beneficial to society' was the third most popular selection by social scientists. 'Justified', 'open', 'legal' and 'respectful' were the least frequently chosen words.

During the project activities it emerged that several other components are thought to be particularly important in the production of high quality science: collaboration, multidisciplinarity, openness and creativity.

Collaboration

Increased collaboration was the most common answer given when survey respondents were asked what feature of the UK research environment is having the most positive effect on science. The respondents (a quarter) who raise this think collaboration is leading to better communication between researchers, greater sharing of data and methodologies, less competition between different research teams, and reduced feelings of isolation among researchers. This, respondents perceive, results in an "explosion of ideas" and more innovation in research.

Multidisciplinarity

The potential for multidisciplinary research to address some of the major questions facing society was highlighted at several of the discussion events. Researchers who have trained in completely different ways need to work together, it was suggested, and the wide gaps between disciplines that existed in the past are now becoming much narrower.

Openness

Sixty-one per cent of survey respondents think that the move towards open access publishing is having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality research. Researchers in the field of computing were particularly positive.

61%

of survey respondents think open access publishing is having a positive or very positive effect on scientists

Photo: Participant at the discussion event held at University College London

> ***Collaborations – an open, friendly environment where people work together to achieve things faster rather than competing needlessly. Additionally I think that the emerging inter-disciplinary (e.g. bio-maths department split PhD programmes) efforts though facing teething problems now will be very valuable in the future.***
>
> **Survey respondent (PhD Student, female, aged 18-25)**

Freedom gives [you] the chance to let your mind wander. Collaboration gets you places more quickly and often to places none of you could reach alone.

Survey respondent (Senior Researcher/ Lecturer, male, aged 36 to 45)

Open access publishing is also the third most popular answer given by survey respondents when asked which features of the UK research environment are having the most positive effect on scientists. Reasons given for this positive effect include making research more accountable to the public, and helping to correct exaggerated or inflated claims made in the media.

Participants in the discussion events were also positive about the potential of open access publishing to promote collaboration, reduce unnecessary duplication, increase reproducibility in research and reduce poor quality research practices. Although concerns about how researchers will cover article processing fees were raised at several of the events, the publishing experts we spoke to expressed the view that the UK is currently in a period of transition and that open access publishing will be the norm in 10-15 years time.

In addition, almost two thirds of respondents believe data sharing policies in the UK are having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science. Respondents believe increased transparency and data sharing are facilitating the dissemination of results, enabling research to be accomplished more quickly and cost effectively, and allowing greater scrutiny of research findings. A greater proportion of respondents aged under 35 think data sharing policies are having a very positive effect overall than those aged over 45 (15 per cent vs. 7 per cent). There are concerns related to data sharing however, with issues about commercial sensitivities and the challenges of making data publicly available raised at several of the discussion events.

Creativity

The importance of creativity in the scientific process was raised during the project in a number of contexts. When asked how different features of the UK research environment are having a positive effect on scientists, academic freedom and variety in research were among the most common answers given by survey respondents. Respondents report that these features encourage creative thinking, leading to diversity in research and innovation as well as encouraging researchers and institutions to follow more ambitious projects. Concerns about a loss of creativity were raised in discussions about a possible culture of 'short-termism' in research (see Short-term funding p23 and Research impact p26) and perceived increases in strategically-directed funding by funding bodies (see p23).

MOTIVATIONS OF SCIENTISTS

The motivations of scientists provide additional insights into how they view research, and the majority of the survey respondents clearly chose a career in science in order to find out more about the world around them. When respondents were asked to rank phrases to describe what they believe motivates them in their work, the top three were:

1. **Improving my knowledge and understanding**
2. **Making scientific discoveries for the benefit of society**
3. **Satisfying my curiosity**

Phrases that came lower down the rankings were (in descending order): 'progressing my career', 'communicating science to others', 'earning a salary', 'training the next generation of scientists', 'gaining recognition from my peers', 'working as a team' and 'gaining recognition from the public' ranked last.

Respondents working in medical research are more likely to cite 'making scientific discoveries for the benefit of society' as their main motivation. 'Satisfying my curiosity' is particularly important for respondents working within computing and physics.

Concerns about the culture of scientific research

COMPETITION

High levels of competition, or 'hypercompetition',[7] in scientific research emerged as a strong theme running through all the project activities. Applying for funding is thought to be very competitive by the majority of the survey respondents (94 per cent), as is applying for jobs and promotions (77 per cent). Around nine in ten think making discoveries and gaining peer recognition is quite or very competitive.

Competition for funding is felt particularly keenly by researchers working in the biosciences, and respondents aged under 45 are more likely to find applying for jobs and promotions to be very competitive when compared to their older colleagues.

Competition appears to be a double-edged sword. Many believe that competition can bring out the best in people as they strive for ever better performance, and that science advances more rapidly as a result. It is also thought that high levels of competition go against the ethos of scientific discovery and can create incentives for practices that are damaging to the production of high quality research.

Views vary depending on gender and academic position. A higher proportion of male respondents to the survey think that competition is having a positive or very positive effect overall (45 vs. 35 per cent female), whilst a higher proportion of female respondents believe it is having a negative or very negative effect (49 vs. 38 per cent male). More professors think competition is having a very positive or positive effect when compared to people nearer the beginning of their careers (60 vs. 35 per cent post-doctoral researchers for example).

A number of potential negative effects of high levels of competition were raised during the project:

Poor quality research practices

Behaviours such as rushing to finish and publish research, employing less rigorous research methods and increased corner-cutting in research were raised by 29 per cent of survey respondents who commented on the effects of competition on scientists. The potential for high levels of competition to encourage poor quality research practices was also raised in several of the discussion events.

Less collaboration

Of the survey respondents who provided a negative comment on the effects of competition in science, 24 out of 179 respondents (13 per cent) believe that high levels of competition between individuals discourage research collaboration and the sharing of data and methodologies. This concern was echoed during several of the discussion events.

Rewarding self-promoters

Of the survey respondents who provided a negative comment on the effects of competition

I think in theory competition should be healthy however I don't think it is, rather it means people do not share ideas/data/thoughts in the same way so that high quality science can be done for the greater good. Rather it is about getting the recognition for yourself as your career/funding is dependent on publications etc.

Survey respondent (Senior Researcher, female, aged 36 to 45)

94%

of survey respondents think applying for funding is very competitive

[7] As described in Alberts B, Kirschner MW, Tilghman S, and Varmus H (2014) Rescuing US biomedical research from its systemic flaws *Proceedings of the National Academy of Sciences* **111(16)**: 5773–7.

in science, 28 out of 179 respondents (16 per cent) believe that 'headline chasing' has increased in prominence, and that people 'shouting the loudest' stand a better chance of gaining promotion and securing funding. This, survey respondents believe, can lead to selfish behaviour and means people who do not behave in this way may be disadvantaged, irrespective of the quality of their work.

FUNDING OF RESEARCH

A number of specific concerns about funding were raised during the project.

Amount of funding

When asked which features of the UK research environment are having the most negative effect, the most common answer given by survey respondents (31 per cent) was the lack of funding available. These respondents believe that the amount of available funding has decreased recently and that too much of their time is wasted applying for what they believe is a shrinking pot of money.

Strategically-directed funding

The survey respondents who think the lack of funding available is having the most negative effect on scientists also comment that researchers are tailoring their work in order to meet strategically-directed funding calls, rather than applying for the original research they had in mind. They believe that creativity and innovation are being lost within the scientific community as a result. This point of view was echoed in the discussion events, with participants commenting that the use of themes and strategic priorities by funders may induce researchers to pursue research they perceive as more 'fundable', which over the long term may exert a distorting influence on what research is conducted. Survey respondents also note that increased competition for funding may be driving researchers to tailor their applications to meet targeted calls, thereby increasing the number of opportunities they have to win funding.

Short-term funding

The potential negative effects of short-term funding were raised in several contexts by survey respondents and event participants. Twenty-eight per cent of respondents commenting on how different features are having a negative effect on scientists point to a general culture of 'short-termism', which they believe results in fewer new ideas, a decrease in the time available to plan good research, greater adherence to safer research topics (where results are almost guaranteed in advance) and people cutting corners in research. The factors cited as causing short-termism include short-term employment contracts caused by short-term project funding and a focus on short-term research outputs and impact (see Research impact p26). Respondents, particularly post-doctoral researchers and professors, believe the current system encourages short-term research proposals and safe research, which may be geared towards commercial development, rather than high risk research in unexplored areas.

Funding for 'risky' research

When asked what they would like to change about the UK research environment, over 42 per cent of respondents comment on funding issues, with some expressing a desire for more funding for 'riskier' projects. There is a feeling that funding bodies have become more conservative and favour safer research projects, where results are almost guaranteed in advance, but this approach, respondents believe, can hamper scientific development. This concern was echoed at the discussion events, with participants expressing a belief that funders are reluctant to take risks with research and tend to fund the same projects or research teams repeatedly.

Funding of large, established research groups

The 42 per cent of respondents who raise funding issues when asked what they would like to change about the UK research environment are also concerned that funding is concentrated towards large, well-equipped research centres and that there is favouritism toward Russell Group universities. They are concerned that these centres tend to explore strategically-directed areas of research and that opportunities for other researchers wanting to explore their own areas of interest are reduced as a result.

> ***Current funding program concentrates on funding research where the research results are within reach, i.e. where the results can be pretty much guaranteed. This type of 'safe' funding also means it's very hard to find funding for un-conventional/ risky/not-trendy approaches. However, these are the ones most able to bring in the big advances in science.***
>
> **Survey respondent (Senior Researcher/ Lecturer, male, aged 36 to 45)**

Positive aspects of the current funding landscape were also raised by some participants during the project. When asked which features of the UK research environment are having the most positive effect on scientists in terms of encouraging high quality science, access to funding for projects was raised by a fifth of respondents, particularly when respondents were comparing the UK situation to that of other countries. Support by funding providers for multidisciplinary and collaborative work was also particularly praised by survey respondents. Forty-one per cent of respondents believe that how multidisciplinary and collaborative research is supported is having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science (compared to 26 per cent who think it is having a negative or very negative effect). Respondents working in bioscience and female respondents were particularly positive in their answers.

I think the lack of funding for small groups and projects means that the focus has moved to larger groups, which reduces thinking 'outside the box'

Survey respondent (Senior Researcher/ Lecturer, female, over 45)

Photo: Participant at the discussion event held at University College London

ASSESSMENT OF RESEARCH

In a competitive system, the criteria used by funding bodies, journals and research institutions to assess the quality and value of science influences what science is pursued and how scientists behave.

Four topics commonly feature in discussions about research assessment processes: journal and article metrics, assessing the wider professional activities of researchers, peer review and the Research Excellence Framework (REF).

Journal and article metrics

Throughout the project we heard repeatedly that publishing in high impact factor journals is still thought to be the most important element in determining whether researchers gain funding, jobs and promotions, along with article-level metrics such as citation numbers. This has created a strong pressure on scientists not only to 'publish or perish', but to publish in particular journals.

Concerns raised by survey respondents and event participants in relation to the use of journal and article metrics in research assessment include:

- **Publication bias**
  High impact journals will usually only publish research that they perceive to be of outstanding scientific importance. A concern raised by participants at several of our events and meetings is that the pressure to publish in these journals is resulting in some types of important research findings not being published or recognised, for example, research with negative findings or research that replicates or refutes others' work.

- **Disadvantaging multidisciplinary research**
  Event participants pointed out that the majority of journals focus on single disciplines or areas of research, which can make the publication of multidisciplinary research difficult, particularly work that has involved unusual collaborations. Therefore, assessment processes that focus on publications in particular journals may be unfairly disadvantaging multidisciplinary research, creating disincentives for this kind of work to be carried out, or resulting in the need to publish across a range of journals covering all the contributing disciplines.

- **Authorship issues**
  Focusing on metrics related to journal articles in the assessment of researchers may be contributing to a culture in which scientists try to gain authorship credits for as many articles as possible, participants of the discussion events suggested. Specific issues raised relating to authorship include: the difficulties of ensuring that appropriate credit for published work is given to researchers at different stages of their careers; and the challenges raised by differing conventions for authorship when comparing publication records across different disciplines and when publishing multidisciplinary research.

- **Other research outputs**
  A range of non-article research outputs was mentioned by survey respondents and event participants, including datasets, software, patents and films. In addition, the internet is providing researchers with the ability to disseminate their research outputs without the help of publishers. Although this will vary across disciplines, it is likely to become increasingly important to include a wider range of research output types in research assessments. The REF already accepts a variety of research outputs for assessment, but it appeared from our discussions that very few researchers are aware of this, or do not believe that anything other than peer-reviewed journal articles will be judged favourably.

The desire for a more diverse set of measures

> ***Research should be evaluated in such a way that it ignores simple metrics like impact factors and numbers of papers and instead tries to take a better overall account of all outputs arising from the research.***
>
> **Survey respondent (Reader, male, aged 56-65)**

of research quality and reach to be used in assessments was raised by many survey respondents throughout their responses. The publishers we spoke to pointed to the San Francisco Declaration on Research Assessment (DORA) as a positive development in this area.

Assessing the wider activities of researchers

Research impact

Participants at several of the events broadly welcome the attempt by funding bodies to assess the impact of future or previous research beyond academia, believing that scientists have obligations to maximise opportunities for and demonstrate the benefit of their work to the public. It also, some believe, focuses researchers' attention on the purpose of their research and forces them to explain their research clearly.

However, others were less enthusiastic about the move to include these wider assessment criteria. Concerns raised by survey respondents and event participants in relation to the assessment of impact include:

- **A culture of short-termism**
  Pressure to create impact is one factor cited by survey respondents as causing a culture of short-termism in the UK (which is thought by 28 per cent of respondents to be having a negative effect on scientists in terms of encouraging high quality science). A culture of short-termism, they say, results in fewer new ideas, a decrease in the time available to plan good research, greater adherence to 'safer' research topics and people cutting corners in research.

- **A focus on applied research**
  Participants at several of the events are concerned that an increased focus on the impact of research is pushing aside interest in and funding of curiosity-driven research. In addition, a focus on impact was, some event participants said, resulting in researchers exaggerating the potential application of research in grant proposals and the timescales in which it might be delivered.

  The Research Councils we spoke to believe they have a duty to explain to the public and the Government the impact of public investment in science. They emphasised that this is done mostly retrospectively, and applicants are not expected to be able to predict at the application stage the economic or societal impacts that research will achieve.

Professional activities

It was suggested during the discussion events that research organisations should pay closer attention to and value the hard-to-measure and often invisible ways in which researchers contribute to the production of high quality science. This may include mentoring, training, teaching, peer review, university administration, public engagement and contributing to the work of national bodies and policy makers. Almost half of the survey respondents believe provision of professional education, training and supervision in the UK is having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science.

Staff development, PhD awards and research collaboration are already recognised by the REF in the 'Environment of research' category and often feature in university promotion criteria, but nonetheless there was a clear perception among the event participants that they are undervalued.

Peer review

Seventy-one per cent of the survey respondents believe the peer review system in the UK is having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science.

However, a number of concerns about the peer review system were highlighted during the project:

- **Inappropriate reviewer behaviour**
It was suggested in some of the discussion events that reviewer anonymity may be allowing reviewers to behave inappropriately, for example by giving unfavourable reviews of research similar to the reviewer's own, and providing rude or unconstructive comments. We also heard during the project about instances of reviewers doing a sub-standard job more generally.

- **Shortage of peer reviewers**
The funding bodies and publishers we spoke to reported increasing difficulties in recruiting peer reviewers. The reason for this was not clear, but it was suggested that busy researchers are struggling to find the time to carry out peer review, especially given that it is not usually paid or well recognised (see Professional activities, above). The increase in academic papers coming from emerging economies without a corresponding increase in the number of established experts to conduct peer review was suggested as another reason for the shortage.

New approaches to peer review
Participants at several of the events raised the need for a review of the way in which peer review is carried out in the sciences. In particular, we heard support for both double-blind and open peer review as alternatives to the current system.

The publishers we spoke to explained that open peer review aims for open and fairer scrutiny of research, and can allow peer reviewers to get more credit for the work they do. Event participants thought that open peer review could help minimise unconstructive or rude comments from reviewers, although some believe it may also deter them from saying anything negative. The publishers point out that any kind of post-publication open peer review requires publishers to act as gate-keepers or moderators to ensure the conversations are constructive and non-abusive.

Double-blind peer review may help to remove from the process biases associated with the profile or academic history of the author, it was suggested by event participants. However, the difficulties of anonymising a manuscript were also highlighted, given that most authors self-reference and the close networks of researchers working in the same field.

Participants at several events raised the importance of peer reviewers of both papers and funding proposals being given time and recognition for their work. It was also emphasised by participants, and the funding bodies that we spoke to, that reviewers need careful training and guidance in order to ensure the policies of funding bodies and journals for which they work are being enacted.

The Research Excellence Framework
The Research Excellence Framework (REF), the research assessment process run by the four UK higher education funding bodies, has occupied the time and minds of many researchers over the past few years and was a frequent topic of discussion during the project activities.

Peer review assumes freedom from politics and bias which is often not the case.

Survey respondent (Professor, female, aged 46-55)

71%

of survey respondents believe the peer review system in the UK is having a positive or very positive effect on scientists

When asked for their views on the REF, 25 per cent of the survey respondents believe it is having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science. However, almost 40 per cent think the REF is having a negative or very negative effect. This view was particularly pronounced among respondents working in psychology and physics. In addition, a quarter of survey respondents highlight the REF when asked which features of the UK research environment are having the most negative effect on scientists in terms of encouraging high quality science.

Many concerns already raised in this section are relevant to discussions about the REF, including the use of journal metrics in research assessment, and the assessment of research impact and the professional activities of researchers. Other concerns raised that specifically relate to the REF include:

- **Driving the pressure to publish**

We heard repeatedly during the project that the REF is thought to be a key driver of the pressure on researchers to publish in high impact journals, with many unaware or untrusting of the instructions given to REF panels not to make any use of journal impact factors in assessing the quality of research outputs.

- **Disadvantaging multidisciplinary research**

It was raised in several of the discussion events that the REF may be disadvantaging multidisciplinary work. There are four main expert panels which allow cross-referencing across a number of sub-panels covering different disciplines, with each REF panel judging the element of work that falls under their remit. Some event participants believe that the panel set-up is deterring researchers from submitting multidisciplinary work to the REF process.

RESEARCH GOVERNANCE AND INTEGRITY

Around a quarter of survey respondents think research governance and contractual processes in the UK are having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science.

Around 30 per cent believe that research governance and contractual processes are having a negative or very negative effect. Professors and senior researcher/lecturers who responded were particularly negative, as were respondents who worked in the field of medicine. Respondents are concerned that governance processes are overly bureaucratic, repetitive, time-consuming, and not understood or taken seriously by all. The risk of over regulation was raised at the discussion events, with participants concerned that heavy-handed regulation threatened to interfere with academic creativity. Eighteen per cent of survey respondents think that research governance and contractual processes are having no effect overall on scientists in terms of encouraging the production of high quality science.

Two topics related to research governance and ethics came up frequently during the project: ethical review processes and research integrity.

Ethical review processes

Over half of survey respondents think ethical review processes in the UK are having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science. This view is especially prevalent among respondents from social science, psychology, medicine and bioscience, and respondents note that ethical standards in the UK are thought to be high in comparison to other countries.

HEI ethical review processes were discussed at several of the events, where participants raised a number of concerns about the current system. Ethical review, participants said, could be insensitive to the level of risk involved in the research, and obtaining approval for what is thought to be low risk research could be inappropriately burdensome. In addition, it was suggested that committees may not always have the appropriate knowledge and experience to make informed decisions about every piece of research they are asked to approve, and that researchers should be better supported by ethics committees to consider different approaches to their work.

Research integrity

Fifty-eight per cent of respondents to the survey are aware of scientists feeling tempted or under pressure to compromise on research integrity and standards, although evidence was not collected on any outcomes associated with this. Twenty-six per cent of respondents have themselves felt tempted or under pressure to compromise on research integrity and standards. A higher proportion of respondents aged under 35 years (33 per cent) stated they had felt tempted or under pressure in comparison with those aged above 35 years (21 per cent).

Thirty-eight percent of the survey respondents who comment on research integrity and standards think the ‘pressure to publish’ can encourage the fabrication of data, altering,

> *Many of these processes are essentially tick box exercises which occupy too much of a scientist’s limited time to conduct research.*
>
> **Survey respondent (Post-doctoral researcher, female)**

58%

of survey respondents are aware of scientists feeling tempted or under pressure to compromise on research integrity and standards

I am aware of others who have been tempted to edit their data to get the 'right' results. I am also aware of data-trawling exercises to 'find' interesting results.

Survey respondent (Reader, female, aged 56-65)

omitting or manipulating data, or 'cherry picking' results to report. Thirty-one per cent of respondents think there is pressure to focus on and report positive results, rather than negative results, and that researchers rushing to publish results may not conduct appropriate replications and scrutiny of their work.

Research integrity came up frequently at the discussion events. Participants noted that honesty and trust is fundamental to science, and high profile cases of research misconduct may be undermining public trust in science. The view was expressed that high levels of competition for scarce resources put scientists under immense pressure which means that scientists are "bound to behave less well".

Participants noted the distinction between research misconduct, such as fraud and fabrication, and other kinds of poor practice, such as poor experimental design, and suggested they should be dealt with separately.

Sixty per cent of survey respondents think that initiatives that promote integrity in science in the UK, such as codes of conduct, are having a positive or very positive effect overall on scientists in terms of encouraging the production of high quality science. We heard from event participants that *The Concordat to Support Research Integrity* can be a helpful reminder of the importance of ethical values in scientific research, and websites such as Retraction Watch help to expose cases of bad practice.

Suggestions for improving research integrity in the UK were made by event participants. Universities, they suggested, have a responsibility to create conditions to support ethical research conduct and demonstrate clearly the consequences of poor research practice. Training in good research practice was thought to be important in this regard, particularly for PhD students, but time pressures on senior scientists might be preventing this from happening at the moment. Universities might also be more open about how individual cases are resolved. The efforts of academic publishers to tackle issues around authorship were praised, although some thought they should have stronger policies on dealing with retractions.

CAREER PROGRESSION AND WORKLOAD

Concerns about the challenges of career progression and heavy workloads for researchers on the production of high quality science were raised frequently during the project. For example, when asked if there is anything they would like to change about the UK research environment, more than a third of survey respondents cite issues related to career structure and progression.

The following concerns were frequently mentioned by survey respondents and event participants:

- Short-term contracts and job insecurity for post-doctoral researchers
- Reliance on external funding for job retention, which drives the 'pressure to publish'
- Pressure to progress but high competition for jobs and funding
- The need to keep relocating in order to take up the next position
- Limited opportunities for women in particular to have career breaks
- Heavy workloads and long hours
- High 'drop out' rates

Almost twice as many female survey respondents as male respondents raise issues related to career progression and the short-term culture within UK research when asked which features of the research environment are having the most negative effect on scientists. This mirrors responses to the survey about the perceived level of competition involved in gaining funding and jobs (see *Competition*, p21).

In terms of how issues relating to careers and workloads affect the production of high quality science, survey respondents believe that they contribute to a culture of short-termism, high levels of stress, a lack of time to think and the loss of talented individuals from academia, which in turn results in a loss of creativity and innovation. Respondents also raise the possibility that high levels of competition for jobs may encourage poor quality research practices.

Suggestions for ways of addressing some of these concerns were raised during our discussions:

Promote the best scientists

Fifty-four per cent of respondents think the way scientists are assessed for promotion during their career is having a negative or very negative effect overall on scientists in terms of encouraging the production of high quality science, compared to 22 per cent who think it is having a positive or very positive effect. Respondents commenting on this issue believe that promotion criteria have changed, mainly due to the REF, and that science is assessed much more on metrics, such as journal impact factors and citations.

The Concordat to Support the Career Development of Researchers[8] was highlighted during the project as a positive development in the improvement of the way in which researchers are promoted and recruited. It commits its signatories – the main UK funders and employers of researchers – to fair, consistent selection processes where researchers are chosen primarily for their ability to advance research at an institution.

' ***The Post-Doc structure disadvantages those who cannot keep moving for family reasons, which particularly affects women.*** **'**

Survey respondent (Researcher/Lecturer, female, aged 46-55)

54%

of survey respondents think the way scientists are assessed for promotion during their career is having a negative or very negative effect on scientists

8 Vitae (2008) *The Concordat to Support the Career Development of Researchers. An Agreement between the Funders and Employers of Researchers in the UK*, available at: **www.vitae.ac.uk/policy/vitae-concordat-vitae-2011.pdf**

Mentoring and career advice

Mentoring of early career scientists and the provision of appropriate career advice was suggested at several of the events as a possible way to help mitigate anxieties and help researchers be realistic about their prospects for a career in scientific research. Mentoring and advice may also help people to plan and develop their career paths at an earlier stage, and ensure they gain experience that will be transferrable to other sectors. PhD students are already encouraged by some funders to spend time in other sectors in order to expand their skills and experience, but the funders we spoke to reported less progress in this area among post-doctoral researchers.

More job security for post-doctoral researchers

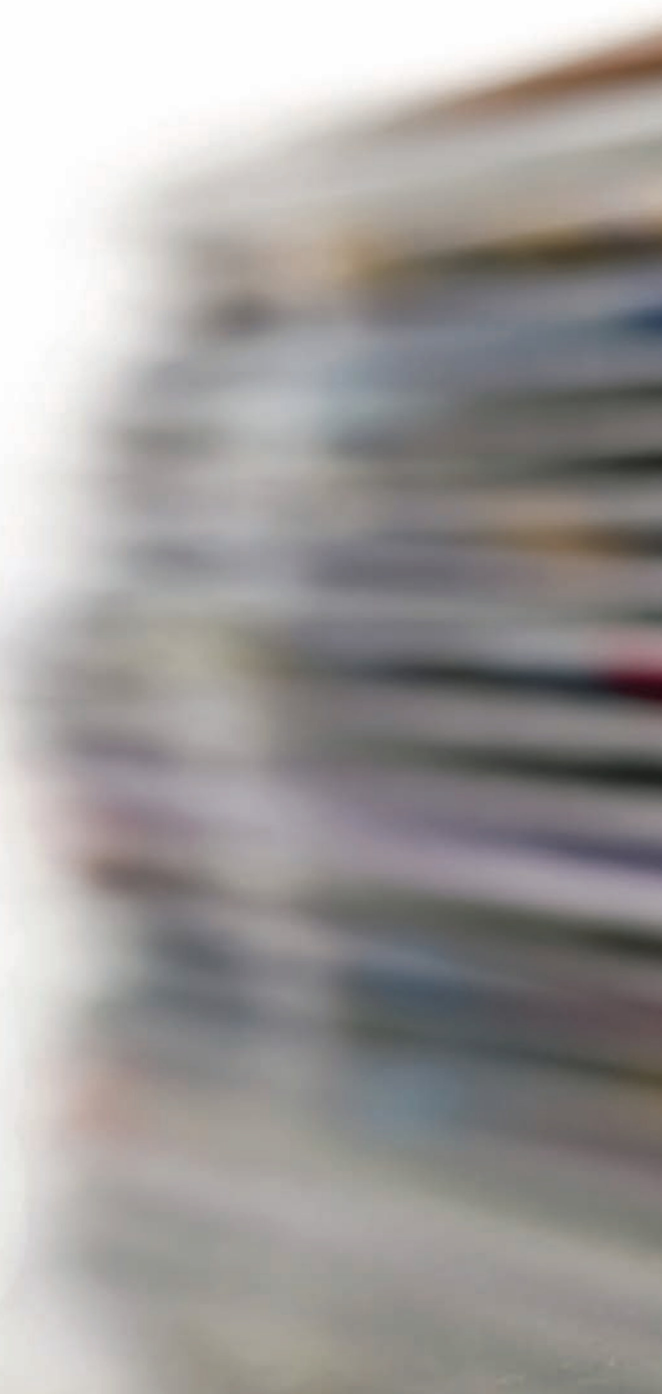
Concerns about the lack of job security for post-doctoral researchers were raised by participants of several discussion events. There was also concern about post-doctoral researchers working on a succession of short-term contracts for many years. Many funding bodies, including charities, already offer individual fellowships that tend to be at least 5-years in length. However, there is often high competition for these fellowships and there will not be a permanent job for everyone at the end.

Changing attitudes to ‘dropping out’

There are far more PhD and post-doctoral researchers than permanent researcher positions available at HEIs, so it is inevitable that a large number of people will leave for other sectors after their initial training, bringing their valuable expertise to non-academic professional roles. Yet, comments made during the project suggest that there is a widespread perception that anyone who leaves academic science has failed. Again, it was suggested by event participants that mentoring and support may help to mitigate feelings of failure in those who transfer to other sectors and to reduce the high levels of competition they currently experience.

Good employment practice for women

Participants at some of the events noted that the number of women in science has increased and that the introduction of formalised research assessment systems may have helped to tackle gender biases which may have formerly influenced decisions about funding allocation and career progression. The Athena SWAN Charter, a national scheme that recognises good employment practice for women working in science, was mentioned at a number of events and is seen as having a positive influence on diversity in science.



OBSERVATIONS AND SUGGESTIONS FOR ACTION

The Steering Group hopes that the findings of this project, as summarised here and in more detail in the full reports of the activities,[9] provides useful evidence about the views, perceptions and experiences of scientists that will advance future debate on the culture of scientific research in HEIs.

Scientists told us they are driven by the desire to improve their knowledge and understanding, to make discoveries for the benefit of society and to satisfy their curiosity. High quality research was described as: rigorous, accurate, original, honest and transparent; and collaboration, multidisciplinarity, openness and creativity are thought to be important for the production of high quality science. Within this context, the findings of the project lead us to make some general observations:

- In some cases the culture of scientific research does not support or encourage scientists' goals and the activities that they believe to be important for the production of high quality science. High levels of competition for jobs and funding, and certain features of researchers' careers, for example, are thought to be contributing to poor quality research practices, less collaboration and a loss of creativity in science.
- There seem to be widespread misperceptions or mistrust among scientists about the policies of those responsible for the assessment of research. For example, while there was general agreement that journal impact factors should not be used in the assessment of researchers by funding bodies, researchers still report a strong pressure to publish in high impact journals.
- Among all the relevant stakeholders, concerns about the culture of research are often on matters that they think are outside their control or are someone else's responsibility.

Although externally-imposed conditions play a role, the culture of research is largely shaped by the actors in the system. We believe there is a collective obligation for those actors to do everything they can to ensure the culture of research supports good research practice and the production of high quality science. As such, we provide suggestions for action for funding bodies, research institutions, publishers and editors, professional bodies and individual researchers. Many of the issues have already been identified and steps are being taken to address them. We present our suggestions, and the evidence that supports them, as encouragement for this work to continue, but also to emphasise that a collective and coordinated approach is likely to be the most effective.

FUNDING BODIES

- Maintain a funding portfolio that provides opportunities for diverse research approaches for researchers at different stages of their careers and for research projects at different stages of development.
- Ensure that the track record of researchers applying for funding is assessed broadly, without undue reliance on journal impact factors.
- Provide training and/or guidance for peer reviewers and grant assessment committee members to ensure they are aware of and follow assessment policies.
- Recognise and reward high quality peer review and committee service.
- Communicate clearly to research institutions and researchers about funding strategies, policies and opportunities, and information about past funding decisions, particularly in areas where there are common misconceptions.

9 Available at: **www.nuffieldbioethics.org/research-culture**

- Support early career researchers to plan their future careers and expand their skills and experience outside of the research environment, and tackle negative attitudes towards those leaving academia.

RESEARCH INSTITUTIONS

- Ensure that the track record of researchers is assessed broadly, without undue reliance on journal impact factors, in processes for making appointments, conducting staff appraisals and awarding promotions.
- Cultivate an environment in which ethics is seen as a positive and integral part of performing research. Ensure researchers, particularly early career researchers, have a thorough grounding in research ethics and access to information and training throughout their careers. Be open about the consequences of research misconduct.
- Recognise and reward high quality peer review and committee service.
- Provide mentoring and career advice to researchers throughout their careers. Encourage them to plan their future and expand their skills and experience outside of the research environment, and tackle negative attitudes towards those leaving academia.
- Ensure institutional ethical review processes are flexible, appropriate and interactive, and that ethics committee members have appropriate guidance, training and knowledge.
- Support leaders in research by providing appropriate training, resources and recognition for their diverse activities.
- Sign up to the principles of the Athena SWAN Charter and adopt other employment practices that support diversity and inclusion.

PUBLISHERS AND EDITORS OF SCIENTIFIC RESEARCH

- Use a broad range of metrics to highlight journal and article strengths.
- Tackle biases in research publishing by considering ways of ensuring that the findings of a wider range of research meeting standards of rigour can be published.
- Consider ways of adapting to the increasing multidisciplinarity of research.
- Consider further ways of improving the peer review system, for example by experimenting with new models.
- Ensure peer reviewers receive appropriate training and/or guidance and recognition for their work.
- Consider further the role of publishers in tackling ethical issues in publishing such as those related to authorship and retractions, and in promoting openness and data sharing among scientists.

RESEARCHERS

- Be familiar with and actively contribute to the adoption of relevant codes of ethical conduct and standards for high quality research, treat colleagues fairly and equally, and try to instil good values in students and staff.
- When assessing the track record of fellow researchers, for example as a grant reviewer or appointments panel member, use a broad range of criteria, without undue reliance on journal impact factors.
- Consider ways of sharing work with others wherever possible, for example, by choosing accessible journals, making published work available in public repositories and sharing datasets.

- Engage with funders, publishers and learned societies to maintain a two-way dialogue and to contribute to policy-making, for example by responding to consultations, attending events or sitting on committees.

- Seek out a mentor and/or be a mentor to someone else.

- Frequently assess your career options and consider opportunities to widen your experience.

LEARNED SOCIETIES AND PROFESSIONAL BODIES

- Promote widely the importance of ensuring that the culture of research supports good research practice and the production of high quality science.

- Take account of the findings of this report in relation to guidelines for members on ethical conduct and professionalism.

- Encourage and support funding bodies, research institutions, publishers and editors and researchers to recognise and fulfil their roles in shaping the culture of research.

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