THE FUTURE OF INTERDISCIPLINARY RESEARCH BEYOND REF 2021

The Physiological Society

Research Consulting

ACKNOWLEDGEMENTS

We are grateful to the members of the Steering Group who offered their time and expertise to ensure the success of the project.

The views expressed in this report should not be attributed to any one individual or organisation that contributed to this work unless otherwise stated. The findings and recommendations in the report do not necessarily reflect the position of the organisations represented on the Steering Group.

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FOREWORD

The role of interdisciplinary research to address research questions posed by global social, economic, ecological and political changes is widely recognised. It is timely that this report should launch as delegates are meeting in Glasgow for the 2021 United Nations Climate Change Conference (also known as COP26), to discuss how the world will meet its 'Net Zero' commitments by 2050. Achieving these targets will require creative and innovative solutions that draw on all the physical, life and social sciences. Beyond the climate crisis, interdisciplinary science is fundamentally important in other areas of research including better understanding and modulating the ageing process.

Physiology is by nature an interdisciplinary science – understanding how fundamental processes work and interact with other systems in the body in good health to then understand how to respond to ill health. My own research for example, is focused on cellular physiology in the heart but by understanding this, we can better understand what causes heart disease and its impact on other organs and systems in the body.

As such, ensuring that interdisciplinary science is fully recognised as part of the next research assessment process will not only support the prioritisation of physiology, but other interdisciplinary disciplines too. This project has also been an excellent opportunity to hear directly from those responsible for reviewing and adapting the next research assessment cycle about concerns raised by the research community with the current system and the policy options that have been presented about how to address them. This puts The Society in a strong position to help inform the consultation process in the coming months and years.

The most recent Research Excellence Framework (REF) cycle not only provides benchmarking information for use within the higher education sector and the wider public but is also responsible for the competitive allocation of over £2 billion of public funding for research. This financial pressure gives extra focus on the need to ensure the outputs of interdisciplinary research are fully recognised. Over time interdisciplinary research can re-shape the landscape creating new fields that consolidate from interdisciplinary origins and combine skills that were previously disparate. That we are launching this report in the shadow of the COVID-19 pandemic is another timely reminder that interdisciplinary research is a prerequisite for tackling major societal challenges.

I would like to take this opportunity to thank everyone that participated in the Steering Group and those researchers that took the time to develop and share the case studies that are dotted throughout the report. Their contributions have undoubtedly shaped and strengthened the final report and, I hope, sparked conversations and potential collaborations that will extend beyond the life of the project.

Professor David Eisner
Chair of the Steering Group

EXECUTIVE SUMMARY

Background

This report was commissioned by The Physiological Society to provide greater understanding of how the Research Excellence Framework (REF) and its associated processes affect interdisciplinary research (IDR). It recognises a research landscape where the ability to work effectively in IDR teams is a growing requirement for many research funders, including industry.

The position and assessment of IDR within research assessment and evaluation is an area of longstanding focus and is manifest in all aspects of the research ecosystem, including access to grant funding, publications, and researcher career development.

This report identifies current views and builds on a growing body of evidence relating to interdisciplinary research focused on the approach to national research assessment. This report provides a contributing input to the 'Future Research Assessment Programme' which will investigate approaches to the evaluation of UK higher education research.

Interdisciplinary research is crucial and features heavily in the research landscape

The role of IDR to address research questions posed by global social, economic, ecological and political changes is widely recognised. Funding for research grants increasingly seeks interdisciplinary research teams, and there is significant overlap between mission- or challenge-led research and the need for interdisciplinary teams and approaches to address these challenges. The need for interdisciplinary skills and approaches is reinforced in the recent *Innovation Strategy* and *R&D People and Culture Strategy*. Over time IDR can re-shape the landscape creating new fields that build from interdisciplinary origins and combine skills that were previously disparate.

This review is informed by a representative set of expert participants

The work and recommendations were informed by a representative set of participants drawn from across the research community, these included academics and institutional research leaders, research managers, representatives from funding bodies, publishers and industry. Their collective experience includes the development and submission of institutional REF returns and involvement in a range of assessment panels, including REF.

In addition, a range of relevant literature and documentary sources has been reviewed, including reviews and analysis of IDR, previous REF consultations and evidence of good practice, challenges and incentives drawn from the wider literature.

There are long-standing concerns over the assessment of interdisciplinary research. This is linked to its contribution to a growing volume of mission- and challenge-led research

This review identifies a number of underpinning issues and associated recommendations for action before the next REF. This work identifies:

- longstanding concerns over IDR including within national research assessment in the UK (dating back to research assessment exercises in the 1990s);
- trust and confidence in peer review for IDR is an underpinning issue, and the discipline-led unit of assessment structure influences the selection of IDR for submission to REF;
- a growing imbalance between the significance and pervasiveness of mission- or challenge-led research in the wider funding landscape and the extent to which this is reflected in the discipline-led REF;

- the difficulties in identifying and understanding the extent of IDR through bibliometrics;
- that IDR is complex with many sub-types and features that influence the risks researchers face in undertaking it, and our ability to understand and segment issues with greater focus; and
- the need for a better understanding of IDR and research teams for effective review and assessment.

Conclusions and recommendations: we recommend that the next REF adopts a structure which explicitly identifies and rewards interdisciplinary research

Our conclusions demonstrate IDR's growing importance to address major research challenges, sector level reward and recognition for interdisciplinary work, and the influence REF has as a policy tool in delivering widespread sector change (evidenced by impact).

We therefore recommend that the next REF adopts a structure which **explicitly identifies and rewards IDR**.

- The structure of a future assessment exercise should provide the flexibility for **universities** to submit coherent evidence of their interdisciplinary research against themes relevant to the strengths and priorities of that university.
- A future REF should introduce flexibility to allow individuals whose research and outputs straddle discipline-based assessment structures to be returned to multiple units. This recognises the **breadth of the research teams** in which they operate and the outputs generated from this.
- We recommend that REF forms contain an option for an additional context narrative to explain the **interdisciplinary context** of research outputs.

THIS REPORT PROVIDES A CONTRIBUTING INPUT TO THE 'FUTURE RESEARCH ASSESSMENT PROGRAMME' WHICH WILL INVESTIGATE APPROACHES TO THE EVALUATION OF UK HIGHER EDUCATION RESEARCH.

Building on the wider evidence and perspectives on interdisciplinary research, the report identifies a number of additional recommendations for the sector:

- We recommend that professional and learned societies develop activities **to support and facilitate the development of interdisciplinary collaborations** with a broad array of different disciplines ("near" and "far" disciplines).
- We recommend further work to establish how **greater understanding and characterisation of IDR can be applied into wider practical use** via a future REF exercise. In particular, the cultural and linguistic distance between disciplines which are 'far' apart is a major factor in researchers' perceptions of risk, including the difficulties in developing the research collaboration, in accessing funding and in dissemination of the research.
- We recommend addressing trust and confidence in peer review. Funders and publishers should work together to identify specific measures to **enhance capacity and capability for interdisciplinary peer review** across all types of review.
- We recommend addressing ongoing perceptions of negative impacts on **career development** for researchers involved in IDR. There is a lack of evidence that provides an up-to-date perspective on this.

1 INTRODUCTION AND APPROACH

1.1 Purpose of this report

This report examines how the Research Excellence Framework (REF), and associated processes affect interdisciplinary research (IDR)[1]. Although commissioned by The Physiological Society, this research is designed to provide a broad view of the IDR landscape and represents perspectives from other disciplines as well as physiology.

It is intended that this report will provide a direct input to the 'Future Research Assessment Programme' (FRAP) which will investigate approaches to the evaluation of UK higher education performance **(UKRI, 2021a)**. The core objective of this work is to provide evidence and recommendations on how IDR can be best considered in future national research assessments.

1.2 Approach and methodology

This work, and the resulting recommendations, were informed by a representative set of participants drawn from across the research community. Participants included academics and institutional research leaders, research managers, research funding bodies, publishers, and industry representatives. Collectively, participants in this work had experience of the development and submission of institutional REF returns and involvement in a range of research assessment panels, including REF.

The remit of this report considered the 'entire REF process', considering how REF influences researchers and universities in advance of the formal assessment (Figure 1).

To deliver this work, we undertook 18 semi-structured interviews with participants, supplemented by two additional workshops. The workshops considered the views of nine early career researchers (ECRs) and eight stakeholders involved in publishing and scholarly communications.

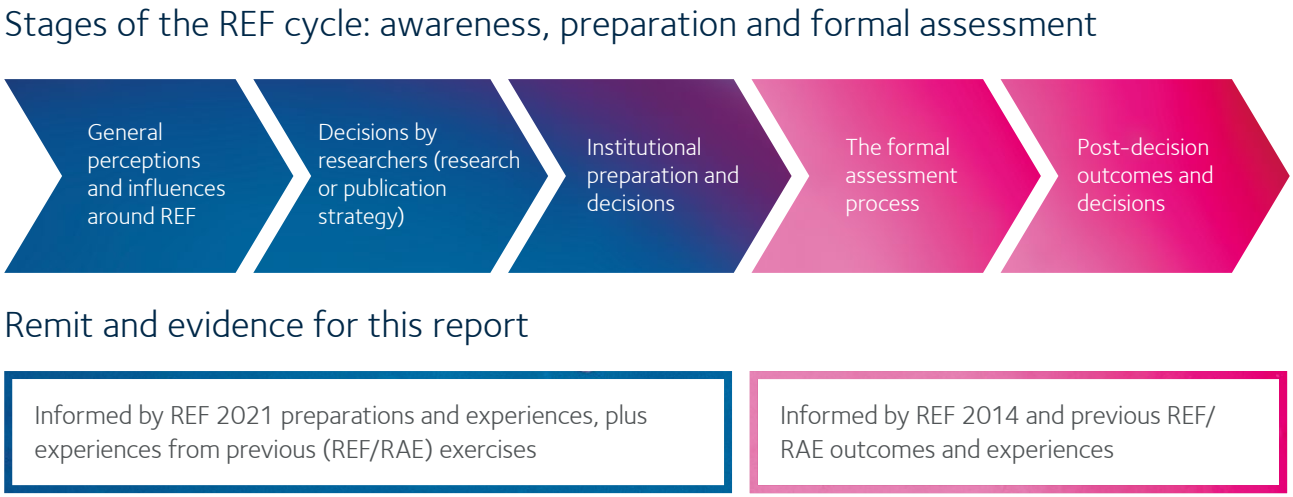
The inclusion of stakeholders from publishing and scholarly communications is based firstly on the weighting applied to outputs in REF 2021 (60%, and the majority of submitted outputs are publications) and secondly on prior evidence indicating concerns in terms of the availability and status of IDR journals **(European Council of Doctoral Researchers, 2014; McLeish & Strang, 2016)**.

In addition, a range of relevant literature and other documentary sources has been reviewed, such as reviews and analysis of IDR and previous REF consultation responses. The literature was reviewed to identify evidence of good practice, challenges and incentives associated with IDR and research assessment.

Limitations and scope

This work was completed between June and September 2021. This review therefore considers evidence from analyses or experiences of previous research assessment exercises and considers REF 2021 guidelines and experiences up to the point of submission for REF 2021. It does not attempt to consider or assess how the live process of review is being undertaken during REF 2021, as illustrated in Figure 1.

Figure 1 Points of influence throughout the REF cycle and the evidence that will have informed consultees' responses for this review



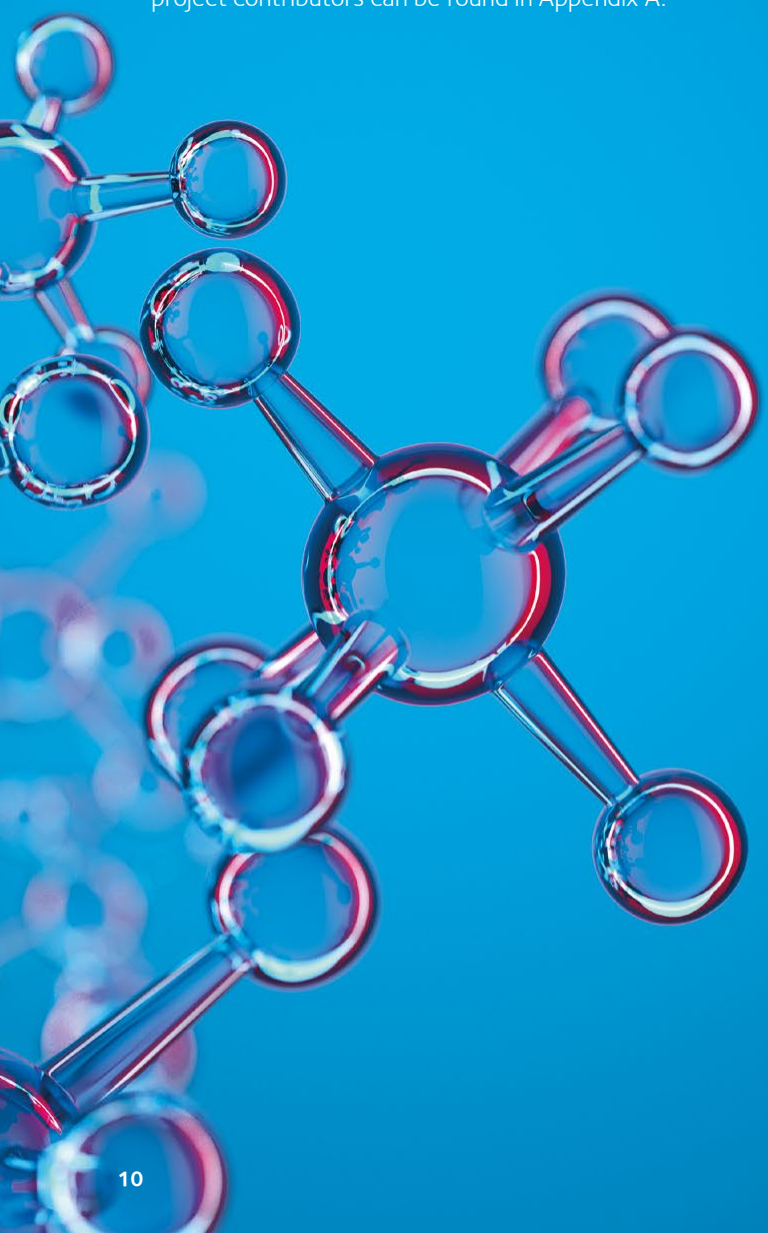
1. The term interdisciplinary research (IDR) is used throughout this report to represent all forms of collaboration between disciplines including multidisciplinary and transdisciplinary research.

In terms of contributions to our research, a long list of participants, representative of the research community, was developed with input from the Steering Group. From this, interviewees were identified via convenience sampling i.e., we spoke to stakeholders that were available at the time of the review. Due to continuing restrictions as a result of COVID-19, all stakeholder consultation was conducted virtually.

Acknowledgements

The project team at Research Consulting gratefully acknowledge the assistance of Andrew Mackenzie, Tom Addison, and Simon Rallison at The Physiological Society for their expert guidance throughout the project. We would also like to thank the expert Steering Group that supported this work, chaired by David Eisner, the members of which can be found listed in Appendix A.

Finally, we record our appreciation for the individuals who were interviewed throughout this project, both for their valuable insights and for their time, without which this study would not have been possible. A complete list of project contributors can be found in Appendix A.



1.3 **Overview and context**

Whilst commonly used, the term interdisciplinary research is subject to many different interpretations **(Tang et al., 2014)**. For example, other terminology, most commonly multidisciplinary, transdisciplinary and crossdisciplinary define specific types of IDR but in practice are used interchangeably **(Davé et al., 2016; Elsevier, 2015)**.

This report uses the definition of IDR recommended by the Interdisciplinary Research Advisory Panel and focuses particularly on the achievement of "outcomes (including new approaches) that could not be achieved by established disciplinary approaches alone:

> "Interdisciplinary research is understood to achieve outcomes (including new approaches) that could not be achieved by established disciplinary approaches alone. Interdisciplinary research features significant interaction between two or more disciplines and/or moves beyond established disciplinary foundations in applying or integrating research approaches from other disciplines."
>
> Interdisciplinary Research Advisory Panel, 2019

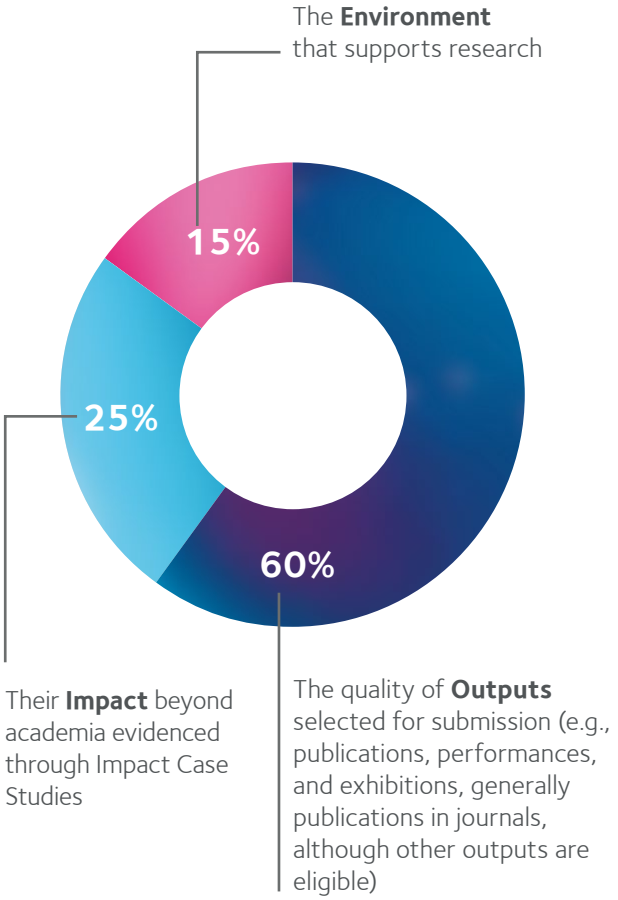
Assessing research excellence in the UK

The Research Excellence Framework (REF) is the UK's system for assessing the excellence of research in higher education providers. The REF outcomes are used to inform the allocation of around £2 billion per year of public funding for universities' research. **(REF, 2019)**.

Research England manages the REF on behalf of all four UK higher education funding bodies: Research England, the Scottish Funding Council, the Higher Education Funding Council for Wales and the Department for the Economy, Northern Ireland. The funding bodies' shared policy aim for research assessment is to, "secure the continuation of a world-class, dynamic and responsive research base across the full academic spectrum within UK higher education" **(REF, 2020c)**.

REF expert panels

The REF is a process of expert review, with discipline-based expert panels assessing submissions made by higher education institutions (HEIs) in 34 Units of Assessment (UoAs) within five main panels (REF, 2020a). Submissions against a UoA include three distinct elements which are weighted differently:



Purposes of the REF

The REF fulfils a number of purposes, directly in terms of the aims of the funding bodies, and indirectly via influence on wider decisions. This purpose is outlined in the REF guidelines **(REF, 2020a)**:

- to inform the selective **allocation of block grants** for research;
- to provide **accountability for public investment** in research and evidence of the benefits of this investment; and
- to enable **benchmarking and reputational yardsticks**, for use within the HE sector and for public information.

In addition, the review of research assessment undertaken following REF 2014 **(Stern, 2016)** identified three further roles fulfilled by the REF and these are recognised in the formal guidance for REF 2021 **(REF, 2020a)** demonstrating the reach and influence of REF.

- to provide a rich **evidence base** to inform strategic decisions about national research priorities;
- to create a strong **performance incentive** for HEIs and individual researchers; and
- to **inform decisions on resource allocation** by individual HEIs and other bodies.

Policy context and drivers for IDR

A number of policy and review activities are ongoing within the UK research landscape. We have identified the following activities that are relevant to this report and IDR more broadly:

- The importance of IDR in delivering impact, linked to the UK *Innovation Strategy* **(Department for Business, Energy & Industrial Strategy, 2021c)** and the increased importance of mission-driven research;
- An increased focus on team science and interdisciplinarity with a likely increase in reporting within REF around how these activities should be encouraged and assessed within an institutional research ecosystem **(Grove, 2021)**;
- Increased emphasis on developing researchers able to deliver IDR **(Department for Business, Energy & Industrial Strategy, 2021b)**;
- The review of research bureaucracy which includes a review of approaches for research assessment **(Department for Business, Energy & Industrial Strategy, 2021a)**.

2 WHY INTERDISCIPLINARY RESEARCH MATTERS

2.1 Benefits and opportunities of IDR

IDR is widely recognised as being vital to addressing complex research questions. The British Academy identifies the "essential role of IDR to address research questions posed by global social, economic, ecological and political changes" **(British Academy, 2016)**. The Physiological Society identified that interdisciplinary working and interdisciplinary sciences "are crucial to address improved lifelong health and healthy ageing" (The Physiological Society, 2019).

Similarly, previous work consistently identifies the strengths and benefits of IDR **(Allmendinger, 2015; British Academy, 2016; McLeish & Strang, 2016)**, which include:

- addressing complex societal challenges through mission- or challenge-led research;
- supporting problem or user driven research, including open innovation;
- extending the potential for serendipity in research into unexpected contexts and new research topics; and
- strengthening translational research to realise real world impact.

Other studies also reported positive benefits of IDR in terms of stakeholder or research user engagement, because they recognised that the research was being approached from different angles **(Tang et al., 2014)**.

IDR within the wider funding landscape

The UK Research and Development Roadmap notes the efforts that UKRI and its research councils have made to deliver more ambitious IDR and innovation **(Department for Business, Energy and Industrial Strategy, 2020)**. This is reinforced in the *Innovation Strategy* and the *R&D People and Culture Strategy* **(Department for Business, Energy & Industrial Strategy, 2021b, 2021a)**.

In particular, the *Innovation Strategy* highlights the need to nurture interdisciplinary innovators as it recommends, "encouraging interdisciplinary innovators who have breadth across disciplines and who can thrive both in academia and in business". It also recognises the importance of design and creative sectors in this, citing the innovator who moved from "game design and neuroscience to artificial intelligence, growing a team that combined insights from both former fields to influence the direction of AI."

Similarly, the *R&D People and Culture Strategy* announced a pilot to help researchers acquire skills and knowledge beyond their own discipline and encourages funders to ensure criteria for grants are supportive of interdisciplinary and intersectoral research, and of researchers moving between fields.

Funding for interdisciplinary approaches and collaborations is frequently through **mission- or challenge-led research**. The *Industrial Strategy* and Global Challenges Research Fund (GCRF) can be cited as examples **(Academy of Medical Science, 2019; Global Research Council, 2021)**.

Shaping the academic landscape through IDR

IDR is also recognised to have the potential to "re-shape the academic landscape…and even transform disciplines themselves" **(McLeish & Strang, 2016)**. This is observed in the trajectory of 'neuroscience' exemplified in 1997 as an area of "emerging international recognition as a new interdisciplinary area of fundamental importance" **(Scottish Universities Research Policy Consortium (SURPC), 1997)** and now firmly established as a discipline evidenced by structural inclusion in university department titles and REF 2021.

IDR and team science

There is also recognition that team-based, IDR is becoming much more impactful when it comes to solving global and national problems, highlighted by Dame Ottoline Leyser, Chief Executive of UKRI **(Grove, 2021)**. Measures to better recognise and support **research teams** are positive for the promotion and recognition of IDR and the extent of new UKRI schemes requiring IDR 'team science' approaches are observed **(Academy of Medical Science, 2019)**.

2.2 Previous analysis of IDR: barriers and challenges

Just as the benefits of IDR are well established, a number of challenges and issues are persistently evident in the literature. In practice, it is acknowledged that "truly transformative IDR remains complex and difficult" **(Gibson et al., 2018)** with a number of barriers present around perceptions, risk and status of IDR **(Gleed & Marchant, 2016)**.

Longstanding perceptions of IDR

Concerns around IDR are **consistent and long-standing** (Lyall & King, 2013; Scottish Universities Research Policy Consortium (SURPC), 1997). These concerns extend beyond the Research Assessment Exercise (RAE) and the REF formats of research assessment, and out to funding for research grants, the development of academic careers, the publishing landscape, bottom-up support and building collaborations for IDR.

Peer review and evaluation of IDR

Peer review and evaluation are consistently cited as areas of concern within IDR assessment and evaluation **(British Academy, 2016; McLeish & Strang, 2016)**. The significance of these has extended to suggestions that peer review and evaluation influences researchers' engagement in IDR. For example, McLeish and Strang note, "the challenges of evaluating IDR have been cited as a barrier to undertaking it" **(McLeish & Strang, 2016)**. A selection of other notable studies relating to the remit of this work include:

Evaluation and peer review:

- An international review of peer review guidelines and evidence for interdisciplinary research, identifying recommendations for good practice **(Lyall & King, 2013)**.
- A detailed analysis of the evaluation of IDR, alongside practical guidelines for the evaluation of IDR research, recognising the importance of national research evaluation exercises to the 'value structure of research'. Building strong evaluative messages into criteria that support highly effective IDR is an imperative **(McLeish & Strang, 2016)**.

Analysis that considers the presence and shape of interdisciplinary research

- *Crossing Paths* **(British Academy, 2016)**, a review of interdisciplinary research and teaching, recognised a "deep need to promote interdisciplinarity" and underlined the importance of "research evaluation as critical to IDR".
- The landscape review of interdisciplinary research in the UK **(Davé et al., 2016)**, which recognised the confusion around terminology and ambiguity in recognising the different types and characteristics of IDR.
- A citation-based approach to identify and measure interdisciplinary research in the UK **(Pan & Katrenko, 2015)**.
- Recent reports on *Practice Research* **(Bulley & Sahin, 2021)**, supported by Research England, which emphasise interdisciplinarity and non-traditional research outputs.

Analysis specific to REF and/or impact considerations

- The review of research assessment following REF 2014, which included analysis and recommendations to address IDR within REF 2021 **(Stern, 2016)**.
- Post-REF 2014 analysis of impact **(King's College London, 2015)** which included consideration of interdisciplinary work and a study of interdisciplinarity within REF 2014 outputs using a citation-based approach **(Elsevier, 2015)**.
- The relationship between IDR and impact was analysed through the lens of selected ESRC-funded projects **(Tang et al., 2014)**, recognising the importance of the 'cognitive distance' between collaborating disciplines as a distinguishing feature.

Inherent disadvantages of disciplinary evaluation for IDR

Higher education systems typically reward 'research excellence' as it is defined by various disciplinary norms, and this is felt to disadvantage IDR **(Laudel & Origgi, 2006)**. Overall, the 'problem of fit' to a relatively rigid set of disciplinary-based structures for assessment is acknowledged to have a disincentive effect for interdisciplinary research **(Woelert & Millar, 2013)**.

An international review by research funding councils on IDR concluded that "there is a strong consensus that there is a need to modify peer review procedures to ensure that they are better suited for IDR purposes" **(Gleed & Marchant, 2016)**.

Evidence that exists around the structures adopted for peer review does not indicate an inherent issue with panel-only review **(Lyall & King, 2013)** with evidence from the US that panels can deal more effectively with interdisciplinary proposals. *Crossing Paths* **(British Academy, 2016)** places greater emphasis on the skills and experience of reviewers, including research users. Alongside this appropriate evaluation criteria for IDR are recommended with good practice identified **(McLeish & Strang, 2016)**.

In summary, interdisciplinary research is strongly featured as an important policy direction for research, and is positioned to address significant research challenges.

However, it is associated with a number of persistent concerns and disincentives that derive in part from the largely discipline-led structures for research. In the following sections contemporary perspectives, focused on the REF, are outlined.

CASE STUDY

Interdisciplinary collaborations to deliver impact: SUNRISE

Swansea University

The Strategic University Network for Revolutionising Indian Solar Energy (SUNRISE) is a transdisciplinary international collaboration led by Swansea University, supported by the Global Challenges Research Fund. The project is developing new, low cost, lightweight solar cells to bring energy to rural communities in India, where 300 million people lack reliable power.

Programme Director Dr Adrian Walters believes the project is on the cusp of delivering societal and economic impact, as well as breaking down pre-conceptions about what academic research can do. As well as bringing together researchers from academia and industry, chemists and other physical scientists are working with psychologists to ensure solutions are tailored to local communities and, where possible, manufactured locally. This interdisciplinary approach has been key. SUNRISE Chief Operating Officer, Dr Ian Mabbett, says: "Researchers often don't realise that when you step back and work with people from vastly different disciplinary backgrounds, the results can be really powerful. "[Although] a lot of the technologies we need to solve global challenges sit within the chemical sciences, we don't have the ability yet to use transdisciplinary research to drive true impact... There's a lot we need to do to broaden training and prepare undergraduate students to work in a more interdisciplinary environment."

3 DEVELOPING PRACTICE AND UNDERSTANDING FOR INTERDISCIPLINARY RESEARCH

OVERVIEW

In discussing IDR with participants, three issues consistently emerged that are relevant to their experience as researchers, but are wider than REF itself. These are:

Understanding the context for IDR, acknowledging the risks and measures to enhance practice.

Trust and confidence in peer review, focused on participation, experience and insights into good practice.

Reward and recognition for IDR, including career development.

3.1 Understanding the context for IDR

In practice there is huge variation between activities which researchers and funders consider to be 'interdisciplinary'. The basic question "how much research is IDR?" is difficult to answer because often IDR is inferred. In this section we outline a need for development to support further understanding of IDR and to better pinpoint where issues are most acute.

Many interpretations of IDR exist, and a gap remains in finding a common language to describe IDR

We lack robust and widely understood language to describe the landscape of research collaborations within the broad church that is 'interdisciplinary research'. Defined terms for types of IDR are identified in literature focused on IDR **(Davé et al., 2016; Lyall & King, 2013)**, but their use more widely is inconsistent. For example, a recent funding call used interdisciplinary, multidisciplinary and cross disciplinary without defined meaning or (seemingly) purposeful distinction.

This impacts our understanding and ability to better quantify IDR and how the risks and challenges differ within this. The basic question of "how much research is IDR?" is difficult to answer without clear and consistently used definitions, and contextual understanding. This view was supported by interviewees, *"it's difficult to glean from abstracts or titles of papers whether a paper is interdisciplinary or not. The quantity of interdisciplinary research is therefore hard to measure"* (Publishers' workshop participant). Fundamentally IDR relates to concepts of integration, but this is dynamic and complex and so difficult to map and define **(Woelert & Millar, 2013)**.

Similarly, the difficulty of defining and categorising IDR, particularly through the lens of individual research outputs, presents some challenge to addressing the *simple* question of how much IDR is being undertaken and submitted to REF. A report on IDR conducted by Elsevier in 2015, highlighted that "there are no accepted definitions or measures of disciplinarity which could be used to track changes in UK research" **(Elsevier, 2015)**.

Underpinning datasets (for bibliometrics) are typically founded on discipline-based codes and categorisation. Interviewees, for example, held the view that, *"there is limited agreement around how existing papers are organised and categorised using current tools and systems. It makes identifying and measuring IDR harder"* (Publishers' workshop participant). Analysis of REF 2014 outputs by a citation-based approach adopted the simple principle that if an article cites papers 'far away' from each other in terms of their topics, it is likely to be interdisciplinary (and monodisciplinary otherwise) **(Elsevier, 2015)**. The proximity of collaborating disciplines is identified as an important characteristic that can is aligned to the risks and challenges researchers' experience.

This suggests that the 'flagging' approach used within REF 2014 and REF 2021 is too simplistic to provide useful evidence around IDR. Inconsistency in the use of IDR flagging was evident in REF 2014 **(Stern, 2016)**, and evidence from those involved in the preparation of submissions for REF 2021 indicates that this may be repeated.

The proximity or cognitive distance between collaborating or contributing disciplines is an important contextual element to IDR

A useful concept is proximity or **cognitive distance (Elsevier, 2015; Tang et al., 2014)** between the collaborating disciplines and this emerges in discussions with participants influencing:

- the risk and challenge associated with developing collaborative relationships, forming a common language, and overcoming disciplinary differences to methods, language and analysis; and
- the pathway to funding and publication of the interdisciplinary research.

Proximity or cognitive distance has a significant influence on the context for IDR and drives the need for a contextualisation of IDR efforts and outputs. It was widely accepted that *"near is easier, far is harder and faces greater barriers in terms of methodology, approaches, language, publishing and academic norms"* (Interview participant).

An ECR perspective was that these 'far' research collaborations are less likely be recognised or wholly supported by their department. Reflecting on a collaboration between a social scientist and a STEM researcher it was observed that *"sadly, I don't see*

it driving my career progression forward, because it doesn't particularly fit within my departmental remit" (ECR workshop participant).

Proximity also underpins bibliometric approaches to IDR **(Elsevier, 2015)**. A citation-based approach based on proximity of cited research was adopted to review REF 2014 outputs to identify IDR. This was based on the premise "interdisciplinary articles are more likely to cite articles from multiple disciplines...and be cited from multiple disciplines".

Cognitive distance has potential as a qualitative, and potentially quantitative, measure in supporting enhanced understanding of interdisciplinary research.

3.2 Trust and confidence in peer review

Trust and confidence in all aspects of peer review is a consistent and long-standing feature in the literature and in views from participants. It was identified as a leading issue in recommendations for IDR in 2016 **(British Academy, 2016)**. For funders involved in competitive grants, perceptions of applicants are still felt to frustrate attempts to instigate more adventurous and wide-ranging interdisciplinary research. As highlighted in the literature, "the core question in any effective evaluation of IDR is the emergence of a new and integrated whole from the disciplinary ingredients" **(McLeish & Strang, 2016)**.

The wider landscape of peer review includes that undertaken for publishing, and we took evidence from stakeholders on their perspectives on peer review and how this might influence REF.

Additional resources and skills are required for IDR

In talking to researchers, funders and publishers, a clear and consistent message emerged: peer review of interdisciplinary work requires more resources to deliver effectively. This view that is consistent with previous studies **(Lyall & King, 2013)**.

Despite the significant funding for grants requiring interdisciplinary approaches, there are issues for funders in supporting IDR via grants. Interviewees note that *"there are still preconceptions and barriers to overcome"* (Interview participant). Notably, significant re-organisation of funding structures and processes at Wellcome is driven by their long-standing commitment to interdisciplinary research. Funding has been organised by career stage with an intent to make peer review discipline agnostic. The Academy of Medical Sciences highlights positive responses to the use of supplementary contextual information, introduced by Wellcome to grant review processes, to better inform how research outputs are assessed **(Academy of Medical Science, 2019)**. As one participant summarised, *"good practice of review of IDR is needed for both grant proposals and outputs – proposal review is more rigorous and has more best practice developed than review of IDR outputs"* (Interview participant).

Challenges in finding peer reviewers

We also heard evidence that identifying and finding suitable peer reviewers is challenging. The importance of reviewer expertise for IDR is recognised widely with evidence citing "a lack of reviewers who understand how to evaluate interdisciplinary research, and the related circular problem that there is a need to expose more reviewers to interdisciplinary projects" **(Gleed & Marchant, 2016)**.

There were concerns that peer reviewers don't have sufficient experience to review complex IDR, particularly where it contains multiple techniques or where originality comes from the IDR approach itself. The observation that the bigger the 'gap' between disciplines, the harder it is to properly review IDR identifies the importance of cognitive distance in IDR evaluation.

This view was also underpinned by interviewees, raising the question, *"if disciplines are really far apart – you can review elements, but who pays attention to the 'middle' or the whole?"* (Interview participant). Participants reported difficulties in securing reviewers for IDR outputs and noted the need for reviewers to be trained to review IDR, highlighting, *"there is a need for 'polymath' reviewers"* (Interview participant). Considering REF, one interviewee suggested, *"it might be better to train panellists to review IDR well than to have an IDR UoA"* (Interview participant).

A positive observation from stakeholders was that an increase in IDR activity by doctoral students and ECRs could make finding reviewers with experience in IDR working easier in the future. Measures to properly develop their reviewing skills to build on this experience are recommended, as one interviewee summarised, *"panels need to be more diverse, less hierarchical and contain more people who have done ground-breaking IDR who can add balance to a panel (and who might not have the seniority or disciplinary track record in the same way as other senior figures)"* (Interview participant).

Extending and developing good practice IDR review from funding panels

There is a growing body of evidence around IDR and supportive good practices, including peer review and guidelines **(Lyall & King, 2013; McLeish**

& Strang, 2016). For example, the SHAPE-ID toolkit, designed to help researchers, universities, funders, policymakers, and societal partners improve interdisciplinary research involving the Arts, Humanities and Social Science.

Good practice for review of IDR is felt to be more established in grant proposal review than for review of REF outputs. For review of IDR research proposals good practice puts emphasis on evaluating the process gone through to develop the proposal to ensure the IDR is high quality (e.g. co-development and integration of ideas across disciplines) **(Lyall & King, 2013; McLeish & Strang, 2016)**. These authors defined a set of contextual questions that support assessment of the IDR nature of a project, demonstrating how the context for IDR is integral to review:

- the diversity of the disciplines, methods and researchers;
- how the insights of the disciplines are integrated;
- leadership and IDR skills of the teams; and
- how interdisciplinarity will be reflected in the project outputs and outcomes.

For IDR research outputs within REF these important contextual aspects are not fully evident.

Experience and practices from publishing

In developing good practice and new approaches to peer review of IDR the significant experience of publishers should be incorporated. Publishers referenced increasing innovation in peer review in publishing, for example in transparency of peer review, pre-prints and group or video peer review. As one participant noted, *"there's a lot of experimentation being done now by publishers"* (Publishers' workshop participant). This is also evident in the wider literature **(Johnson et al., 2018)**. Similarly, a publisher stated, *"my takeaway from this is whether we in the publishing world can do more to support the fair and the transparent evaluation of interdisciplinary research"* (Publishers' workshop participant). There is also a need to consider how the rapid publication of research in response to COVID-19 influenced this landscape.

The pace of change was also noted by publishers, and consideration of this factored into the consultation and planning: *"we should consider what the future direction of reviews is, in 5-10 years, for example pre-prints, developments around group peer review and video peer review, and how the iteration of articles develops things"* (Publishers' workshop participant).

3.3 Reward and recognition

Perspectives from academia on reward and recognition for IDR

For researchers, REF is part of a wider landscape of reward and recognition. In this section we highlight those areas most frequently identified in this work. For researchers contributing to this work, these include:

- impacts their overall career development;
- alignment to departmental and research group core interests; and
- their role and contribution to larger IDR teams on projects or programmes.

It was clear from the participants in this study that although they experienced challenges, they found IDR rewarding and were positive about the value of using IDR approaches in their research. Participants described the way that developing interdisciplinary research drives new thinking and the importance of new tools, techniques and methods to support that IDR.

One contributor said, *"I find interdisciplinary research extremely rewarding, on the other hand the challenges are real. It can feel that funding bodies and institutions don't really help you address those challenges adequately, although they keep telling you that they want interdisciplinary research"* (ECR workshop participant).

Perceived risk to academic career progression

Researchers consulted in this study, particularly ECRs, continued to express concerns that a focus on IDR would impact their career development. For example, an interviewee shared the concern that, *"as an interdisciplinary researcher, you often form your own niche or discipline – but this means not having a clear disciplinary home, a clear place to publish papers, and a clear trajectory"* (Interview participant). Examples of work within universities to improve understanding of IDR career pathways in promotion criteria and decision making were referenced.

ECR participants recognised the value of professional and learned societies in creating a community for interdisciplinary members and providing training for their members to understand other disciplines, encouraging IDR.

In reviewing the literature, we observe a lack of longitudinal evidence on how IDR impacts long term career development and progression for researchers. This is a knowledge gap that UKRI and professional and learned societies are well placed to consider and has particular significance for ECRs involved in IDR. Work in this area should directly address the perception that involvement in IDR impacts career progression and consider different typologies of experience in IDR.

There is a case to suggest that analysis should not be limited to academic career development. The recent strategies for innovation and people and culture make clear the importance of interdisciplinary working and skills from an industry and innovation perspective. An industry perspective on the importance of IDR recognised that *"all the major scientific challenges now need an interdisciplinary approach; they are so vast"* (Interview participant).

The ability to work across disciplines is a critical requirement in industry and for ECRs or academics moving into industrial R&D. Within industrial R&D teams we heard that success is linked to an ability to develop a 'bilingual' knowledge of disciplines, with the skills to understand more than one discipline in depth and to participate and deliver in multi-disciplinary teams. Researchers who successfully move to industrial R&D are *"typically strong in the skills that equip them to work effectively in multi-disciplinary teams"* (Interview participant) in problem-focused contexts.

Recognition and reward within interdisciplinary teams

Interviewees noted that the contributions of co-investigators have become more easily accepted in interdisciplinary research. However, some concerns remained over how researchers providing supporting or 'contributing' knowledge are valued in the longer term. One participant noted that, *"IDR works well when each party sees the distinct value brought by the different disciplines"* (Interview participant).

ECRs had experience of being enrolled in projects to offer a different disciplinary perspective but there was a feeling that there was an ambivalence around what their role was, or a sense of inequality in the research collaboration. Ensuring that larger interdisciplinary projects are a strong development opportunity for all participants is noted. *"More junior staff often have method development roles in big IDR projects and don't necessarily see the bigger picture for that project"* (Interview participant).

Underpinning these issues for researchers collaborating on IDR are attitudes about IDR in universities, particularly around authorship. Of particular relevance to REF is the *"difficulty for IDR teams to publish in a way that outputs work well for all disciplines and UoAs involved"* (Interview participant).

SUMMARY

These wider issues are contemporary and also evident as longstanding areas of concern for interdisciplinary research. Whilst they reflect perspectives of a landscape that goes beyond REF, they are central to the experience and perspectives of researchers' involvement in REF. The next section considers how REF influences interdisciplinary research.

CASE STUDY

Convening interdisciplinary teams to tailor treatment for severe respiratory failure caused by COVID-19

King's College London

Severe respiratory failure from COVID-19 pneumonia not responding to non-invasive respiratory support requires mechanical ventilation. Although ventilation can be a life-saving therapy, it can cause further lung injury if airway pressure and flow and their timing are not tailored to the respiratory system physiology of the individual patient. The pathophysiology of severe SARS-CoV-2 infection can lead to a pattern of lung injury in patients with severe COVID-19 pneumonia.

Understanding the underlying pathophysiology, duration of symptoms, medical imaging and lung mechanics in individual patients is crucial for the appropriate choice of mechanical ventilation settings to optimize gas exchange and prevent further lung injury. By collaborating with clinicians, physiologists are improving the outcomes of COVID-19 patients on ventilators by researching how ventilation can be tailored to the individual patient based on their respiratory system mechanics and function.

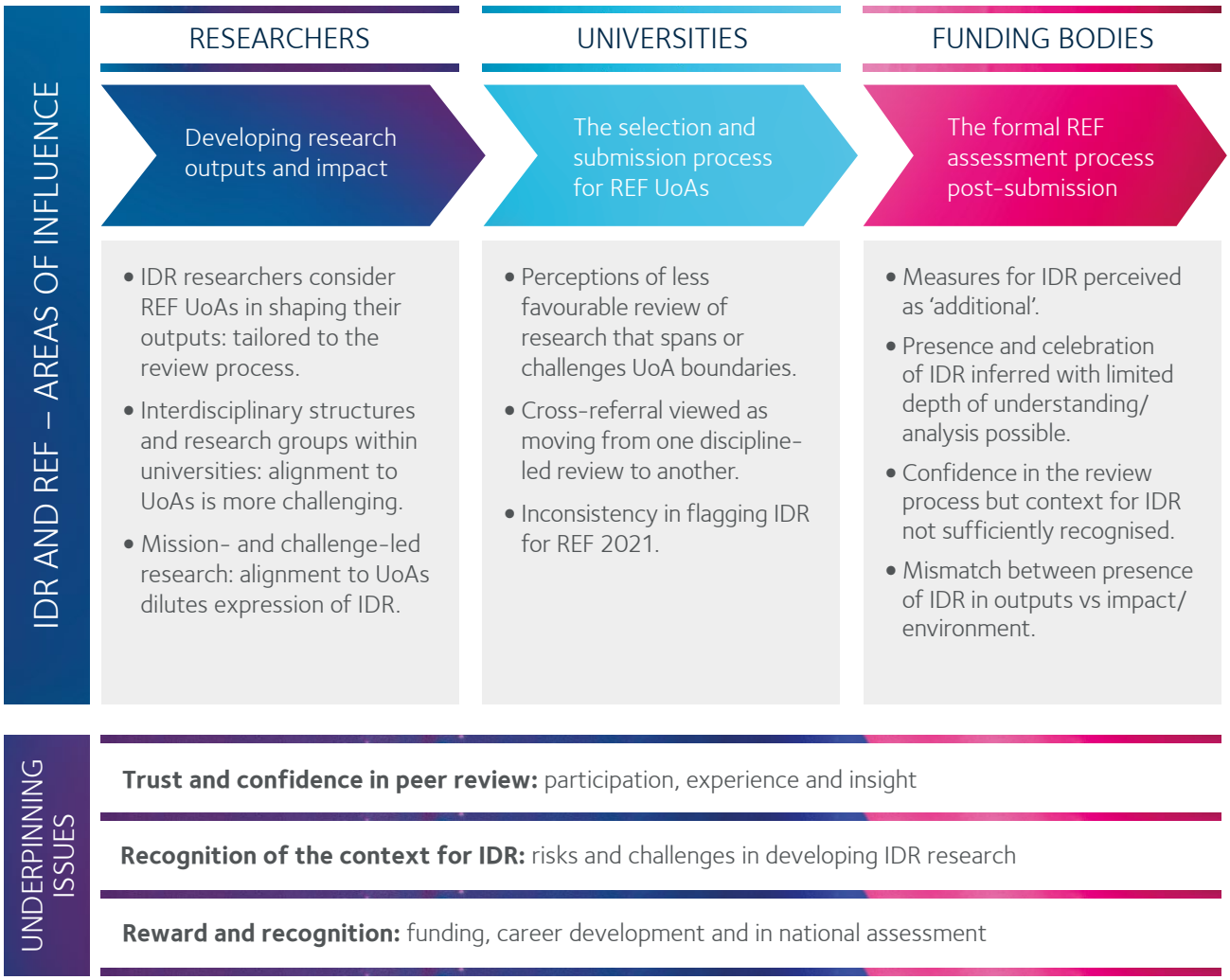
4 HOW THE REF INFLUENCES INTERDISCIPLINARY RESEARCH

OVERVIEW

In this section the evidence from interviews and focus groups is considered against two questions. Firstly, how does REF influence interdisciplinary research? Secondly, how IDR is reflected within submissions to REF and previous assessment exercises? This considers the entire REF process (see Figure 2) as experienced by researchers and universities, and also considers how IDR is valued within different parts of the REF submission (Environment, Impact Case Studies and Outputs).

Perspectives on the REF process and how it influences IDR are summarised across three stages in Figure 2. The three stages reflect the activities and influence of three groups of stakeholders: researchers who develop research at the pre-submission stage; universities who select and develop the REF submission and the REF funding bodies who oversee the assessment process and make use of the findings. It also identifies three underpinning issues considered in Section 3, as it is important that a future REF is seen to address these.

Figure 2 The influence of REF on interdisciplinary research, alongside three underpinning issues that affect wider perspectives on IDR.



4.1 How does REF influence interdisciplinary research?

The REF is currently weak in providing incentive and encouragement for the submission of IDR

Consultations with project stakeholders gathered mixed views on how REF encourages and reflects strengths in IDR. Some participants suggested that REF incentivises IDR as part of its role in encouraging greater performance in research at the level of individual institutions. In particular, this was suggested where internal university structures for research were based around interdisciplinary research themes as opposed to traditional departments.

However, at the individual researcher level, there were more consistent views that REF did not sufficiently incentivise or recognise IDR. For example, one interviewee noted, *"IDR is more strongly featured in funding calls and research funding than it is in the REF"* (Interview participant). The reasons for this were anchored in two structural aspects of the process:

- the discipline-led units of assessment which for some IDR presents challenges in 'fit', for individuals and areas of research; and
- the selection process for outputs adopted by universities in the development of REF submissions which (naturally, in view of the resource allocation purpose of REF) seeks to optimise the submission and tends towards conservative approaches where research strays outside this boundary.

This latter point is consistent with experiences in grant funding, identified by both researchers and funders. Perceptions of what will 'find favour' with reviewers are strong influences and there was evidence from interviews that these perceptions continue to frustrate funders' aims in stimulating interdisciplinary projects.

CASE STUDY

Natural BionicS: Natural integration of bionic limbs via spinal interfacing

A Synergy Project sponsored by the European Research Council

Missing a limb leads to dramatic impairments in the capacity to move and interact with the environment and to a substantial worsening in quality of life. Bionic limbs substitute biological limbs in patients with limb deficiency, such as due to traumatic injury, and therefore provide patients with a way to increase their functional capacity, independency and quality of life.

The design and interfacing of bionic limbs with the human body however presents several challenges and requires highly interdisciplinary teams. The project Natural BionicS sponsored by the European Research Council aims at synergistically combining breakthrough achievements in neurosurgery, neural interfacing and robotics. The project focuses on the surgical creation of bio-connectors to access the spinal cord circuitries by using biological pathways for encoding and decoding neural information. This requires going beyond the state of the art in nerve transfer surgery. The surgical advances will proceed in parallel with the efforts in neural interfacing, which combines neuroscience and engineering, so that the surgically created bio-hub can be used to extract and to input information from and to the spinal cord.

In this way, Natural BionicS aims at creating a fully integrated, symbiotic replacement of human limbs with robotic parts that the user will feel and command as part of the body. The project is highly interdisciplinary and patient-centred. A Bionic Clinical Board, which covers multiple disciplines (surgery, robotics, neuroengineering, physiotherapy, orthopaedics, rehabilitation doctors, etc.), has been established at the beginning of the project to regularly explore the clinical cases of patients and the engineering solutions to be adapted to the clinical challenges.

The Unit of Assessment (UoA) structure of the REF can have negative implications for academics in IDR

There was evidence that requirements for REF drive the nature of research for some IDR academics, with some reporting papers 'constructed' specifically to align to the REF UoA they are to be submitted to, or developing a narrative that linked their research to a UoA.

There was a sense from participants that *"IDR can get diluted or re-worked to fit to a UoA, under-representing the value of the research and consortium"* (Interview participant). The impacts of this may not be evenly felt, as differences in the size and shape of UoAs means that some constitute multiple disciplines, and some are still predominantly single disciplines.

Interviewees felt that some UoAs are therefore better able to assess IDR because they inherently involve members from multiple disciplines. An example given was UoA 2 (Public Health, Health Services and Primary Care) which has a very broad remit including research into all aspects of public health, health services and/or primary care and all their cognate disciplines **(REF, 2020b)**.

We observed that these issues are not new and 'pre-filtering' of submissions excluding IDR to better fit the criteria and perceived biases of the panel was recognised in the 1992 and 1996 Research Assessment Exercises **(Scottish Universities Research Policy Consortium (SURPC), 1997)**.

The influence of REF on IDR is felt throughout the entire process, and for some researchers this shapes their approach to publishing

Our primary research findings were consistent with previous analysis of the UK's national research assessment: the pre-submission stages are where IDR was felt to be most strongly affected.

For some individuals, REF can influence their strategies for the development of outputs well before the submission stage. It can also dilute the presence of mission- or challenge-led research. During the preparation of submissions by universities, the selection process looks to optimise the competitiveness of the submission. One interviewee highlighted, *"If you don't have the disciplinary focus of a UoA you are submitted to, you can end up writing papers on topics purely because of the REF, to meet the requirements for 'REF-able' publications"* (Interview participant).

The influence of REF on IDR was observed to be most significant before the submission. Once submitted there was greater confidence in the ability of REF to deal fairly with interdisciplinary research. In terms of the ability of panels to review IDR in REF 2021, there was qualified confidence in the approach, with concern focused on how reviewers are placed to consider the whole and not just the discipline elements. Whilst there were positive observations from our interviewees, *"there is not a problem for review of IDR in REF, how panels are put together should give the ability to review IDR"* (Interview participant), others felt that there were *"questions whether interdisciplinary research is really understood on REF panels, although they do a good job in many respects"* (Interview participant).

There was a consensus that REF has an impact on IDR because of its interpretation by higher education institutions, rather than because of the approaches or composition of UoA panels. Factors include the need for alignment of individuals to a single UoA (giving a focus on disciplinarity), not on IDR and there can also be a reluctance (risk-aversion) to putting complex IDR outputs forward.

However, the move to a more institutional submission, putting in place recommendations from the Stern Review was seen as very positive and the focus away from individuals had improved decision making about IDR.

The Outputs in a REF submission account for 60% of the score and remain predominately academic papers

The Outputs element of a REF submission accounts for 60% of the score for a UoA. However, by its nature, IDR may involve links to industry, policymakers, the general public or other stakeholders. As a result, IDR may generate diverse forms of Outputs. While the REF guidelines do permit a range of Output types, the majority of submitted outputs are traditional academic publications or monographs. As highlighted by one interviewee, *"broader types of Outputs should be returned to REF, for example my institution didn't include policy reports published by a government department"* (Interview participant).

Previous studies have identified concerns in terms of the availability of IDR journals **(McLeish & Strang, 2016)**, and that most high-impact journals remain

discipline-based, which risks putting IDR and its researchers in an unfavourable position in terms of recognition **(European Council of Doctoral Researchers, 2014)**.

Views from participants were consistent in considering that there were few issues in publishing IDR at the level of the *'top journals and the major research outcomes emerging from IDR'* (Interview participant). Elsewhere concerns remained, but participants recognised an improving picture with more journals focused on interdisciplinary research. One contributor suggested, *"Interdisciplinary research in the earliest stages can be harder to publish, it's easier to go backwards and publish in a discipline led journal than sometimes progress with an overtly interdisciplinary publication"* (Interview participant).

We considered the question 'where is publishing of IDR considered to be good?'. We consistently heard from researchers and publishers that the field of environmental or environment research was an area where the publishing landscape for IDR worked well.

It is not clear if the conservatism around submission of output types has a differential impact on IDR compared with discipline-led research. Participants observed that Outputs from some interdisciplinary collaborations may be more complex and so perceived as riskier. It was recognised that some IDR collaborations may be more likely to generate different Output types. However specific examples were limited. We note recent reports on practice research which provide some evidence on the link between interdisciplinary work and non-traditional outputs **(Bulley & Sahin, 2021)**. This is an aspect of IDR within REF that warrants further examination as part of the Interdisciplinary Research Advisory Panel (IDAP) review of REF 2021.

4.2 How is IDR reflected within REF submissions

Impact and Environment aspects of REF are more favourable to including IDR

Within the REF submission there is a difference in how IDR is viewed and therefore presented in the submissions. The previous section relates primarily to the inclusion of **Outputs** (which are largely publications). **The Impact Case Studies** and **Environment** are consistently cited as the areas of REF where IDR is more positively included, particularly environment (where universities can explicitly discuss approaches to supporting IDR).

Currently Impact and Environment account for the minority of weighting (25% and 15% respectively). The discrepancy in IDR presence in different aspects of the submission was previously observed **(Stern, 2016)**. One interviewee observed a *"segregation of IDR in the REF – where it's seen to be good in Impact Case Studies and Environment but less so or downplayed in Outputs"* (Interview participant).

Mission- or challenge-led work is not well featured in REF, and is strongly aligned to IDR approaches and teams

Mission- or challenge-led research is a key component of the UK research funding landscape. It is central to many funding calls for large competitive grants and has played a significant role in increasing the volume of IDR, particularly through the establishment of large consortia. A consistent theme in responses from participants was the significant overlap between interdisciplinary research and mission- or challenge-led research.

Despite the importance of mission- or challenge-led research in national R&D strategy being reflected in funder priorities and the needs of research users, it is not felt to be well reflected in REF. This was highlighted during our consultation with project contributors: *"Mission or challenge led research is a key question – it's core to the competitive grant side of things but not well reflected in REF"* (Interview participant).

The UKRI *Global Challenges Research Fund* (GCRF) for example was frequently referenced by participants and is recognised in the wider literature as strongly enabling IDR **(Gibson et al., 2018)**. It is notable that GCRF 'designed-in' interdisciplinary approaches to grants and supported 12 interdisciplinary research hubs working across a range of development challenges.

A future REF must be designed to better reflect national research performance in areas of critical challenge

With growing investment and public funding for mission- or challenge-led research in the UKRI competitive grant portfolio, the accountability purpose of REF suggests that a future REF should

be designed to do more to enable universities to coherently demonstrate the scale and excellence of research and to reward excellent research accordingly. In some areas, such as climate change and COVID-19 research, significant public interest is also an important consideration. *"Mission- or challenge-led research should be addressed within the research assessment process more effectively"* (Interview participant).

There is however limited evidence of national research evaluation adopting structures to better reflect mission- or challenge-led research. In Australia, a pilot focused on research impact was organised against socio-economic objective codes as opposed to disciplines **(Morgan Jones et al., 2013)**. However, when launched, Australia's Engagement and Impact assessment protocol reverted to alignment with the disciplines in the output-based assessment Excellence in Research for Australia.

The presence of IDR within REF needs further contextual information

Interviewees noted that the language around types of interdisciplinary research needs greater clarity and consistency, *"the term interdisciplinary is so unhelpful because it covers such a wide range of combinations and types of working across disciplines"* (Interview participant). There was an acknowledgement that Research England had worked hard on a definition of what the word 'discipline' means but it had been interpreted in different ways and it hadn't been possible to generate a definition that everyone uses consistently. There was a view that the REF 2021 'flagging' approach should represent situations where there are significant challenges to IDR or where disparate disciplines are working together.

Linked to a lack of clarity around the definition of IDR, were observations from stakeholders that flagging of IDR outputs had not been consistent in the submissions to REF 2021. For example, one interviewee said, *"it should have been mandatory but wasn't and so has been used inconsistently: it wasn't prioritised as a key part of the submission"* (Interview participant). Use of the IDR flag may have depended on the perceived ability of the UoA to accommodate that IDR, rather than flagging the output as being IDR or not. In UoAs that were perceived to be inherently cross-disciplinary, there was a perception that IDR is seen as normal so doesn't warrant a flag or cross-referral for it to be reviewed. There was also a lack of understanding on the role of the interdisciplinary leads on REF 2021 panels.

These observations led to concerns that data on the numbers of flagged IDR outputs would be used to infer observations about IDR within the UK research ecosystem more broadly, and that REF data would not be fit for that purpose. One contributor highlighted, *"I'm concerned that the funding bodies will look at the numbers of flagged IDR outputs and use those data to infer something about IDR more broadly, there is potential for better (qualitative) information from analysis of the Environment statements"* (Interview participant).

Environment statements are a valuable source of evidence on IDR

It was felt that the opportunities in the UoA Environment statements for a narrative around the work beyond their boundaries had been a positive driver to promote IDR. There was also an observation that there is potential for better (albeit qualitative) information on IDR from analysis of the Environment statements.

More could be done within the Environment statements to align the flagging of IDR outputs, and to provide the evidence of how the IDR was encouraged and facilitated through training and support for collaborations, particularly for ECRs.

SUMMARY

Creating a future REF where researchers are confident that discipline-led and interdisciplinary research can be selected, reviewed and rewarded by the process remains a challenge. Primary evidence from this study indicates that REF 2021 is likely to continue to under-represent interdisciplinary research and concerns over recognition remain for researchers active in IDR. There is a strong alignment between IDR and mission- or challenge-led research and the extent to which it is reflected in REF is contrasted with the priority attached to it in competitive grant funding. Understanding of the presence of IDR within REF needs further examination and measures to better understand the characteristics of IDR require development.

CASE STUDY

Promoting interdisciplinary research through industry collaboration

King's College London

Ageing Research at King's (ARK) is a cross-faculty multidisciplinary consortium of investigators which brings together scholarship and research in ageing in several complementary areas. ARK represents King's research on the biology of ageing, from the basic mechanisms in biogerontology to clinical translation and the social impact of ageing.

The primary purpose of ARK is to enhance multidisciplinary research collaborations within King's to better understand the mechanisms of ageing and improving health-span. As ageing consists of complex systems at the levels of biology, mental health and society, in order to understand the processes of ageing and the nature of old age itself, it is important to bring together learning and research from a number of key disciplines.

Providing a centre of biological expertise and building on the Framework Agreement between King's and Unilever established in 2016, collaboration brings Unilever researchers and King's academics together in a shared space at Guy's Campus of King's to focus on research in the biology of healthy ageing. Unilever has funded research at King's with over £3 million since 2014 in a variety of areas, such as skin biology, neuroscience, regenerative medicine, cardiovascular science, nutrition and dentistry. The relationship has the ambition to scale up in the future to cover other areas of ageing research.

For example, King's and Unilever are working collaboratively to better understand the relationship between ageing and inflammation of the skin.

Photo: King's College London

CASE STUDY

Developing new imaging techniques for measuring key physical parameters that characterise the function of the GI system

University of Nottingham

The University of Nottingham's REF 2014 submission included a description of new methods to study the biophysical action of the human digestive system that were developed using high speed magnetic resonance imaging (MRI). They have been used by the food and drug industry to develop new products; an early-stage technology development company to develop an artificial Dynamic Gut Model (DGM) which is now being applied commercially to characterise the effects of drug and food ingestion. Current studies include using MRI to define the mode of action of laxatives as well as how food structure alters fermentation and hence tolerability of dietary fibre.

Echo planar imaging (EPI) is the most robust magnetic resonance (MR) imaging method for quantifying biophysical parameters. The use of this technique to study the function of the gastrointestinal (GI) tract has been pioneered by the Nottingham MRI group in the Physics department, who have collaborated closely with Professor Robin Spiller, a clinician specialising in gastroenterology at the University of Nottingham.

This collaboration has grown to encompass a large research team including industry-sponsored research assistants, CaSE-funded PhD students, and an interdisciplinary senior research fellow, a physicist who was a member of the MRI group until he transferred to the University's Division of Gastroenterology. This collaboration has relied on expertise in quantitative and high speed MRI to develop novel non-invasive methods for measuring key physical parameters that characterise the function of the GI system.

5 RECOMMENDATIONS

Recommendations to support the design of the next REF and address knowledge gaps in IDR

Recommendations from this work have been developed to support the design of the next REF. We have also identified a number of areas of further activity, development and engagement that are needed to fill gaps in the knowledge and evidence base on IDR to inform research assessment. The persistence of concerns around IDR within research assessment, coupled with the growing priority and volume of activity in grant funding relating to IDR, indicate that a future REF needs to take a more direct approach to ensure IDR is appropriately reflected in evidence submitted.

Lessons from impact: can REF deliver a strong incentive effect for IDR?

Many participants acknowledged that REF has had a significant influence on sector wide changes in approach and values instigated by the inclusion of Impact Case Studies in REF 2014. This demonstrates the significance of REF as a policy vehicle to affect sector wide changes in perceptions, priorities and approaches. Considering the evidence of need in this report leads to the question **can a future REF deliver a similar incentive effect for interdisciplinary research?**

5.1 Summary of recommendations

Our conclusions draw from the growing importance of interdisciplinary research to address major research challenges, linked to the need to address, reward and recognise interdisciplinary work in national research assessment. As evidenced by the sector-wide changes through Impact, REF has significant influence as a policy tool that can deliver widespread sector change.

A high-level summary of the recommendations is presented below, with details and further discussion in sections 5.2 and 5.3. Section 5.2 considers recommendations for a future research assessment exercise. Section 5.3 recommends actions to address issues and knowledge gaps *before* the next REF.

Summary of recommendations for a future research assessment exercise

We recommend that the next REF adopts a structure which **explicitly identifies and rewards interdisciplinary research**.

The structure of a future assessment exercise should provide the flexibility for universities to submit coherent evidence of their interdisciplinary research against **themes relevant to the strengths and priorities of that university**.

A future assessment exercise should introduce flexibility to allow individuals whose research and outputs straddle discipline-based assessment structures to be returned to multiple units **recognising the breadth of the research teams** in which they operate and the outputs generated from this.

We recommend that REF Outputs contain an option for an additional narrative to explain the **interdisciplinary context** of research outputs.

Summary of recommendations and actions to address issues and knowledge gaps before a future research assessment exercise

We recommend that professional and learned societies develop activities to support and facilitate the **development of interdisciplinary collaborations with 'near and far' disciplines** and generate additional evidence on **how interdisciplinary research shapes research careers**.

We recommend further work to establish how greater **understanding and characterisation of IDR can be applied into wider practical** use via a future research assessment exercise. In particular, the 'cognitive distance' between collaborating disciplines is a major factor in researchers' perceptions of risk, including the difficulties in developing the research collaboration, in accessing funding and in dissemination of the research.

To address trust and confidence in peer review we recommend that funders and publishers work together to identify specific measures to **enhance capacity and capability for interdisciplinary peer review** across all types of review.

Address ongoing perceptions of negative impacts on **career development** for researchers involved in IDR where there is a lack of evidence that provides a contemporary perspective on this.

5.2 Recommendations for the future of research assessment

Recommendations for a future assessment exercise are for consideration by the funding bodies and to be explored further as part of wider consultations on the future of REF. They provide other stakeholders with a perspective on interdisciplinary research within their wider perspectives and consultation responses on REF.

RECOMMENDATION 1

We recommend that a future research assessment exercise adopts a structure which explicitly identifies and rewards research that is founded on interdisciplinary approaches. Specific recommendations include:

- A structure which provides the flexibility for universities to submit coherent evidence of their interdisciplinary research against themes relevant to the strengths and priorities of that university.
- A new type of case study at university level which should exemplify and contextualise the environment contributing to identified outputs and outcomes realised. The case studies would be rewarded proportionately, to balance the reward (resource allocation) returned through disciplinary and interdisciplinary evidence.

- The formation of panels to review these case studies should draw on academic and research user experience, working to guideline criteria that draw on existing good practice in peer review.

RECOMMENDATION 2

We recommend that a future research assessment exercise allows outputs from individuals whose research straddles UoAs to be returned to multiple UoAs recognising the breadth of the research teams in which they operate.

This will increase flexibility within discipline-led review, addressing the concerns of individual interdisciplinary researchers and how UoAs can fragment their work.

RECOMMENDATION 3

We recommend that a future research assessment exercise allows outputs which contain an option for an additional narrative to explain the interdisciplinary context of research outputs. This will support peer review of IDR and build on good practice elsewhere.

This may include the interdisciplinary contexts, the challenges associated with the work (potentially drawing on cognitive distance) and description of team science approaches. This narrative would set the context for the review approach managed by the UoA panel. This approach also encourages the contextualisation of "disciplinary" outputs from an interdisciplinary study, and **provides important evidence to support further analysis and understanding of IDR within research assessment**. It also aligns to recommendations emerging from examination of research practice and Outputs.

RECOMMENDATION 4

We recommend that the funding bodies undertake a substantive review of interdisciplinary research within REF 2021, expanding the scope of the planned Interdisciplinary Research Advisory Panel (IDAP) report.

This should consider process and the extent to which *presence* of IDR is reflected within all areas of REF (Outputs, Environment and Impact Case Studies). The review should consider:

- the extent to which the characteristics of IDR (e.g. cross, multi, inter, trans; the cognitive distance evidenced in IDR teams) are evident in the exercise;
- the extent to which the submission of alternative or different output types is aligned to interdisciplinary research;
- a qualitative review of IDR within the Environment statements;
- how interdisciplinary research is reflected against mission- or challenge-led research objectives and delivery; and
- how the 'field making' potential of IDR is manifest in the evidence as an outcome.

5.3 Recommendations for interdisciplinary research

RECOMMENDATION 5

We recommend that the funding bodies should develop improved criteria and guidelines for IDR that will enhance the understanding of IDR sub-types. Understandable descriptions of sub-types of IDR can describe and differentiate between forms of IDR and REF.

The 'cognitive distance' between collaborating disciplines is a major factor in researchers' perceptions of risk, including the difficulties in developing the research collaboration, in accessing funding and in dissemination of the research. Assessments of IDR need to consider this more fully within the assessment process and in recognising the context for IDR.

RECOMMENDATION 6

We recommend further work by a task group comprising representatives from UKRI, the publishing community and researchers involved in IDR to bring together understanding and knowledge gaps relating to data-driven assessment criteria evidence for interdisciplinary research.

It is unclear how a move towards metrics-based assessment may benefit (or otherwise) the inclusion and recognition of IDR. The structures of publication databases and university metrics are largely based on disciplines, and interdisciplinarity is inferred. If peer review in future exercises is diminished in favour of metrics, these need to be tested to ensure that there is understanding on how the interdisciplinary aspects of research are recognised.

Further work to understand how the presence of IDR can be understood and assessed through bibliometric approaches is required. Building on the post-REF 2014 analysis, there is a need to consider the development of bibliometric approaches that can consider within fields of research how IDR is represented and can be understood at an aggregated scale.

RECOMMENDATION 7

We recommend that UKRI design evaluation approaches to the COVID-19 research response to inform how national research assessment can better reflect interdisciplinary and mission- or challenge-led research.

The research response to COVID-19 provides an opportunity to better understand research excellence through the lens of a strongly interdisciplinary and challenge-led research requirement, in an area of significant public interest. Evaluation and assessment evidence from the research response to the COVID-19 pandemic should also be set-up to inform the design of the next REF. This should consider:

- the range of contributing disciplines and research teams delivering the research;
- the presence and nature of interdisciplinarity in this body of work; and
- the nature and range (typology) of outputs from this work.

RECOMMENDATION 8

We recommend that funding bodies and publishers work together to identify specific measures to enhance capacity and capability for interdisciplinary peer review.

This should include major funders, (for example UKRI and Wellcome), working with publishers of interdisciplinary research and other stakeholders to assess the requirement and approach.

Trust and confidence in peer review remain a strong underpinning issue, which affects peer review in grant review and publishing as well as national research assessment. This could be developed as a peer review 'academy' established explicitly to develop good practice in developing and delivering IDR reviewer skills across the spectrum of peer review activities. We recommend that this should focus on the cohort of researchers whose experience sees them emerging as active peer reviewers in the next few years.

RECOMMENDATION 9

We recommend that professional and learned societies develop activities to support and facilitate the development of interdisciplinary collaborations with 'near and far' disciplines.

Through their breadth of membership and connections to other societies, there is an opportunity for professional and learned societies, like The Physiological Society, to enhance support for and recognition of interdisciplinary research.

Supporting and facilitating interdisciplinary research networks, directly addresses barriers for researchers and may have particular value for ECRs, balancing the need to develop discipline and interdisciplinary skills and networks.

RECOMMENDATION 10

We recommend that professional and learned societies, working with stakeholders including universities, research users and UKRI should instigate a study to provide further evidence on how engagement in interdisciplinary research shapes research careers, within and beyond academia.

Perceptions of negative impacts on career development for researchers involved in IDR are longstanding. There is a lack of evidence in the literature that provides a contemporary perspective on this. We recommend that professional and learned societies instigate a study to provide further evidence and assurance on this issue. This should be linked to work to address research cultures and skills development.

CASE STUDY

Sheep Pig Goat

Royal Central School of Speech and Drama, University of London

The research brought together performers from across artforms (dancers, singers, musicians), a number of livestock animals (sheep, pigs and goats) and academic researchers from various disciplines (history, design, philosophy, political theory, biology, literature) to explore, collaboratively and in public, a set of interrelated questions concerned with interspecies empathy and communication. The research was originally commissioned by Wellcome Collection for the exhibition Making Nature, and then further developed in collaboration with the University of Surrey School of Veterinary Medicine.

Key findings of the research concern methodological advancements in Human-Animal studies, specifically the need for multi- and interdisciplinary approaches, and multi-valent, cross-species perspectives, in order for non-human animals to begin to be seen as active subjects rather than passive objects. It foregrounded the value of embodied and non-verbal knowledge and research methodologies, insisting upon the rigour of arts-based research in scientific/medical contexts (Wellcome and University of Surrey Vet School).

Through a methodology that was both multi-disciplinary (drawing on knowledges and methods from multiple disciplines) and interdisciplinary (producing new methods and knowledges through combination), Sheep Pig Goat proposed that this multi-perspectival approach is essential in order for human knowledge of non-humans to move beyond cultural, scientific, historical and epistemological constructions. As Bruno Latour has said, 'to understand what animals have to say, all the resources of science and of the humanities have to be put to work' (Latour in Despret 2016: vii).

Photo: Royal Central School of Speech and Drama, University of London

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APPENDIX A.

Steering Group and contributors

The following stakeholders contributed to our project.

Table A1 Steering Group.

NAME	ROLE	ORGANISATION
Laura Childs	Senior Policy Advisor	Institute of Physics
Professor David Eisner (Chair)	Professor of Cardiac Physiology, Steering Group Chair	The University of Manchester
Professor Dario Farina	Chair in Neurorehabilitation Engineering	Imperial College London
Dr Catriona Firth	Head of REF Policy	Research England
Charlotte Lester	Senior Policy Advisor	The Royal Society of Chemistry
Dr Sarah Main	Executive Director	Campaign for Science and Engineering (CaSE)
Dr Laura Marshall	Head of Science Policy	Royal Society of Biology
Rachel Persad	Policy Manager (Research and Innovation)	GuildHE
Tanya Sheridan	Policy and Evidence Manager	The Royal Society of Chemistry
Stephanie Smith	Head of Policy	Russell Group
Joseph Taylor	Senior Policy Advisor	The Royal Society
Dr Harry Witchell	Discipline Leader in Physiology	The University of Sussex

Table A2 Project contributors.

NAME	ROLE	AFFILIATION	CONTRIBUTION
Dr Iddo Amit	Assistant Professor, Department of Engineering	Institute of Physics and Durham University	ECR workshop
Dr Rosalind Attenborough	Postdoctoral Research Fellow	University of Edinburgh	ECR workshop
Julie Bayley	Director of Research Impact Development	University of Lincoln	Interview
Emily Chenette	Editor In Chief	PLOS ONE	Publishers' workshop
May Copsey	Editor	Royal Society of Chemistry	Publishers' workshop
Professor Tim Curtis	Chair of Vascular Physiology	Queen's University Belfast	Interview
Professor Maria Delgado	Director of Research	Royal Central School of Speech and Drama	Interview
Franziska Fischer	Masters in Bioscience Enterprise Programme Manager	Cambridge University	ECR workshop
Jack Harrington	Portfolio Manager: Humanities & Social Science	Wellcome	Interview

NAME	ROLE	AFFILIATION	CONTRIBUTION
Professor Mark Horton	Director of Research	Royal Agricultural University	Interview
Phil Hurst	Publisher	Royal Society	Publishers' workshop
Dr Sophie Laurie	Associate Director of Interdisciplinary Programmes and Capability in UKRI	Natural Environment Research Council	Interview
Senior Leader	Industrial R&D leading multi-disciplinary teams	AstraZeneca	Interview
Dr Rebecca Lovell	Lecturer in Biodiversity, Health and Policy	Exeter Medical School	Interview
Professor Catherine Lyall	Professor of Science and Public Policy	University of Edinburgh	Interview
Jen McCall	Publishing Development Manager	Emerald Publishing	Publishers' workshop
Dr Jamie Macdonald	Head of School of the School of Sport, Health and Exercise Sciences	University of Bangor	Interview
Dr Carol Maddock	Research Officer, Public Health	University of Swansea	ECR workshop
Professor Hugh Montgomery	Professor of Intensive Care Medicine	University College London and NHS	Interview
Dr Suzy Moody	Lecturer in Eukaryotic Microbiology	Kingston University	ECR workshop
Professor David Paterson	Professor of Cardiovascular Physiology	University of Oxford	Interview
Professor Ole Petersen	Academic Director, Academia Europaea Cardiff Knowledge Hub	Cardiff University	Interview
Professor Emma Raven	Head of School of Chemistry	University of Bristol	Interview
Rebecca Robertson	PhD Student	University of Leeds	ECR workshop
Dr Malcolm Skingle	Director, Academic Liaison	GSK	Interview
Adrian Stanley	Chief Innovation and Development Officer	JMIR	Publishers' workshop
Dr Claire Smith	Non-Clinical Lecturer in Respiratory Paediatrics	University College London	ECR workshop
Professor Lisa Smith	Professor of Criminology and Director of the Leicester Institute for Advanced Studies	University of Leicester	Interview
Tim Smith	Associate Director	Institute of Physics	Publishers' workshop
Dr Joshua Vande-Hey	Lecturer in Environment & Health, Earth Observation Science Division	University of Leicester	ECR workshop
Professor Christine Williams	Professor of Nutrition	University of Reading	Interview
Dr Calum Wilson	Research Fellow	University of Strathclyde	ECR workshop
Dr Astrid Wissenburg	Director of Research	University of Exeter	Interview
Jo Wixon	Director of Portfolio Strategy	Wiley	Publishers' workshop

APPENDIX B.

Overview of the development of the Research Excellence Framework

OVERVIEW

This section draws together some of the relevant history and developments associated with the REF, focusing on those aspects aligned to the treatment or presence of interdisciplinary research.

The REF is the system for assessing the excellence of research in UK higher education providers

The Research Excellence Framework (REF) is the UK's system for assessing the excellence of research in higher education providers. REF outcomes are used to inform the allocation of c. £2 billion per year of public funding for universities' research environment and activity **(REF, 2019)**.

Research England manages the REF on behalf of all four UK higher education funding bodies: Research England, the Scottish Funding Council, the Higher Education Funding Council for Wales and the Department for the Economy, Northern Ireland. The funding bodies' shared policy aim for research assessment is *'to secure the continuation of a world-class, dynamic and responsive research base across the full academic spectrum within UK higher education"* **(REF, 2020c)**.

Inputs shaping the IDR approach within REF 2021

The assessment of IDR within REF's discipline-based approach has been a sustained area of concern **(Academy of Medical Science, 2009; Scottish Universities Research Policy Consortium (SURPC), 1997; Wellcome Trust, 2016)**.

The assessment of IDR within research assessment has been a sustained area of concern

Previous REF consultation responses have raised the concern that adjudicating panels do not have the full range of necessary expertise to fairly assess interdisciplinary research **(Academy of Medical Science, 2009; British Sociological Association, 2016; Royal Academy of Engineering, 2016; Royal Society of Biology, 2016; Royal Society of Chemistry, 2016; Stern, 2016)**.

An IDR identifier was introduced in REF 2014 but was observed to have seen "varied use of the identifier by institutions, and some uncertainty around its purpose" **(Stern, 2016)** leading to recommendations in advance of REF 2021 to address IDR more substantively, both for the assessment itself, but also to inform future understanding of IDR. "REF data should be captured in a way that supports the future analysis and identification of interdisciplinary research" **(Wellcome Trust, 2017)**.

Whilst recognising disincentives to the submission of research outputs to REF 2014, Stern identified "no specific concerns relating to the handling of IDR output once in the review process" **(Stern, 2016)**. Nevertheless, the review proposed a number of specific recommendations for REF 2021, of which only some were incorporated. In particular Stern recommended:

- explicit encouragement to the submission and identification of IDR in REF with greater consistency of use in flagging; and
- consideration of extra weighting to outputs that are strongly interdisciplinary should the discrepancy in submission to REF continue.

The second point presents significant practical challenges in defining what criteria and contextual information would robustly meet this.

REF 2021 approach to managing IDR – dedicated panel members and cross-referral between panels

Following the recommendation of the Interdisciplinary Research Advisory Panel (IDAP), established ahead of the 2021 REF exercise, it was agreed that:

- Each sub-panel will have at least two appointed members to oversee and participate in the assessment of interdisciplinary research submitted in that UOA, with a specific role to ensure its equitable assessment. This role will include liaison with corresponding members on other sub-panels.
- To enable better identification of interdisciplinary research that falls within the oversight of the appointed members described above, an 'interdisciplinary identifier' (non-mandatory) for outputs will be retained in the submission system.
- A discrete section in the environment template on the submitting unit's structures in support of interdisciplinary research (or to provide a clear rationale as to why structures supporting interdisciplinary research are not appropriate for that unit) **(REF, 2021b)**.

An assessment protocol for IDR flagged outputs was developed – the Interdisciplinary Research Protocol **(REF, 2021a)**.

Beyond REF 2021 – a review of research assessment

In May 2021, the 'Future Research Assessment Programme' was launched with an objective to understand what a healthy, thriving research system looks like and to investigate approaches to the evaluation of UK higher education performance **(UKRI, 2021a)**. In establishing the terms of reference for the Future Research Assessment Programme, the funding bodies identified a number of key open questions, with a programme of work expected to conclude by late 2022 **(UKRI, 2021b)**. Beyond broad programme review components, notable aspects include:

- What are the benefits and negative implications of moving from discipline-oriented research assessment to an evaluation organised at the level of the institution?
- How can the assessment system contributes to a positive research culture that enables talented, diverse people and teams to thrive?
- How can unnecessary bureaucracy be reduced?
- How can the system better recognise diversity in approaches to research, rewarding a broad range of outputs and impacts, within and across disciplines?

GLOSSARY

FRAP - Future Research Assessment Programme
GCRF - Global Challenges Research Fund
IDR - Interdisciplinary research
RAE - Research Assessment Exercise
REF - Research Excellence Framework
UKRI - UK Research and Innovation
UoA - Unit of Assessment

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