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# International good practice in the peer review of interdisciplinary research

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*Report of a scoping study conducted for the RCUK Research Group by Professor Catherine Lyall and Dr Emma King, The University of Edinburgh*

October 2013

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### Publication

Catherine Lyall retains the right to publish academic articles based on this report as stated in the consultancy agreement for this study.

“Research Councils look for the single disciplinary weakness rather than the interdisciplinary strength”

## 1. Summary

- 1.1. Improved evaluation criteria and processes are the key to achieving a more stable and consistent role for interdisciplinary research (IDR) and for improving its intellectual status in academia. Appropriate evaluation of interdisciplinary research can also play a role in delivering improved value for money for the investments being made in this area.
- 1.2. Research funders clearly have a role to play in framing calls for interdisciplinary proposals and developing rigorous evaluation processes (Lyall et al. 2013) but must be willing to make the internal, structural changes necessary to review IDR (Feller 2006). Good IDR requires greater partnership between funders and researchers (Roux et al. 2010) and four elements of evaluation need to be adapted to make IDR peer review fit for purpose (Pohl et al. 2011):
  - the composition of the panel
  - the selection of external reviewers
  - the design of the review process
  - the questions that must be answered by the reviewers
- 1.3. In this scoping study, we have searched the publicly available peer review guidelines of over 20 national and supra-national research funders and assessed the published academic literature and ‘grey’ literature produced by funders, learned academies and think tanks in order to distil good practice across these four elements.

## 2. Introduction

- 2.1. This scoping study was commissioned by the RCUK Research Group in order to access information about international good practice in the peer evaluation of interdisciplinary/multi-disciplinary research grant proposals in the context of a re-focusing of RCUK’s cross-disciplinary themes.
- 2.2. In the UK, Research Councils constitute important drivers of interdisciplinary research and play an essential role in:
  - identifying questions that need an interdisciplinary approach in order to be tackled effectively
  - launching and shaping initiatives, making funding available
  - establishing the architecture of an interdisciplinary programme (e.g. choice of leader, location, streams of funding, accountability)
  - establishing appropriate evaluation processes
  - building capacity
  - facilitating emergence of longer term impacts

- 2.3. With such critical roles to play, funders' own structures and procedures seek to reflect good practice in the support of interdisciplinarity, especially when interdisciplinary programmes require cross-council collaboration. Nevertheless, even as opportunities for interdisciplinary research grow, the view persists that evaluation of interdisciplinary research proposals urgently needs to be tailored more appropriately - as the opening quote from a current member of the UK research community demonstrates. Do we fund the best IDR proposals or those that most resemble mono-disciplinary research?
- 2.4. Individuals do not want to be penalised for proposing interdisciplinary approaches which, by definition, are unconventional and often regarded as risky in a system that is often seen to work against the inclusion of even the most rigorous interdisciplinary work. By the same token, it can be harmful to standards of genuine interdisciplinarity if researchers receive funding for projects that do not meet acceptable quality standards.
- 2.5. Various studies have evidenced strong support for peer review as an essential mechanism to ensure that only high-quality research is funded, published and rewarded but, nevertheless, acknowledge a number of criticisms, for example, that the selection of reviewers may introduce bias into the system; that the judgements made are subjective and inconsistent; that it tends toward conservatism and stifles innovation which raises particular concerns regarding the treatment of interdisciplinary research (RCUK 2006; Research Information Network 2010; League of European Research Universities 2012; Abramo et al. 2013). Indeed, this is not a new issue: citing the Boden report (conducted on behalf of the Advisory Board for the Research Councils in 1990), the British Academy's statement on peer review (British Academy 2007), echoes Boden's concerns that peer review disadvantages early career track researchers, the most innovative research, and interdisciplinary research.
- 2.6. In this scoping study we have not dwelt on the many definitions that abound in the literature of research that crosses disciplinary boundaries (see for example, Lyall et al. 2011a; Frodeman et al. 2012) and have generally used 'interdisciplinary' as a generic descriptor. However, the fact that 'interdisciplinary' research can take many forms with different goals leading to very different research designs is key to understanding what we are trying to assess and, at the same time, makes it impossible to provide a blueprint for one single model of peer review<sup>1</sup>. Although this issue is addressed in the academic literature (e.g. Pohl et al. 2011; Klein 2006; Lyall et al. 2011a), these distinctions are rarely addressed in any funders' guidance that we have found and only the European Science Foundation (ESF) (European Science Foundation 2011) really drills down in to what the distinctions might mean for peer review (§4.16).

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<sup>1</sup> For example, criteria appropriate to evaluation of academically-oriented interdisciplinary research may often be different from those used for problem-focused projects and programmes (Lyall et al. 2011a).

### 3. Methods

3.1. This was a short, desk-based scoping study conducted during September and October 2013. Our search strategy comprised:

- Initial email correspondence with a dozen international, interdisciplinary scholars to gather published materials and to develop an initial understanding of peer review practices within their own national contexts. This encompassed the experience of four international interdisciplinary research networks<sup>2</sup> and reached nine countries across four continents
- Email correspondence with a similar number of officials in national and supra-national funding agencies in Europe and the US in order to identify existing documentation in the form of guidance materials produced by funding agencies, other relevant policy documents and 'grey literature'
- A web search including websites of key funding agencies, learned academies, think tanks and other research institutes
- A literature review focusing on academic, peer reviewed journal articles

3.2. Peer review processes and the amount of input from researchers under review vary widely between country and between funding bodies (Langfeldt 2006). For this reason we have generally not attempted to differentiate between the processes required for the peer review of individual research projects compared with multi-project research programmes or other larger scale initiatives and we have tended to use the term 'reviewer' to cover both the external (remote) peer reviewer or reader as well as members of assessment panels.

### 4. Evidence from international comparators

4.1. The topic of IDR receives quite a lot of attention in the academic literature where it is widely acknowledged that interdisciplinary peer review requires special consideration. However, it remains the case that evaluation is one of the least understood aspects of IDR (Klein 2008) with the issue of how panels actually assess IDR considered to be missing from the literature (Feller 2006). Key challenges centre on questions of 'What constitutes quality in ID research?' and 'Who is an appropriate peer reviewer?'

4.2. In contrast, consideration of specifically interdisciplinary peer review is much less evident in the public-facing websites of research funders that we have searched. Nevertheless, several of the funding agency officials with whom we have had contact expressed an interest in this issue and in hearing

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<sup>2</sup> Including td-net [www.transdisciplinarity.ch/e/](http://www.transdisciplinarity.ch/e/); INIT International Network for Interdisciplinarity & Transdisciplinarity [www.inidtd.org/](http://www.inidtd.org/); the Association for Interdisciplinary Studies [www.units.muohio.edu/aisorg/index.shtml](http://www.units.muohio.edu/aisorg/index.shtml) and I2S Integration and Implementation Sciences <http://i2s.anu.edu.au/>

further about the findings of this study. This suggests that it is a topic with which many international funders are engaged but few have yet achieved a formula for success.

- 4.3. It is generally acknowledged that funding organisations may face significant barriers in facilitating IDR where the risk-taking and administrative complexities may be greater than those of single-discipline programmes (National Academies 2005). ESF talks about the need for standard peer review models to be “sharpened and calibrated” (European Science Foundation 2011). The National Academies’ report goes on to note that an essential feature of interdisciplinary funding models is innovative, risk-taking leadership within the funding body. They suggest that funding organisations should regularly evaluate, and if necessary redesign, their proposal and review criteria to make them appropriate for interdisciplinary activities: in particular, criteria need to be developed to ensure that proposals are truly interdisciplinary and not merely adding disciplinary participants. Expertise in IDR, as well as in the constituent and related disciplines, is therefore required to review interdisciplinary projects fairly and award credit for the contributions of project members (National Academies 2005).
- 4.4. The Global Research Council (GRC) has collated information about national guidelines on merit/peer review<sup>3</sup> in (see **Table 1** in Appendix). Of the 19 agencies included on their website, eight make no mention of interdisciplinarity, five make only a passing mention and only three provide detailed information about peer review procedures for interdisciplinary research<sup>4</sup>.
- 4.5. Of these, the Australian Research Council (ARC) describes a process whereby council officials review the appropriateness of proposals assigned to each panel and may transfer proposals to different panels if required. They also identify interdisciplinary proposals that will require assessors from more than one selection panel.
- 4.6. In contrast, the Swiss National Science Foundation (SNSF) evaluates all projects declared as interdisciplinary by the applicant using a Specialised Committee Interdisciplinary Research, established in 2008. Members are selected according to their own interdisciplinary background and receive a special briefing<sup>5</sup>. This committee was established because SNSF noticed that interdisciplinary proposals had a much lower success rate than single discipline ones. After a test phase (2006-2008), SNSF concluded that there was a need to create specific funding instruments and a specific evaluation body for interdisciplinary proposals<sup>6</sup>. The committee includes two or three members of the regular SNSF disciplinary divisions and six external members. The committee draws on external peer reviews (at least two per proposal) and concentrates their evaluation on the interdisciplinary aspects of the proposal.

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<sup>3</sup> [www.globalresearchcouncil.org/documents](http://www.globalresearchcouncil.org/documents)

<sup>4</sup> Three of the organisations listed had broken weblinks

<sup>5</sup> In German only

<sup>6</sup> [www.snf.ch/E/funding/projects/interdisciplinary-projects/Pages/default.aspx](http://www.snf.ch/E/funding/projects/interdisciplinary-projects/Pages/default.aspx)

- 4.7. Research Foundation Flanders (FWO) does not have specific guidelines for peer reviewers evaluating interdisciplinary proposals but does have a process for checking the eligibility of an interdisciplinary proposal before it is evaluated. For those proposals that are accepted as being interdisciplinary, the chair of the panel would work with more pre-reporters (i.e., panel members who read in depth and comment on the proposal), than is usual - often four or five reporters, from the different fields involved rather than two or three reporters which is more usual for monodisciplinary proposals. The Netherlands Organisation for Scientific Research (NWO) similarly takes account of the interdisciplinary nature of proposals when choosing referees and tries to select referees from different disciplines, and preferably with knowledge of comparable (what they term) multidisciplinary research.
- 4.8. Although the Finnish documents curated by GRC do not explicitly mention IDR, the Academy of Finland has sponsored one of the main empirical studies conducted by a funder/learned academy of interdisciplinary review (Bruun et al. 2005). This report recommends that the Academy develop its research assessment procedure into a *coaching* process, in which the planning and assessment of research are conducted collaboratively among researchers, officials of the Academy and external reviewers, with the long term vision of developing interdisciplinary research capacity. Bruun et al. (2005) further recommend that the Academy establish the position of an *ombudsman* for interdisciplinary research in each research council to assist the council in treating interdisciplinary proposals in a competent way.
- 4.9. These authors cite the example of two different approaches to creating an interdisciplinary review panel: either to convene a panel of disciplinary experts or, alternatively, to select generalist researchers with a strong interdisciplinary background. Expertise within both of the two types of panel is broad in aggregate but it is distributed differently across panel members and they note that discussion in these panels was very different—in the panel with established scientists, experts had serious difficulties in understanding each other in reaching consensus about the criteria, whereas in the generalist panel, communication was fruitful and qualified. Bruun et al. (2005) note that the moral of this example is that the *selection* of experts really matters.
- 4.10. There is a view in the academic literature that research funders in Finland, Sweden (Langfeldt 2006) and Norway (Gulbrandsen 2005) are supporting good IDR without many of the associated peer review problems. According to Langfeldt, around half of the applications to the Finnish and Swedish research councils are multi- or interdisciplinary, she finds no evidence of lower funding success for such projects (although radically interdisciplinary projects still met with lower funding success). Gulbrandsen concludes that the balance of disciplinary and interdisciplinary work is managed well within the Research Council of Norway (RCN) which has a separate division for bigger projects, with an emphasis on IDR.
- 4.11. Despite the fact that the National Science Foundation (NSF) hosted the inaugural global summit on merit review in May 2012 that released a set of



merit review principles and established the Global Research Council<sup>7</sup>, neither of the main US funders is included in the GRC list.

4.12. When we contacted NSF directly, we were told that the Foundation is quite decentralised, so that different parts of NSF handle reviews quite differently. We were told that, with regard to interdisciplinary peer review, different approaches are taken: when the proposal is in response to a specific call for proposals ('solicitation'), there will be a solicitation-specific management plan that lays out the details of the review process, and the solicitation itself will contain any additional review criteria (beyond the standard ones that apply to all NSF proposals). For unsolicited proposals submitted to standing NSF programmes, such a proposal will be reviewed by the primary programme to which the proposal is submitted, and it is at the discretion of any secondary programmes (e.g., from other disciplines) as to how they deal with the proposal. Co-review by multiple programmes is common in such cases.

4.13. Public information about NSF review processes<sup>8</sup> addresses this issue of Multi-Panel Review and Inter-Divisional Co-Funding but suggests that this is not unproblematic:

*"NSF does not ask PIs to identify formally whether or not a proposal is interdisciplinary, and it is not possible currently to make a direct count of the number of interdisciplinary proposals NSF receives. Indeed, a precise definition of interdisciplinarity is elusive and likely to be time-dependent. For example, a research area that, when it emerges, straddles the boundary of two different disciplines may, over time, come to be recognized as a new discipline. However, one can examine a number of characteristics of proposals, awards and the review process that may provide information on proposals that cross the boundaries of NSF's established program areas."* (NSF 2013)

4.14. In discussing different national approaches to peer review, and specifically the fact that some funders dispense with referees altogether, relying on panel assessment only, RCUK (2006) noted that some perceive interdisciplinarity to be a potential obstacle to panel-only review, whereas the NSF, which increasingly uses panel-only review, believes that panels can often deal more effectively with multidisciplinary or interdisciplinary proposals. This report (ibid.) went on to note that NSF's greater use of expert programme managers, with more responsibility for deciding outcomes, may help instill greater confidence in the one step process. The recent performance review by NSF (NSF 2013) confirms this increasing role for agency staff:

*"The growing emphasis on interdisciplinary and cross-directorate programs, together with innovative approaches to encouraging transformative research proposals, has led to a growth in coordination activities. Program officers are also tasked with an increasing number of programmatic activities, e.g., increased program accountability, training, outreach, and mentoring new staff."*

4.15. Further investigations directly with the National Institutes for Health (NIH) elicited the information that their peer review policies apply to all applications and no special policy exists for interdisciplinary science other

<sup>7</sup> [www.nsf.gov/news/news\\_summ.jsp?cntn\\_id=124178&org=NSF&from=news](http://www.nsf.gov/news/news_summ.jsp?cntn_id=124178&org=NSF&from=news)

<sup>8</sup> [www.nsf.gov/bfa/dias/policy/merit\\_review](http://www.nsf.gov/bfa/dias/policy/merit_review) ; [www.nsf.gov/nsb/topics/MeritReview.jsp](http://www.nsf.gov/nsb/topics/MeritReview.jsp)

than recruiting a broader scope of expertise. The NIH document on the core values of peer review (NIH n.d.) makes no mention of interdisciplinarity although previous working groups (e.g. special Working Group on Review of Bioengineering and Technology and Instrumentation Development Research) have in the past been created to develop a set of principles to guide the NIH Center for Scientific Review in establishing a review infrastructure that will fairly evaluate interdisciplinary research.

4.16. The ESF Peer Review Guide (European Science Foundation 2011) is the only document that we have found that stratifies their recommended peer review processes depending on the type of interdisciplinary research under review. ESF identifies four different types of interdisciplinarity (multi-, inter-, cross- and trans-disciplinarity, MICT) and offers different peer review scenarios for each (**Figures 1 and 2** in Appendix). They highlight the desire to avoid “unduly penalising MICT proposals by excessive assessments and inflated scrutiny” and advise that the primary step in the peer review process is the ability to identify the nature and levels of interactions required or expected from the contributing disciplines. They suggest that proposals should first be screened by staff with the required level of expertise within the funding organization in order to exclude any monodisciplinary proposals and categorise remaining proposals according to their MICT character with the goal of selecting the most appropriate route to peer review (see **Figure 2**).

4.17. While the European Research Council (ERC) guidance for reviewers (ERC 2012) states that proposals of an interdisciplinary nature “are strongly encouraged” there is scant mention of detailed processes to review such proposals (which was confirmed in email correspondence). In a short section entitled “The approach to inter-disciplinary proposals” it is stated that:

*“The broad definition of the panels allows many inter-disciplinary proposals to be treated within a single panel [which they term “mainstreaming of interdisciplinarity”]. During the evaluation process, potentially interdisciplinary proposals (i.e. across panels or across domains) are flagged as such, and the panel may request additional reviews from appropriate members of other panel(s) or additional remote referees.”...*

*“The initial choice indicated by the applicant when submitting his/her proposal is paramount in determining the panel under which a proposal is evaluated. An applicant who is considering his/her proposal as interdisciplinary (i.e. cross panel or cross domain) can also explicitly mention a second panel in the application form.”*

In further describing the role of the panels, the guidance states that:

*“The responsibility to ensure that cross panel/cross domain proposals receive equal and fair treatment rests fundamentally with the panels to which they are allocated. No proposal is allocated to multiple panels, ensuring an equal treatment of all proposals.”*

...

*“ the review panels can come to clear recommendations on the potential of the Principal Investigator, and the quality of the research proposed, even while recognising that certain scientific aspects of the proposals may not be fully covered by the panel's specialities”*

4.18. Luukkonen’s (2012) review of ERC peer review finds strategic practices

operating within panels. In 2010, a specific procedure was reserved for clearly interdisciplinary proposals: if such proposals passed the threshold for fundable projects, a panel comprised of chairs of the domain-specific panels assessed them. However, Luukkonen finds that domain-specific panels retained the most highly ranked interdisciplinary proposals on their main ranking list to guarantee their funding, sending the less highly ranked interdisciplinary proposals to the interdisciplinary final panel. The noteworthy point, as Luukkonen states, is that this implies that the 'best' interdisciplinary proposals were judged as such according to domain-specific criteria; she concludes that interdisciplinary proposals were not judged more harshly than single-discipline proposals.

- 4.19. Probably the most detailed guidelines that we have found for the review of applications in interdisciplinary research is to be found in the Natural Sciences and Engineering Research Council of Canada's Peer Review Manual (Natural Sciences and Engineering Research Council of Canada 2012) and on their website<sup>9</sup>. This document addresses referee selection and notes the particular challenges of interdisciplinary peer review, for example:

*"For interdisciplinary research, ensure that the referees selected have (individually or collectively) expertise in all the relevant disciplines and aspects of the proposal."*

*"The indicators of achievement and excellence in interdisciplinary research, or in emerging areas, are often not as evident as those for research in the mainstream of a given field. Therefore, Evaluation Groups should recognize and appreciate the additional challenges inherent in interdisciplinary research."*

*"Proposals that relate to interdisciplinary endeavours may appear somewhat unfocused when compared with other applications. Evaluation Groups are asked to take this into account when assessing interdisciplinary applications, as well as to keep an open mind to the practices and methodologies of disciplines other than their own."*

(Key extracts from this guidance are reproduced in the Appendix.)

## 5. Strategic themes arising from the academic literature

### Establishing quality criteria

- 5.1. The academic discourse on quality in IDR does not take place in a homogeneous scholarly community but in scattered, diverse groups. The often-temporary nature of these collaborations leads to shifting peer groups making it both difficult to capture and share learning and virtually impossible to devise standardised quality criteria.
- 5.2. Given that there is no consensus or canon concerning quality criteria, the challenge of assessing excellence is a theme that runs through the academic literature. There are widely held views that IDR often cannot be situated

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<sup>9</sup> Natural Sciences and Engineering Research Council of Canada [www.nserc-crsng.gc.ca/nserc-crsng/policies-politiques/prepinterdiscip-prepinterdiscip\\_eng.asp](http://www.nserc-crsng.gc.ca/nserc-crsng/policies-politiques/prepinterdiscip-prepinterdiscip_eng.asp)

readily within the literature (Pohl 2011), may be disadvantaged by conventional evaluation methods (Wolf et al. 2013) and generally suffers from bias against risky research (Klein 2006). This is compounded in new fields and areas of high innovation where “the knowledge domain is still being charted and consensus on validation criteria is lacking” (Klein 2010). Many authors highlight the tendency to measure IDR against its constituent disciplines, exacerbated by the fact that different disciplines often have different notions of what constitutes quality in research (Öberg 2009). Others point to the problem that, without accepted disciplinary paradigms, IDR has nothing against which it can be judged. Each reviewer will bring his or her own individual ideas about quality, which must be negotiated and managed as part of the review process (Boix Mansilla et al. 2006). Without acknowledged reference points, peer reviewers must fall back on other criteria, such as researcher prestige (Langfeldt 2006) and, in the absence of knowledge about a field, reviewers may simply base decisions on projects that they personally find interesting (Lamont et al. 2006).

- 5.3. Researchers may engage in IDR, not because their project demands this approach, but because they perceive IDR as attracting more funding: an essential component of the quality assessment must therefore be to evaluate whether such an interdisciplinary approach is necessary (Perper 1989; Pautasso and Pautasso 2010).
- 5.4. If it is not possible to define a set of quality criteria, can we instead define a framework to shape the key criteria by which IDR proposals can be evaluated thereby providing better tools to design ID evaluation? As discussed below, many authors (e.g. Öberg 2009; Wickson et al. 2006; Bruun et al. 2005; Pohl et al. 2011) suggest checklists of questions to clarify, for example, the extent of integration within the proposed research. Clarity of expression, the ability to communicate the research to a generalist audience of peer reviewers, and situating the proposal clearly within the literature are also considered to be marks of quality (Huutoniemi et al. 2010; Pautasso and Pautasso 2010).

### **Selecting peer reviewers**

- 5.5. Interdisciplinary research groups may be less firmly institutionalised with researchers coming together in temporary work teams and networks, which then dissolve when a problem is solved or redefined (Gibbons et al. 1994). While this may have the advantage of transferring knowledge and skills into new contexts, it does also mean that interdisciplinary researchers have a shifting peer group and lack the clear-cut “invisible college” of their mono-disciplinary colleagues.
- 5.6. This means that assessment is usually not conducted by true peers and reviewers may not have the expertise to judge the contributions of different disciplines (Bruce et al., 2004). Reviewers are seen to judge proposals based on their own background (Laudel 2006): peer reviewers who are too embedded within single disciplines find it hard to review IDR, whereas reviewers too specialised might be biased and those without specialisation may not be able to understand the work proposed (Porter and Rossini 1985). When panelists know little about the research area in question they

will often defer to others who are considered to have more expertise; when evaluation is undertaken by referees who do not know the area well or by experts from component disciplines they may be overly harsh (Lamont et al. 2006; Bammer 2012; Huutoniemi 2012a).

- 5.7. Tactics to counter these challenges include drawing reviewers from a wide range of fields (Porter and Rossini 1985); identifying reviewers by their primary and secondary fields of expertise (Perper, 1989); ensuring that review panels consist of both specialists and generalists (Pohl et al. 2011); including a role for *interpreters* on review panels to negotiate across disciplines (Laudel 2006; Boix Mansilla 2006); and calls for reviewers who are competent to judge the impact and methodology of IDR, without which knowledge the reviewer cannot decide if proposed work will be furthering the current state of the art (Lee 2006).
- 5.8. Regardless of this finessing, many would still regard traditional academic peers, from the same background, as the cornerstone of peer review (Holbrook and Hrotic 2013) but identifying new colleges of appropriate peers, who undertake similar kinds of interdisciplinary investigations and are therefore in the best position to evaluate each other's investigations (Bammer 2012) remains a key challenge. As in any form of peer review, funders must also remain vigilant about the inherent tendency of established disciplinary researchers and committees to appropriate funding for themselves (Nightingale and Scott 2007); IDR appears more likely to suffer from this form of "cognitive cronyism" than mainstream research (Luukkonen 2012).

### **Supporting peer reviewers**

- 5.9. The academic literature remains rather silent on the issue of how best to support and train interdisciplinary peer reviewers, but does offer some guidance on the need to develop the questions which peer reviewers are expected to answer.
- 5.10. As public funding increasingly calls for performance accountability, evaluations may also be based on fulfilling the policy of the funding agency (Roux et al. 2010); this requires clear guidance and expectation management in order to align goals and criteria (as stated in calls for proposals) with instructions for applicants, reviewers and panels. a (2012a) reports that reviewers worried more about not knowing what criteria to use than they did about gaps in their knowledge.
- 5.11. The expertise of the reviewer needs to be carefully managed in order to promote good ID reviewing (Boix Mansilla et al. 2006) and this may require a process of coaching on the part of the funder (Klein 2006; Defila and Di Giulio 1999). Developing a more collaborative or partnership approach (Klein 2008; Laudel 2006; Huutoniemi et al. 2010), which enables pooling of expertise among reviewers (Huutoniemi 2012a), and negotiating a means of resolving differences between reviewers (Luukkonen 2012) can be key to a successful IDR review process. At minimum, this requires extra time at the beginning of a panel meeting to develop common understanding of the programme and criteria by which interdisciplinary bids are to be judged

(Lyall et al. 2013). Others go further and recommend encouraging opportunities for greater reflexivity among reviewers (and applicants) so that they reflect on personal standpoints and biases and how this may affect the decision-making process (Huutoniemi, 2012a; Boix Mansilla et al. 2006; Wickson et al. 2006; Pautasso and Pautasso 2010; Roux et al. 2010).

- 5.12. Pohl et al. (2011) give some of the best practical advice on the selection of reviewers and the conduct of the review process; we reproduce some of their material below (§6.16).

### **Tailoring the application process**

- 5.13. Peer reviewing of IDR is generally viewed as more complex and costly (Feller 2006; Langfeldt 2006). Securing best value may require the application process to be tailored in order to acknowledge some of the differences inherent in IDR.

- 5.14. Interdisciplinary research does not occur automatically by bringing together several disciplines in a research project (Lyall and Fletcher 2013). Extra effort is needed to promote the formation of a cohesive research team involving researchers from different disciplines, to combine expertise from several knowledge domains and to overcome communication problems among researchers from different disciplines. Establishing a rapport between researchers is a crucial aspect of IDR: how the team will be managed to foster communication is also a necessary criterion for evaluation (Klein 2008).

- 5.15. All of this means that interdisciplinary projects tend to be slightly larger, more expensive, and may take longer to deliver high quality publications. In practical terms, this might also mean more travel to liaise with project team members on a more frequent basis and attendance at a greater number of more diverse conferences in order to reach all potential audiences. Given that successful, interdisciplinary research is more resource intensive than monodisciplinary research, reviewers therefore need to recognise that effective interdisciplinary integration takes time and that this can have an impact on the perceived value for money of projects. Disciplines act to give structure to research: the broader scope of IDR must be recognised by reviewers, so that proposals are not branded 'unfocused' (Bruce et al. 2004). Other issues that the reviewer should be aware of are that:

- a more flexible timetable may be required to allow for development of research design
- the applicants may be based in non-traditional departments
- the proposed publication outputs may not be the top-ranking, discipline-based journals
- the proposed research may not be at the cutting-edge of any single discipline

but none of these factors automatically implies that it is not a high-quality proposal (Lyall et al. 2011b).

- 5.16. The grant proposals themselves may need to be longer in order to allow additional space to justify the interdisciplinary research design (Bammer

2012) and this has implications when proposals have to be submitted using the RCUK joint electronic submission system.

- 5.17. Some review processes already include a “right of reply” (sometimes termed a “rejoinder” or “rebuttal”) to allow researchers to address misunderstanding between the proposers and reviewers (e.g. Porter and Rossini 1985). Some authors recommend taking this further so that the peer review is structured more like a debate (Laudel 2006): this might include discussing with the proposers the appropriate quality indicators (Boix Mansilla 2006); giving researchers the right to choose or veto their reviewers (Laudel 2006); or allowing first round external reviewers an opportunity to defend their decision in front of the final selection panel (Luukkonen 2012). All of which would have resource implications.

### **Broader institutional issues**

#### **5.18. Role and influence of funders**

We have noted in previous work (Meagher and Lyall 2009) that funding schemes can develop different persona depending on which funder is administering them within a bi- or tri-lateral partnership between funders. This can be frustrating for applicants and reviewers who may be familiar with one set of procedures and routines and who must then adapt to a different set of rules. This can be exacerbated when there is a lack of clarity from the funders over what they expect of IDR (e.g. Tress et al. 2005; Huuttoniemi et al. 2010), especially within multi-funder schemes.

- 5.19. This can raise issues about who provides leadership especially in the case of interdisciplinary programmes where the academic Programme Director may play a key role in shaping interdisciplinarity (Lyall et al. 2013). Concerns may be voiced if influencing the shape and direction of a programme leads to claims of interference and lack of transparency in the peer review process.

#### **5.20. Gender**

Given evidence to suggest that more female researchers participate in IDR than male (e.g. Rhoten and Pfirman, 2007; van Rijnsoever and Hessels 2011), funders may wish to ensure that their peer review processes do not introduce any issue of gender bias.

#### **5.21. Early Career Researchers**

Experience of IDR can be seen as both a help and a hindrance to a future academic career (Bruce et al. 2004; Meagher and Lyall 2005) but, given the issue of shifting peer groups discussed above, it may be harder for early career researchers (ECRs) to achieve success given that track record may play a greater role in evaluation decisions for IDR (Luukkonen, 2012; Langfeldt 2006). Luukkonen (2012) further suggests that the opportunity to build networks, for example having a background in industry, a fragmented or a long career, was mostly likely to positively impact on interdisciplinary researchers and this again may count against ECRs. Funders may therefore wish to consider whether their review processes disadvantage younger ID researchers.

## 6. Emerging elements of good practice

- 6.1. There is clearly a view that effective evaluation of IDR proposals may not be possible with traditional peer review which relies primarily on experts in a single discipline (e.g. National Academies 2005) and that we need to go beyond simply assessing scientific excellence in order to ascertain the quality of integration in such proposals. As we discuss in this section, several authors therefore suggest additional questions to complement – but not replace – criteria to assess the quality of interdisciplinary proposals.
- 6.2. This exposes a key tension in the evaluation of IDR: while recognising that they require special treatment, funders must seek to avoid creating additional hurdles for interdisciplinary proposals in comparison with disciplinary proposals. Balancing flexibility with parity and cost efficiency will present some challenges to funders and – it should go without saying – funders should ensure that any additional requirements are apparent before applications are made.

### Composition of the panel

- 6.3. As we have already noted, peer review processes vary widely between country, and between funding bodies. In the descriptions that we have read, we have observed considerable variation between funders as to whether interdisciplinary proposals are reviewed by a separate interdisciplinary panel or ‘mainstreamed’ into regular panels.
- 6.4. The evidence suggests that interdisciplinary research fares better when it is the subject of a dedicated call and this makes the specialist panel a relatively straightforward option. A more challenging issue is how to treat what RCUK would term ‘responsive mode’ applications and this may require some refinement to current practice.
- 6.5. The literature would suggest that panels should be a mix of specialists and generalists and include interpreters – experts who are able to explain a specific approach or method in an easy understandable language to other members of the panel.
- 6.6. Panel members should be chosen depending on context of evaluation (e.g. academically-oriented or problem-focused interdisciplinary research); discipline-based experts should be selected for their breadth of disciplinary understanding rather than expertise; and a significant number of members should themselves have a successful IDR track record (Lyall et al. 2011b).
- 6.7. Although we have not identified much in the way of specific advice, there is clearly a recommendation in the literature that both peer reviewers and panel members benefit from training that, at minimum, should constitute a pre-panel meeting briefing. We have also found in previous work (Meagher and Lyall 2013) that the ‘mock panel’ as used by the ESPA programme to be very beneficial. Further suggestions include (Lyall et al. 2011b) ensuring that the panel is given guidance on how to deal with disagreements on the value of different disciplinary contributions and what weight to give to disciplinary contributions in relation to overall interdisciplinary quality. The Panel chair plays a crucial role in ensuring that guidelines are



implemented and not side-lined in favour of traditional disciplinary criteria and may require additional coaching in order to fulfil this role.

### **Selection of external reviewers**

6.8. There is general agreement that interdisciplinary proposals will require a higher number of individual/remote reviewers but that these can be harder to identify when proposals may cross the funder's normal disciplinary remits. As discussed in the following section, the literature suggests that the selection of reviewers (and of the criteria of evaluation) should become more of a joint process among reviewers, the panel and the applicants. RCUK might also consider the establishment of a shared interdisciplinary reviewers' college (consisting of individuals expert in a range of interdisciplinary areas) to address the common challenge of finding reviewers who are sympathetic to interdisciplinary research and understand how to evaluate it both rigorously and appropriately.

### **Design of the review process**

6.9. In order to address the plurality of standards of validation and the plurality of goals of interdisciplinary research, several scholars suggest changing the process of evaluation by making the process more participatory. As Pohl et al. (2011) describe, based on their own review of the academic literature for the Swiss National Science Foundation, an alternative process would be for the applicants, together with the panel to first select the reviewers. The reviewers and the applicants would then meet and discuss before the proposal is submitted. The first submission would be followed by a critical discussion of reviewers, panel members and the submitting researchers.

6.10. This proposal could prove quite impractical from the funders' perspective but might, nevertheless, indicate other potential refinements to the interdisciplinary review process.

6.11. The first of these would be to consider the role of funding agency officials. Several sources recommend greater eligibility screening carried out by experienced and dedicated administrative staff who are better able to identify suitable peer reviewers and guide the deliberations of interdisciplinary panels. This might suggest developing a cadre of ID specialists (potentially an Interdisciplinary Champion in each research council) on the staff who are able to provide training and support for colleagues, so that they are more able to distinguish genuine interdisciplinarity and deal effectively with issues that arise during the evaluation process. An alternative would be to establish a shared RCUK resource for interdisciplinary investments with dedicated administrators experienced in the particular requirements of interdisciplinary research and research training.

6.12. A second refinement would be to request an extra section specifically for interdisciplinary bids, in which applicants could describe the distinctive benefits of, and need for, an interdisciplinary approach and convey their appreciation of the supplementary processes involved in interdisciplinary research. Where proposals are submitted from a team of researchers, an explicit strategy for building and managing the research team to best effect

is crucial and the proposal should indicate expected synergistic outcomes from the combination of disciplines/approaches (Tait and Lyall 2001; Lyall et al. 2011b).

6.13. In their study for the Academy of Finland, Bruun et al. (2005) recommend that, at minimum, all applicants proposing interdisciplinary projects should also address the following generic questions:

- Why is an integrative approach necessary?
- What kind of integration is proposed?
- What fields, approaches, and methods will be integrated?
- How will integration be carried out, from both intellectual and organisational standpoints?
- What is the level of preparedness of participants, including prior experience in integrating knowledge?
- Is the integration feasible in terms of scope as well as material and human resources?

6.14. Given the debate about what constitutes 'quality' within the highly heterogeneous field of IDR, several commentators suggest that applicants should also be asked to reflect on what the quality standards for this particular research community are in order to guide the evaluation.

6.15. Thirdly, we observe a number of recommendations to include the opportunity for (i) applicants to exercise a right to reply to the remote assessments before the review panel meeting and (ii) for those reviewers to justify their assessments to the review panel. While some RCUK schemes do already permit a right of reply, a more structured, bespoke approach where applicants are asked to address specific issues arising from the review (e.g., taking into account questions in the bullet list above) rather than a general rebuttal of reviewers' criticisms, would go some way to addressing the calls for a more structured and participatory debate among applicants, reviewers and panels.

### **Questions to guide reviewers**

6.16. Both peer reviewers and panel members need to be guided towards an examination of whether the proposed research demands an interdisciplinary approach and is truly integrative in nature. This means, for example, searching for evidence of a joint research question, joint theory formation and shared methods, data and materials. Several commentators (e.g. Öberg, 2009; Wickson et al., 2006; Pohl et al. 2011; Lyall et al. 2011b) have suggested sets of questions that reviewers might adopt to probe quality indicators and we conclude by offering an aggregated checklist for reviewers.

### **Checklist for reviewers**

#### **What does a successful interdisciplinary proposal look like?**

1. Does the proposal describe clear goals, adequate preparation, appropriate method, significant results, effective presentation, reflective critique?
2. How was the problem formulated?
3. How diverse are the disciplines, methods and researchers and how suitable is the combination of disciplines?
4. Is there a clear justification for the choice of disciplines based on the needs of the research questions?
5. Is the study sufficiently anchored in relevant literature?
6. What is the relationship with the methodology?
7. How will communication be tackled?
8. Does it describe how the disciplines involved will be integrated (in the design and conduct of the research as well as in subsequent publications) and how this relates to the type of interdisciplinarity involved; does it demonstrate how the quality of integration will be assured?
9. How is the collaboration organised – is there an understanding of the challenges of interdisciplinary integration, including methodological integration, and the ‘human’ side of fostering interactions and communication, and an effective strategy to achieve this?
10. Is the leadership role and management strategy to deliver the desired outcomes clearly articulated?
11. Do the researchers involved have demonstrable interdisciplinary skills and experience?
12. In particular, is there evidence of interdisciplinary leadership?
13. Is there an appropriate plan for stakeholder/user engagement from the outset of the project?
14. Does the proposal budget for, and justify, the additional resources needed?
15. Is it clear how interdisciplinarity will be reflected in the project outputs and outcomes?

## 7. Suggestions for further work

- 7.1. The expectation was that this scoping study might form the first part of a more extended study. One extension to this current report, which could be delivered fairly shortly, is the inclusion of some brief case study material that would draw on existing and current work that we have conducted on behalf of NERC (Lyall et al. 2011c) and ESPA (Meagher and Lyall 2013). The latter is not yet publicly available but we have the Director's permission to reproduce it once the report of our learning review of ESPA's interdisciplinary peer review processes has been accepted in November.
- 7.2. There are clearly some limitations to a short, desk-based study such as this where we have relied almost exclusively on information available in public documents. We have sought to probe a little further through email discussion with 25 individuals in the IDR community and national funding bodies but their role has essentially been limited to signposting key documents. If the Research Group wished to obtain further information about the rationale behind, for example, consultation processes that have led to changes in national funders' approaches to interdisciplinary peer review, then this would best be achieved through a series of telephone interviews or more in-depth email discussion. From the information gathered to date, follow up interviews with key informants within SNSF, NSF, ARC and NSERC (all of which have implemented changes to their interdisciplinary peer review processes) and with the Nordic research councils (whose procedures are viewed in the academic literature as being supportive of interdisciplinarity) might be quite productive.
- 7.3. Additionally, there are some academics who have made a study of interdisciplinary evaluation including, notably Dr Katri Huutoniemi (University of Helsinki) who recently completed a PhD on this topic (Huutoniemi, 2012b) and Prof Robert Frodeman (Center for the Study of Interdisciplinarity, University of North Texas) who led a recent NSF-funded study on Comparative Assessment of Peer Review: discussion with a few scholars such as these individuals should prove fruitful.
- 7.4. One issue that this current study has alluded to but not explored in depth is the role of programme directors in shaping interdisciplinary programmes. From other research that we have conducted (Lyall et al. 2011c; Meagher and Lyall 2013), we know that the potential issue of two-stage review which assesses first the quality of the science and then secondly seeks to influence interdisciplinary outcomes, may be problematic and could bear further investigation if this is an aspect of interdisciplinary peer review that the Research Group wished to examine further.
- 7.5. Finally, and longer term, Prof Lyall has been invited to participate in an EU COST network which, if funded, would examine aspects of interdisciplinary research policy, including peer review, across some 13 partner countries.
- 7.6. We would be happy to discuss incorporating any or all of these suggestions into a second phase of this project subject to the Research Group's interests and the availability of the research team.

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## Appendix

**Table 1: Global Research Council National Guidelines on Merit/Peer Review** (Source: [www.globalresearchcouncil.org/documents](http://www.globalresearchcouncil.org/documents))

Country	Agency	Link	Mentions ID? *
Austria	FWF Der Wissenschaftsfonds	<a href="http://www.fwf.ac.at/en/projects/decision-making-procedure/fwf-decision-making-procedure.pdf">http://www.fwf.ac.at/en/projects/decision-making-procedure/fwf-decision-making-procedure.pdf</a>	x
Australia	ARC	<a href="http://www.arc.gov.au/general/assessment_process.htm">http://www.arc.gov.au/general/assessment_process.htm</a>	✓✓
Brazil	FAPESP	<a href="http://www.fapesp.br/en/FAPESP_peer_review_20111012.pdf">http://www.fapesp.br/en/FAPESP_peer_review_20111012.pdf</a>	x
Belgium	FWO	<a href="http://www.fwo.be/Evaluatieprocedure.aspx">http://www.fwo.be/Evaluatieprocedure.aspx</a> <a href="http://www.fwo.be/CMSDownload.aspx?ID=159e23cf-3b96-4be5-a18f-d8ba00bb0f16&amp;L=nl">http://www.fwo.be/CMSDownload.aspx?ID=159e23cf-3b96-4be5-a18f-d8ba00bb0f16&amp;L=nl</a> <a href="http://www.fwo.be/CMSDownload.aspx?ID=db02c7b7-76d6-4f83-a57a-d1b60841a21e&amp;L=nl">http://www.fwo.be/CMSDownload.aspx?ID=db02c7b7-76d6-4f83-a57a-d1b60841a21e&amp;L=nl</a>	✓
Canada	NSERC	<a href="http://www.nserc-crsng.gc.ca/_doc/Reviewers-Examineurs/CompleteManual-ManualEvalComple_t_eng.pdf">http://www.nserc-crsng.gc.ca/_doc/Reviewers-Examineurs/CompleteManual-ManualEvalComple_t_eng.pdf</a>	✓✓✓
Estonia	Estonian Science Foundation	<a href="http://www.etf.ee/public/files/evaluation_guidlines_2012.pdf">http://www.etf.ee/public/files/evaluation_guidlines_2012.pdf</a>	x
European Union	ERC	Broken link	
European Union	European Commission	Broken link	
Europe	ESF Peer Review Guide	<a href="http://www.esf.org/">http://www.esf.org/</a>	✓✓✓
Finland	Academy of Finland	<a href="http://www.aka.fi/Tiedostot/Tiedostot/Arviointitoiminta/Instructions_Panels_2011.pdf">http://www.aka.fi/Tiedostot/Tiedostot/Arviointitoiminta/Instructions_Panels_2011.pdf</a> <a href="http://www.aka.fi/Tiedostot/Tiedostot/Arviointitoiminta/Instructions_Individual_Reviewers_2011.pdf">http://www.aka.fi/Tiedostot/Tiedostot/Arviointitoiminta/Instructions_Individual_Reviewers_2011.pdf</a>	x

Germany	DFG	<a href="http://www.dfg.de/download/pdf/foerderung/antragstellung/begutachtung/dfg_begutachtungsverfahren_091214_en.pdf">http://www.dfg.de/download/pdf/foerderung/antragstellung/begutachtung/dfg_begutachtungsverfahren_091214_en.pdf</a>	✓
Hungary	OTKA	<a href="http://www.otka.hu/index.php?akt_menu=1366">http://www.otka.hu/index.php?akt_menu=1366</a>	✗
Netherlands	NWO	Broken link	
Norway	Research Council of Norway	<a href="http://www.forskningsradet.no/en/Application_processing/1138882215874">http://www.forskningsradet.no/en/Application_processing/1138882215874</a>	✗
Portugal	FCT	<a href="http://www.fct.pt/apoios/proyectos/concursos/2010/docs/guia_avalicao">http://www.fct.pt/apoios/proyectos/concursos/2010/docs/guia_avalicao</a>	✗
Russia	RFBR	<a href="http://www.rfbr.ru/rffi/eng/assessment">http://www.rfbr.ru/rffi/eng/assessment</a>	✗
Slovenia	ARRS	<a href="http://www.arrs.gov.si/en/akti/prav-sof-ocen-spremljivost-razisk-dej-260111.asp">http://www.arrs.gov.si/en/akti/prav-sof-ocen-spremljivost-razisk-dej-260111.asp</a>	✓
Sweden	VR	<a href="http://www.vr.se/download/18.122a0d251301f4f33458000922/Evaluation+Handbook+NT+2011.pdf">http://www.vr.se/download/18.122a0d251301f4f33458000922/Evaluation+Handbook+NT+2011.pdf</a>	✓
Switzerland	SNSF	<a href="http://www.snf.ch/SiteCollectionDocuments/snf_beschreibung_auswahlverfahren_e.pdf">http://www.snf.ch/SiteCollectionDocuments/snf_beschreibung_auswahlverfahren_e.pdf</a>	✓

\* Authors' assessment: ✗ no specific mention of IDR; ✓ some mention; ✓✓✓ more extensive mention

Note: This GRC database did not include the US funders e.g. NIH, NSF

**Natural Sciences and Engineering Research Council of Canada: Guidelines for the Preparation and Review of Applications in Interdisciplinary Research** (Source: extract from [www.nserc-crsng.gc.ca/nserc-crsng/policies-politiques/repinterdiscip-prepinterdiscip\\_eng.asp](http://www.nserc-crsng.gc.ca/nserc-crsng/policies-politiques/repinterdiscip-prepinterdiscip_eng.asp))

**In the review of interdisciplinary proposals, special attention should be paid to the following:**

- Selection of referees who are involved or familiar with interdisciplinary research. Additional referees should be sought to cover the range of research areas in the proposal.
- The peer review process should not create additional hurdles for interdisciplinary proposals in comparison to disciplinary proposals. Where needed, additional peer review mechanisms (e.g., site visits, sub-committees, consultations between committees) should be used to ensure the completeness and fairness of the peer review process.
- Some differences are inherent in interdisciplinary research: it may require a longer time frame; proponent(s) may lack a track record in a new, developing area or in an area new to them; and it may call for a more collaborative approach.
- As always, the evaluation of the quality and impact of research contributions should be of primary importance and not the journal in which the publication appears, or the vehicle used for disseminating results. Interdisciplinary journals that focus on new and emerging areas may not be as mature or as well known as more established discipline-based ones.
- The proposed research and the applicant's contributions should be assessed in the broader context of interdisciplinary research and not just in the narrower context of the reviewer's own discipline and research interests.

**Selection committees and panels will consider the following when assessing interdisciplinary applications:**

- What is the "added value" of the interdisciplinary approach? Will new knowledge from the interdisciplinary research have an impact in different fields, or are technologies and methodologies from different fields being used to further knowledge in one discipline?
- Have the perspectives of all relevant disciplines been considered in defining questions, methodology to be used, etc.?
- Does the applicant(s) demonstrate an understanding of the core problems and basic theoretical assumptions of the other fields involved?
- Is the terminology used clearly explained to audiences from different disciplines?
- Is all the required expertise available?
- For collaborative research, is there clear leadership, coordination and communication?
- Is there sufficient time to complete the research?

## FIGURE 1 EXTRACT FROM ESF PEER REVIEW GUIDE

### Multidisciplinarity

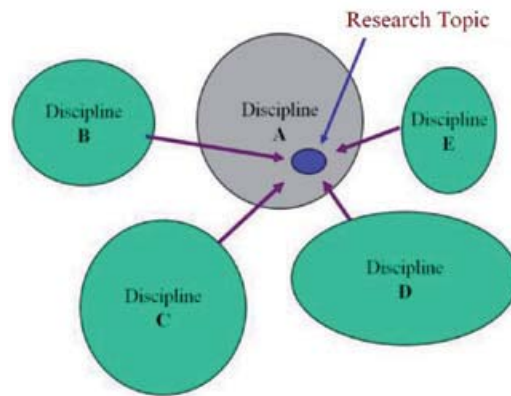
is concerned with the study of a research topic within one discipline, with support from other disciplines, bringing together multiple dimensions, but always in the service of the driving discipline. Disciplinary elements retain their original identity. It fosters wider knowledge, information and methods.

#### Examples

*Research Topic:* Discovery of a particular drug

*Host discipline:* Pharmacology

*Complementing disciplines:* Biochemistry, Chemistry, Medicine.



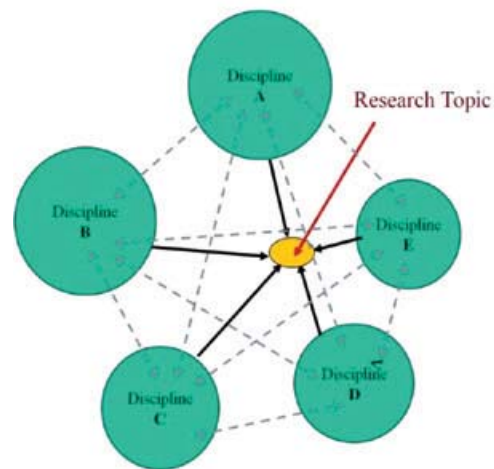
### Interdisciplinarity

is concerned with the study of a research topic within multiple disciplines, and with the transfer of methods from one discipline to another. The research topic integrates different disciplinary approaches and methods.

#### Example

*Research Topic:* Robotics

*Host versus complementing disciplines:* this has changed over the years and with the expansion of the field, there could be different host(s) and complementing disciplines from Mechanical, Electrical and Computer engineering, Mathematics, Informatics and Computer Science, Neuroscience or Psychology.



### Crossdisciplinarity

is concerned with the study of a research topic at the intersection of multiple disciplines, and with the commonalities among the disciplines involved.

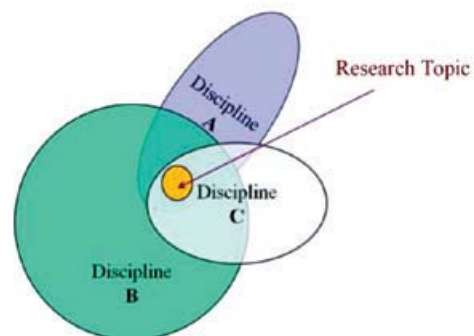
#### Example

*Research Topic:* Biologically Inspired Engineering

*Host disciplines:* Engineering, Material science

*Complementing disciplines:* Biology, Zoology

Interactions are very strong with commonalities in the way biological systems and engineering counterparts are viewed.



### Transdisciplinarity

is concerned at once with what is between, across and beyond all the disciplines with the goal of understanding the present world under an imperative of unity of knowledge.

#### Examples

*Research Topic:* Synthetic Biology, Cognition, Artificial Intelligence

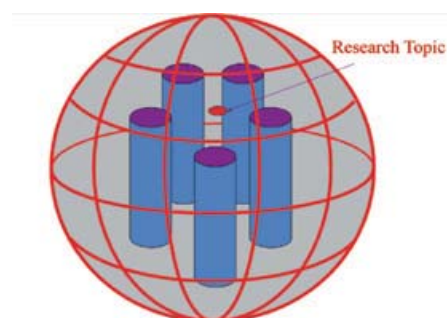


Table 5. MICT definitions and examples

**FIGURE 2 EXTRACT FROM ESF PEER REVIEW GUIDE**

	Multidisciplinary	Interdisciplinary	Crossdisciplinary	Transdisciplinary
	Scenario A	Scenario B	Scenario C	
Main features	<ul style="list-style-type: none"> <li>• Clear distinction between the relevance of ONE driver or host discipline with other complementing disciplines</li> <li>• Scope of the research motivated in host discipline</li> <li>• Expected results will occur in host discipline</li> <li>• New applications within the host discipline for concepts, methods, devices and systems that are primarily conceived within the complementing disciplines</li> </ul>	<ul style="list-style-type: none"> <li>• Distinction between the relevance of ONE host discipline and other complementing disciplines</li> <li>• Scope of the research motivated in host discipline but triggered by or strongly linked to other complementing disciplines</li> <li>• Cross-fertilisation expected in host and some of the strongly complementing disciplines</li> <li>• Results go beyond finding new applications in the host discipline</li> </ul>	<ul style="list-style-type: none"> <li>• Similar degree of relevance and connection to all implicated (host) disciplines</li> <li>• Scope of the research motivated collectively by all host disciplines</li> <li>• Strong need for integration of disciplinary perspectives and approaches</li> <li>• Cross-fertilisation expected across host disciplines</li> <li>• May lead to new paradigms or new disciplines</li> </ul>	
Peer review stages	<ul style="list-style-type: none"> <li>• Two-stage: individual assessments plus one review panel with rebuttal</li> </ul>	<ul style="list-style-type: none"> <li>• Two-stage: individual assessments plus one review panel with rebuttal</li> </ul>	<ul style="list-style-type: none"> <li>• Three-stage: individual assessments in each host discipline plus two review panels with rebuttal</li> </ul>	
Individual assessment reviewers	<ul style="list-style-type: none"> <li>• Three from the host discipline + one from each of the complementing disciplines, or</li> <li>• at least three experts covering all the topical expertise (keyword matching)</li> </ul>	<ul style="list-style-type: none"> <li>• Sufficient number of experts (at least three) with the required levels of topical expertise (keyword matching), or</li> <li>• three from the host discipline + two from the strongly complementing discipline + one from other disciplines</li> </ul>	<ul style="list-style-type: none"> <li>• Three from each of the host disciplines</li> <li>• One from each of the complementing disciplines</li> </ul>	
Review panel	<ul style="list-style-type: none"> <li>• One panel with members from host discipline will make final peer review decision</li> </ul>	<ul style="list-style-type: none"> <li>• One panel with members from host discipline and from strongly complementing disciplines will make final peer review decision</li> </ul>	<ul style="list-style-type: none"> <li>• One panel for each host discipline with members from that discipline making a preliminary disciplinary judgment</li> <li>• A second consolidating panel will synergise all the information and make a final decision</li> <li>• Some or all members of the consolidating panel may be representatives from the disciplinary review panels</li> </ul>	

**Table 6.** Summary of the suggested peer review scenarios