

Response to the British Academy's call for evidence on '*Interdisciplinarity*'

Summary

- Many of the major challenges that society faces today will require solutions developed through interdisciplinary research and cross-disciplinary collaboration. Improving support for and addressing the barriers to this work could contribute to major scientific breakthroughs at the interface of disciplines, develop new technologies and ultimately support the economy and develop novel solutions to societal challenges.
- Universities and funders have made recognisable commitments to promoting interdisciplinary and multidisciplinary research. However, current structures often continue to favour single-discipline research and despite efforts to increase provision, there is scope for interdisciplinary and multidisciplinary work to be supported more effectively. This could, in part, be achieved through greater interdisciplinary training and informal discussion networks, and would be particularly helpful for researchers at the early stages of their career.
- For researchers moving into new areas without a track record of expertise, such as interdisciplinary and multidisciplinary research, there is greater risk compared to single discipline research. Yet this should be encouraged, acknowledging the potential for bigger breakthroughs and more frequent failures that are possible in multidisciplinary and interdisciplinary research.
- There are fewer avenues for publishing interdisciplinary research than single-discipline research. This can reduce the incentive for those trying to forge a career in interdisciplinary research and potentially limit the dissemination of findings from important interdisciplinary projects. The Royal Society would like to see the expansion of journals with more varied remits.
- Interdisciplinary research can be more challenging to peer review than single-discipline research, and there should be greater flexibility in review processes for interdisciplinary funding applications and research papers. These processes may require more reviewers to be involved in the assessment process and greater collaboration between reviewers in different disciplines to ensure the right mix of expertise and knowledge is brought to bear.

Introduction

1. The Royal Society welcomes the opportunity to respond to the British Academy's call for evidence on '*Interdisciplinarity*.' The Royal Society is the national academy of science for the UK. It is a self-governing Fellowship of many of the world's most distinguished scientists working across a broad range of disciplines in academia, industry, charities and the public sector. The Society draws on the expertise of the Fellowship to provide independent and authoritative scientific advice to UK, European and international decision makers.
2. This submission sets out the Society's positions on interdisciplinarity and multidisciplinary research and higher education. It builds on the Society's previous positions and contributions to discussions about this topic and draws on advice from several of the Society's Fellows. The Society is also an academic publisher of interdisciplinary journals and a funder of research across the full breadth of natural sciences. This submission therefore also draws on the Society's experience in these areas.

3. Under the title '*Interdisciplinarity*', this Call for Evidence covers a wide range of research taking place across disciplines. In this response the Society distinguishes between interdisciplinary and multidisciplinary research. The Society refers to interdisciplinary research where there is integration between two different disciplines that creates new areas of research. The Society refers to multidisciplinary research where individuals from different disciplines work in collaboration on a project. The Society refers to both methods of research throughout this response, but recognises the distinction between the two, particularly as these types of research can require different systems of support.
4. Broadly reflecting the Call for Evidence, the Society's response is divided into five sections:
 - Interdisciplinarity and multidisciplinary in research
 - Interdisciplinarity and multidisciplinary in higher education
 - Research Funding
 - Publishing
 - Conclusion

Interdisciplinarity and multidisciplinary in research

5. Many new and exciting discoveries have resulted from research across the boundaries of traditionally distinct disciplines, for example, plate tectonics was understood because physicists started working in geology.¹ Similarly, strength in mathematical, statistical and computational methods is key to progress in many of the biological sciences. As research becomes ever more cross-disciplinary the boundaries between different types of research fields are likely to become ever more permeable.²
6. The need for more and better interdisciplinary and multidisciplinary research is in part driven by the nature of many of the major challenges of the 21st century. The impacts of an ageing population, food security and climate change, will require solutions drawing on expertise across the full range of the engineering, social, physical, medical, chemical, biological and mathematical sciences.³ Interdisciplinary and multidisciplinary research and collaboration will only become more important as we tackle global issues on this scale. For example, tackling climate change and improving energy policy will require engineering as well as economics. Developing biotechnology will involve research in medicine as well as physics. To address cybersecurity threats people will need to be trained in ethics and international law, as well as data analytics.
7. There is a growing sense that the different technical and professional skills, and approaches used in interdisciplinary and multidisciplinary research can lead to more effective solutions.⁴ Interdisciplinary and multidisciplinary research is often challenge-led, or inspired by a particular issue that requires a combined approach. This means that it can often take a more holistic approach than single discipline research. Where single discipline research can sometimes isolate one factor from its natural setting and measure it to a very high level of precision, interdisciplinary

¹ Royal Society (1996) *Interdisciplinarity – Transport and the Environment*
https://royalsociety.org/~media/Royal_Society_Content/policy/publications/1996/10203.pdf

² The Royal Society, the Academy of Medical Sciences, the British Academy and the Royal Academy of Engineering (2014) *Response to BIS consultation on proposals for long-term capital investment in science and research*
<https://royalsociety.org/~media/policy/Publications/2014/040714-joint-academies-response-to-capital-consultation.pdf>

³ The Royal Society, the British Academy, the Royal Academy of Engineering and the Academy of Medical Sciences (2013). *Fuelling prosperity. Research and innovation as drivers of UK growth and competitiveness.*
https://royalsociety.org/~media/Royal_Society_Content/policy/publications/2013/2013-04-22-Fuelling-prosperity.pdf

⁴ Nesta (2010) *Creating value across boundaries. Maximising the return from interdisciplinary innovation.*
https://www.nesta.org.uk/sites/default/files/creating_value_across_boundaries.pdf

and multidisciplinary research can explore all aspects of a complex and challenging problem.⁵ In crossing the boundaries of academic disciplines to tackle major challenges, working across disciplines can deliver high-impact research.⁶

8. Interdisciplinary and multidisciplinary research can feed into the development of new technologies, which can generate spinouts and new devices, for example in biotechnology. The development of new technologies through interdisciplinary and multidisciplinary research can offer opportunities for entrepreneurial endeavour. As a result of this innovation, investment in interdisciplinary and multidisciplinary research can feed into the economy and develop novel solutions to societal challenges. The value of interdisciplinarity in research is demonstrated not only by the outputs of research, but also through improvements to the research methods that can result. Interdisciplinary research can create new models of thinking and new techniques of developing knowledge, such as 'big data' analytics, which translate across other boundaries.
9. As science becomes increasingly interdisciplinary, the boundaries between previously distinct fields blur as ideas and tools are exported from one discipline to another. These shifts challenge the way that science is funded, conducted, communicated, evaluated and taught.⁷
10. The UK has a world-leading research base with excellence across the breadth of academic disciplines.⁸ The excellence and productivity of UK researchers and institutions make them attractive partners for the best and most ambitious in the rest of the world, which is crucial to keeping UK research at the cutting edge.⁹ This strength and breadth in the UK's research base, as well as the UK's role as a hub for international collaboration, makes UK researchers particularly well-placed to work together across disciplines to address major national and global challenges.
11. Multidisciplinary research can require researchers and practitioners to work collaboratively across disciplines that vary greatly in methodologies, terminologies and philosophies, such as the natural and social sciences. Different disciplines can also often deal with different time-scales, which can make for complications in constructing models that are valid for both.¹⁰
12. Researchers specialising in traditional disciplines can benefit from having experience working across different disciplines. Individual researchers do not necessarily have to focus all their time on interdisciplinary and multidisciplinary research, but can develop relevant skills and experience that will enable them to collaborate across disciplines.
13. The lack of effective means of communication can be a barrier to interdisciplinary and multidisciplinary research, and it is important for researchers to establish a common language. Effective communication within research teams is vital to ensure that the variation in methodology and terminology between disciplines is understood. Successful communication is often forged over time, but can be enhanced if researchers are able to broaden their own expertise, by seeking out the opportunities to learn beyond their specialist areas.

⁵ Royal Society (1996) Interdisciplinarity – Transport and the Environment

https://royalsociety.org/~media/Royal_Society_Content/policy/publications/1996/10203.pdf

⁶ Bridle, H. et al. (2013) Preparing for an interdisciplinary future: A perspective from early career researcher. *Elsevier*
<http://www.sciencedirect.com/science/article/pii/S0016328713001158>

⁷ Royal Society (2012) Science as an open enterprise

https://royalsociety.org/~media/royal_society_content/policy/projects/sape/2012-06-20-saoc.pdf

⁸ Department for Business, Innovation and Skills (2014) Our plan for growth: science and innovation

https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/387780/PU1719_HMT_Science_.pdf

⁹ The Royal Society, the British Academy, the Royal Academy of Engineering and the Academy of Medical Sciences (2015). Building a Stronger Future: Research, Innovation and Growth.

<https://royalsociety.org/~media/policy/Publications/2015/building-a-stronger-future-research-innovation-growth.pdf>

¹⁰ Royal Society (1996) Interdisciplinarity – Transport and the Environment

https://royalsociety.org/~media/Royal_Society_Content/policy/publications/1996/10203.pdf

14. Effective communication between researchers and practitioners in different disciplines can be facilitated by creating opportunities for formal and informal interaction. For example, in 2015 the Royal Society held a meeting on 'The paradigm shift for UK forensic science,' which brought together scientists from many different disciplines within the field of forensic science, to discuss new areas of research. The Society also brings together researchers at similar career stages in different disciplines at conferences for Society-funded Research Fellows. These events include discussion sessions across disciplines and offer opportunities for informal networking.
15. Universities, research funders and systems of research assessment are slowly adapting to interdisciplinary work, but still often reinforce disciplinary borders and prohibit more creative collaborations.¹¹ For instance, funding streams and tenure criteria often preserve the existing structural standards within academic departments.¹² Structures and cultures within Higher Education Institutions (HEIs) can act as barriers to work with an interdisciplinary focus. The structural division of academic disciplines into discrete departments can also create a 'silo mentality' and discourage collaborative research.¹³
16. The Society welcomed the changes made to the Research Excellence Framework (REF) to include four new measures to support interdisciplinary research.¹⁴ The results of the REF 2014 showed that interdisciplinary research was found to be of equal quality to disciplinary outputs.¹⁵ It is still too early to say if this support has helped to overcome the challenges faced by those working in interdisciplinary research, but support for the recognition of interdisciplinary research in the REF should continue in the future.

Interdisciplinarity and multidisciplinary in higher education

17. Many of the challenges for interdisciplinary and multidisciplinary research described above affect higher education too, as the people, practices and institutions involved are often the same. The Society therefore hopes that the British Academy will consider these issues together. This section covers those issues that are specific to higher education.
18. As discussed above, there is scope for all researchers to develop professional and technical skills to support their ability to collaborate across disciplines. However, some researchers will focus specifically in interdisciplinary areas, and interdisciplinary training is an important pathway into research, particularly for fields with an interdisciplinary character. Interdisciplinary training can help develop the practitioners that society needs. It provides a way for individuals who do not plan to go on to postgraduate research to broaden their undergraduate expertise, and develop knowledge and skillsets that span multiple disciplines. Such training provides a way of connecting disciplines and developing strength in other areas, such as mathematical, statistical and computational methods, before research is commenced.¹⁶
19. Interdisciplinary training is currently being delivered as part of 3+1 doctoral programmes within some Centres for Doctoral Training (CDTs). While their remit has now broadened, CDTs were

¹¹ Royal Society (2010) The Scientific Century: securing our future prosperity https://royalsociety.org/~media/Royal_Society_Content/policy/publications/2010/4294970126.pdf Jacob, W. (2015)

¹² Interdisciplinary trends in higher education. *Pelgrave Communications* <http://www.palgrave-journals.com/articles/palcomms20151>)

¹³ Royal Society (2011) Knowledge, Networks and Nations. Available at: https://royalsociety.org/~media/Royal_Society_Content/policy/publications/2011/4294976134.pdf

¹⁴ Royal Society (2009). Response to HEFCE's second consultation on the assessment and funding of higher education research. RS Policy Document 12/09 https://royalsociety.org/~media/Royal_Society_Content/policy/publications/2009/1111111396.pdf

¹⁵ Research Excellence Framework (2014) Research Excellence Framework 2014: The results <http://www.ref.ac.uk/media/ref/content/pub/REF%2001%202014%20-%20full%20document.pdf>

¹⁶ Royal Society (2015) Response to BIS consultation on postgraduate support. <https://royalsociety.org/~media/policy/Publications/2015/190515-letter-postgraduate-support-consultation.pdf>

initially set up to increase capacity in interdisciplinary research activities.¹⁷ Many retain an explicit interdisciplinary focus, such as the Bristol Centre for Complexity Sciences¹⁸. There are advantages to this cohort-based doctoral training model, particularly in the context of interdisciplinary research where it is beneficial to be located outside of the rigid confines of university departments. However it should be noted that the development of CDTs is still a relatively new phenomenon - the impact of the concentration of funding and research disciplines has yet to be reviewed.¹⁹

20. It would be beneficial if the kind of interdisciplinary training offered through CDTs was made more widely available, including through standalone taught Masters.²⁰

Research Funding

21. There is more provision for interdisciplinary and multidisciplinary research in the funding landscape now than there was previously. For example the cross-Council Research Programmes, established by the Research Councils (RCUK) in 2007, coordinates the delivery of multidisciplinary research across six key research areas.²¹ In 2012, the RCUK joined G8 countries from across the world, in a funding initiative worth €20 million, to provide an international framework for cooperation across a broad range of disciplines.²² These efforts represent a shift towards more multidisciplinary and interdisciplinary-focused research, but it is difficult to measure the proportion of funding that is spent on interdisciplinary work due to variety in the remits of different funding schemes and the way they classify and support research across disciplines. Nonetheless, existing efforts by funding organisations still fall short of providing adequate support for interdisciplinary and multidisciplinary work. National funding streams still tend to be highly discipline-based and obtaining funding for emerging areas of research can be challenging.
22. Funding bodies can often be structured around disciplinary boundaries and review panels for grant applications can lack the knowledge needed to provide input across different disciplines.²³ Interdisciplinary research also needs substantial time commitment, and complexity of the research means results cannot always be produced within periods that grants currently run.²⁴ The opportunities for making interdisciplinary grant applications are therefore still relatively restricted. However, for funding streams that are more focussed on individual researchers, interdisciplinary experience could be beneficial, supporting the individual to develop a more-diverse range of skills, which can differentiate their application from others.
23. Interdisciplinary research might be at a disadvantage when reviewed by research funders, as there can be greater risk where researchers are moving into areas in which they do not have a track record of expertise. This could result in researchers being discouraged from pursuing interdisciplinary research. Funding bodies should find appropriate ways to support work across disciplines, acknowledging the higher risk that this can entail and the potentially greater rewards.

¹⁷ Institute of Physics 2015 Survey of Physics and Astronomy Doctoral Research Students' Experiences and Career Intentions http://www.iop.org/publications/iop/2015/file_65623.pdf

¹⁸ <http://www.bris.ac.uk/bccs/>

¹⁹ Royal Society (2015) Response to BIS consultation on postgraduate support.

<https://royalsociety.org/~media/policy/Publications/2015/190515-letter-postgraduate-support-consultation.pdf>

²⁰ Royal Society (2015) Response to BIS consultation on postgraduate support.

<https://royalsociety.org/~media/policy/Publications/2015/190515-letter-postgraduate-support-consultation.pdf>

²¹ <http://www.rcuk.ac.uk/research/xrcprogrammes/>

²² Gewin, V. (2014) Interdisciplinary research: Break out

<http://www.nature.com/naturejobs/science/articles/10.1038/nj7509-371a>

²³ Conole, G., Scanlon, E., Mundin, P. and Farrow, R. (2010) Interdisciplinary research: findings from the Technology Enhanced Learning Research Programme. <http://www.tlrp.org/docs/TELInterdisciplinarity.pdf>

²⁴ Royal Society (1996) Interdisciplinarity – Transport and the Environment

https://royalsociety.org/~media/Royal_Society_Content/policy/publications/1996/10203.pdf

Royal Society Research Funding

24. The Royal Society provides a range of grant schemes to support the UK scientific community and foster collaboration between UK-based and overseas scientists, across the breadth of the natural sciences. The majority of the Society's Grants schemes are open to researchers from all disciplines and selection criteria are focussed on the strength of the candidate and the quality of their research, rather than their fit within a specific discipline. Interdisciplinary applications are welcomed.
25. The assessment process varies between schemes but may include a shortlisting process, peer review and an interview. Funding decisions are made by the relevant appointment panels, which are usually chaired by a Fellow of the Royal Society. For larger schemes, there are several panels focussed in different subject areas and for smaller schemes, there is one panel, comprising experts from different subject areas. Applications from interdisciplinary researchers are sometimes passed between panels or individuals in order to ensure that they are reviewed by appropriate experts. Having sufficient flexibility in the Society's assessment process is fundamental to the Society's ability to fairly review interdisciplinary applications.
26. The Society also operates a number of international schemes for capacity building, collaboration and travel. Some schemes issue calls in specific research priority areas, which are challenge-led rather than focussed on a specific discipline, for example 'water and sanitation'. These types of schemes can elicit interdisciplinary applications from consortia of researchers working in quite disparate disciplines, from soil microbiology to economics. Ultimately, the potential of the proposed approach to tackle the challenge at hand guides the selection process, rather than whether the work is interdisciplinary per se.

Publishers and editors

27. For academic scientists and researchers, publishing is a key part of professional life and it plays an important role in a scientist's career trajectory. There are currently a limited number of interdisciplinary research publications and many 'prestigious' journals cater specifically to traditional disciplines. It can be difficult to define areas of interdisciplinary research, and therefore for researchers to find a place within the available range of academic journals. If it cannot find a route for dissemination, interdisciplinary research can be disadvantaged relative to work in traditional disciplines.²⁵

Royal Society Publishing

28. The Royal Society publishes cutting edge science in ten journals covering the broad spectrum of the life and physical sciences, including the longest running science journal in the world, *Philosophical Transactions*.
29. Historically, the Society's journals were divided between the physical sciences and life sciences. In May 2004 the Royal Society launched *Interface*, its first new journal for over 60 years. It was a response to feedback from scientists who were finding it difficult to publish interdisciplinary work that crossed the traditional boundaries between the physical and life sciences. *Interface* publishes work which is not easily categorised into the classical subject areas. For example the mathematical modelling of infectious disease spread, or the engineering of new organisms.²⁶

²⁵ Lee, C. (2006) Perspective: Peer review of interdisciplinary scientific papers. *Nature*
<http://www.nature.com/nature/peerreview/debate/nature05034.html>

²⁶Royal Society (2010) The Scientific Century: securing our future prosperity
https://royalsociety.org/~media/Royal_Society_Content/policy/publications/2010/4294970126.pdf

30. Rather than shoring up the boundaries between fields, *Interface* acknowledges their blurring. The rapid emergence of areas such as synthetic biology has brought together authors from engineering, biology, computer science and elsewhere. In less than three years, *Interface* became the fourth most highly-cited interdisciplinary journal in the world, behind *Science*, *Nature* and the *Proceedings of the National Academy of Sciences*. The number of articles submitted to the journal has grown rapidly (30% per year on average). This rapid rise in submissions is indicative of demand for such publications.
31. In August 2008 the Society launched *Interface Focus*, its second interdisciplinary journal. *Interface Focus* covers the same subject remit as *Interface*, but publishes themed issues, rather than individual submitted research articles. Topics may be newly emerging areas of research or dynamic aspects of more established fields.
32. In 2014, the Society published a total of 2447 articles across all journals, of these 17% were in the two interdisciplinary journals, *Interface* and *Interface Focus*. The interdisciplinary nature of *Interface* and *Interface Focus* means that they cater for new audiences, and the two journals have built a strong following and helped define a community of authors and readers.
33. Interdisciplinary research poses challenges for peer review compared to traditional, disciplinary research. The reviewers may be limited by their unfamiliarity with the subject and understanding of the methodology. The Society's two interdisciplinary journals address this issue by using more reviewers (often 5 or 6, compared with 2 or 3 in traditional journals) and encourage a more collaborative review process to better deal with such articles.

Conclusion

34. The complex global challenges we face today require expertise and collaboration across a host of disciplines. Facilitating and promoting interdisciplinarity in research and higher education, and supporting researchers from different disciplines to work together, is vital if we are to tackle major issues such as climate change and cybersecurity threats. In recent years, the current system has become more accommodating of research that crosses traditional disciplinary boundaries, yet challenges for research and education in institutions, funding and publication can still act as a barrier to interdisciplinary and multidisciplinary research.
35. To continue to establish interdisciplinarity and multidisciplinary as normal ways of working within research and higher education the appropriate structures and cultures need to be in place. The Society looks forward to seeing the outcomes of this project and hopes that this will identify steps to better support interdisciplinary and multidisciplinary research in the future.

For all enquires please contact Becky Purvis, Head of Public Affairs becky.purvis@royalsociety.org