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RCR – A Danish textbook for courses in Responsible Conduct of Research

Karsten Klint Jensen, Louise Whiteley and Peter Sandøe (eds.)

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Contents

1 About this book

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1. Introduction

The Danish Code of Conduct for Research Integrity, issued in 2014, recommends that all researchers receive teaching and training in the responsible conduct of research (RCR). Since 2011 it has in fact been mandatory for all new PhD students at the University of Copenhagen to take a course in RCR. PhD students in the Faculty of Science and the Faculty of Health and Medical Sciences have attended courses with the same content and roughly the same structure. For the first few years, course participants were given a compendium of texts to read. This involved inevitable overlaps and a lack of terminological consistency. In addition, many of the texts originated in the US, where the regulatory framework on RCR differs from that found in Denmark. A number of the people involved in teaching the two courses have therefore joined forces to produce a more complete, consistent and concise text. This book is the result.

The aims of this book are to present the RCR course content in an accessible form; to set out and encourage the use of clear and consistent terminology; and to describe the way RCR is dealt with in Denmark and at the University of Copenhagen. The intended readers are from two faculties where the great majority of research projects fall under the umbrella of the natural sciences, broadly construed. The book therefore deals with 'research' as it is typically understood and practiced in the natural sciences. Researchers from the social sciences and humanities may not always feel comfortable with the way we describe research, but we hope that the book will enrich the reflections of students from all disciplines – many of the issues are shared across disciplines, and in any case identifying interdisciplinary differences can be illuminating. We also hope that PhD supervisors and other researchers will find the book useful as a common meeting point for discussion between students and their supervisors.

So we had a course that needed a textbook, but why have the course in the first place? In other words, what do we hope to achieve by teaching the subjects presented here? This is the first question we will address in this brief introductory chapter. We will then consider the scope of the textbook, and finally we will say a little about the book's structure and use.

2. Why RCR teaching?

The University of Copenhagen was the first university in Denmark to introduce RCR courses for all PhD students. The immediate cause of this was a scandal in 2010 involving Professor of Biomedicine Milena Penkowa and centred on alleged research misconduct dating back about 10 years. It led to criticisms and complaints alleging that senior management at the University and in the Faculty of Health and Medical Sciences had not responded in a timely and adequate manner to a number of warnings over the years (read more about this case in Chapter 3).

Following the scandal, a number of initiatives were taken, first at the University of Copenhagen and later nationally, to prevent research misconduct and promote RCR. The first of these initiatives was to require courses in RCR for future researchers, i.e. PhD students. Due to national guidelines, the requirements for RCR taching have then been expanded to cover PhD supervisors and students at BA and Master's level.

This raises the questions: Are mandatory courses in RCR effective in combating research misconduct? Will they prevent cases like that of Milena Penkowa in the future? The short answer is "no". Cases of serious research misconduct seem to have occurred at regular intervals historically and are often closely linked to the personalities and specific circumstances of the researchers involved. There is every reason to think that such cases will continue to occur.

What then is the point of the course? First, it may provide knowledge and tools to deal in a more timely way with cases of serious misconduct when they occur. Although mandatory courses in RCR would have been unlikely to prevent the Penkowa case, they might have enabled university management and concerned fellow scientists to effectively investigate and deal with the case at a much earlier stage. Secondly, it is important to underline that although a case of serious research misconduct was the immediate reason

for establishing the course, RCR also focuses on wider and much more common issues in the grey zone between research misconduct and acceptable scientific practice – in other words, on everyday issues that all researchers face.

For instance, authorship issues are very important in RCR, but only in serious cases would they constitute research misconduct. Questions about authorship include: Who should be co-authors of a publication? How should the order of the authors be decided? Who should be the corresponding author? In what ways should co-authors be consulted before the final version of a paper is submitted for publication? What kind of information and/or documentation about the relative contributions of the respective authors should be provided? It is important for all PhD students to be clear about the answers to these questions, particularly those whose theses are composed of journal articles. If authorship issues are not managed well, they could lead to authorship disputes, delays in publication or detraction from scientific quality. However, most issues of these kinds amount to questionable research practices (QRP, see Chapter 2) rather than serious research misconduct.

It is our hope that the course teaching sessions, together with this textbook, will help young scientists to maintain high standards of research integrity in their early career; that they will become better at dealing with authorship issues as well as other key areas where questionable research practices can arise, such as data management, intellectual property rights, conflicts of interest, and communication with the wider society. It should also be noticed that Danish researchers are not alone in having to learn about RCR. Researchers in countries such as the US have for some years had to pass exams in RCR to hold federal grants and to be appointed to faculty positions. Moreover, an understanding of RCR principles, reflection, and regulation are increasingly required as a precondition of international research collaboration.

3. The scope and limits of the book

In some cases, there are clear principles of responsible conduct that students should know: for example, that you must obtain the explicit consent of all co-authors before submitting a paper. But in many instances we cannot give clearly defined answers as to the right way to behave. This is not because we are uninformed or vague; rather it is because there are grey zones where rules and established norms do not give clear answers. For example, as will become clear in Chapter 4, there is no precise, objective and universally applicable rule setting out what contribution one must have made to qualify as a co-author. Minimum requirements are set out, including making a substantial contribution to content, but what it means for a contribution to be "substantial" is itself difficult to define and differs across disciplines, institutions, and research groups.

Where clear rules and guidelines cannot be given, we instead aim to enable the reader to become better at reasoning about the issues; to find her or his own stance. This is a critical part of learning to be a scientist, but it is often conducted ad hoc, in private, and alone. We hope to promote a growing climate of openness about what it is to be a responsible researcher, and about the boundary between acceptable shortcuts and irresponsible conduct.

The demands of RCR are not static – quite the contrary. What is considered good practice is constantly shifting. Take, for example, data management. Until recently there were no rules about how researchers at the University of Copenhagen should keep and share research data. Now the various faculties are developing detailed rules and policies, and international norms regarding data sharing are developing rapidly. Another aim of the course and this textbook is therefore to inform researchers about recent developments, whilst also encouraging them to keep themselves up to date.

It should be noted that some subjects that are typically covered by RCR courses in other countries are not covered here. In particular, ethical issues raised by the use of human subjects and animals in research are not part of the RCR courses in Denmark.

4. The content and structure of the book

Following this introductory chapter, two chapters provide a general framework for understanding RCR, and how it has developed and been institutionalized.

Chapter 2 explains how interest in RCR has developed since the 1980s, starting in the US and then spreading across the world. Key terminology in RCR is then set out and defined. Most importantly, we explain the distinction between *research misconduct* and *questionable research practice*. The former is fraudulent research behaviour involving *falsification*, *fabrication* and *plagiarism*. The latter covers the many 'grey zone' issues that are ubiquitous in scientific life.

In Chapter 3 we describe how the regulation of RCR has developed in Denmark and specifically at the University of Copenhagen. We explain how a series of dramatic cases of research misconduct led to the development of new institutions and codes, including the Danish Committee on Research Misconduct, the Practice Committee at the University of Copenhagen, the Named Person, and the Danish Code of Conduct for Research Integrity. We conclude the chapter with an overview of how to handle issues in responsible research conduct.

The remaining five chapters cover a number of specific issues that we consider likely to be of relevance to young researchers. Thus, in Chapter 4 we look at issues regarding publication and authorship which are often a young researcher's first explicit encounter with questions of research integrity. In Chapter 5 we deal with another dimension of RCR that most readers will need to understand: data management. In what way, and for how long, should we store research materials and data, and when and how should we share them with other researchers? Chapter 6 examines an issue that is a mandatory part of the course but will be relevant only to some readers, namely patenting and other methods of commercialization of research results. In Chapter 7 we discuss conflicts of interest. Financial conflicts of interest should be considered by all researchers who are funded by, or collaborate with, the industry. But conflicts of interest need not be financial; they arise at every stage of the research process, where pressures on researchers' time and productivity can undermine RCR. In the final chapter we look at communication between science and the wider society, discussing why, when, and how public science communication work should be undertaken. This subject may seem a little remote for some PhD students, and it is true that it is primarily the responsibility of the institution rather than the individual researchers. However, even PhD students who decide not to get involved in public communication are required to write a popular article based on their thesis which may be quoted by media sources.

Each chapter starts with a summary. Information about rules, institutions and cases appear in text boxes, and links to useful documents and further reading are provided. Finally, at the end of each chapter there are "test yourself questions", which in some cases remind you of the key points and in others encourage you to consider complexities which may not have a simple answer.

The subjects covered by this book are developing all the time. We therefore foresee regular updates to the present text, and we hope that our readers will offer feedback that can be used to improve future versions. Comments can be sent to Karsten Klint Jensen at kkj@ifro.ku.dk or Louise Whiteley at lowh@sund.ku.dk

2
General introduction to responsible conduct of research

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* This text grew out of a draft by Hanne Andersen ("Responsible Conduct of Research: Why and How?", *RePoSS: Research Publications on Science Studies*, 29, Aarhus: Centre for Science Studies, Aarhus University (2014)). The author is grateful to Hanne Andersen for permitting her text to serve as source for the present version with the minor overlaps this might involve. Thanks are also due to Peter Sandøe, Louise Emma Whiteley and Mathias Willumsen for valuable comments.

Summary

This chapter describes how the field of research misconduct management developed, first in the US and later elsewhere in the world, driven by a number of spectacular cases. It goes on to ask why researchers engage in misconduct, and this leads to a short discussion of the modern institution of science. The competitive nature of contemporary science incentivizes not only serious misconduct, but also much more widespread questionable research practices. The chapter concludes by describing recent initiatives to promote research integrity, internationally as well as in Denmark

1. Introduction

In Denmark, research integrity has been summarized under the headline features of honesty, transparency and accountability (see the Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014), and see more in Section 5 below).

Research misconduct may have serious consequences for patients or consumers, who may experience harmful effects from a treatment or a marketed product which is made available on the basis of false and misleading information in the name of science. Alternatively, as happened in the Wakefield case (see Box 1) individuals may suffer as a result of *not* using a product, after being exposed to fraudulent claims about negative effects, again made in the name of science. In the bigger picture, the worry is that science as an institution may lose credibility, and as a consequence diminish in importance, leaving society vulnerable to more irrational decision-making.

Following several spectacular cases of research misconduct, there has been a gradually increasing focus on promoting *responsible conduct of research* (RCR). This development started in the US, but has now spread across the world. Most countries have set up regulatory mechanisms for institutions to deal with cases of *research misconduct*, a category generally defined internationally by the three notions of *fabrication, falsification, and plagiarism* (FFP, see more below). Within the scientific community the importance of promoting responsible conduct of research has also been increasingly acknowledged, with the goal of discouraging less serious but far more widespread questionable research practices, which may not amount to serious misconduct but nevertheless threaten the integrity of science. Thus a number of international and national codes for *research integrity* have been formulated.

RCR and its failure, i.e. research misconduct and questionable research practices, have become notions which no researcher

BOX 1: WAKEFIELD AND THE VACCINATION SCARE

In 1998, the British medical doctor Andrew Wakefield together with 12 co-authors published a study in the journal *The Lanc*et of 12 children with diagnoses of developmental disorders including autism or autistic spectrum disorder, in which they suggested a possible link between the triple MMR (measles, mumps, rubella) inoculation and what they identified as developmental regression and bowel disease. Before the paper was published Wakefield called for the suspension of the MMR vaccination programme at a press conference. This fuelled an MMR vaccination scare, which was followed by a decline in vaccination rates in the US, the UK and Ireland. The paper, and Wakefield's later warnings, also seemed to produce more general mistrust of childhood vaccination. However, other studies failed to reproduce Wakefield's findings. In 2007 a hearing began to examine charges of misconduct against Wakefield and two of his co-authors, and in 2010 the 1998 paper was declared dishonest because it involved deliberate falsification of data. This led to a retraction of the paper by *The Lancet*. Although he claimed to be innocent, Wakefield was then barred from practicing in the UK. However, he continued to do research in the US, and to this day he defends his claims and continues to warn against the MMR vaccine. It is believed that the vaccination scare is responsible for serious illness and deaths in thousands of children.

Main sources: Godlee et al. (2010), Editors of The Lancet (2010).

can afford to ignore. Thus, in the wake of the Penkowa case, the University of Copenhagen found it necessary to focus more energetically on how to deal with deviations from RCR. Among other things, it set up mandatory courses for PhD students and senior researchers. A similar tightening up has occurred in universities all over the world, and many journals are now enforcing stricter requirements which their authors must meet.

BOX 2: THE SOMAN CASE

In 1978, Helena Wachslicht-Rodbart submitted a manuscript to *New England Journal of Medicine*. One reviewer, Professor Philip Felig of Yale, passed on the paper to his junior, Vijay Soman, and they recommended rejection. However, two other reviewers recommended acceptance subject to revision. During her work on the revision Wachslicht-Rodbart was asked by *The American Journal of Medicine* to review a paper written by Soman and Felig. The paper looked very similar to her own. Some paragraphs and an equation were identical, and it appeared that the authors had been the very people to recommend rejection of her own paper. Wachslicht-Rodbart complained about plagiarism to *New England Journal of Medicine*, and she also expressed doubts to Yale about whether Soman and Felig had conducted a study at all. However, no investigations were initiated. On the contrary, all parties seemed to prefer a quiet cover-up; even Wachslicht-Rodbart's superior, who happened to be an old friend of Felig's, tried to silence her and threatened to dismiss her. The Soman-Felig paper was published, but new problems with the paper appeared, and finally an investigator was appointed. Soman then admitted to having fabricated the data and agreed to resign. Further investigations uncovered fraud in 12 other papers by Soman, on most of which Felig was a co-author. Felig was fired from a prestigious new position at Columbia, but returned later to Yale. Wachslicht-Rodbart decided to leave research.
Main source: Hunt (1981).

The need for open discussion and teaching in RCR is underpinned by the fact that in many cases it is not clear where the line should be drawn. Between the clear-cut cases of responsible conduct, on the one side, and research misconduct, on the other, there is a grey zone within which *questionable research practices* remain a problem, and this zone has vague boundaries. It is therefore necessary for researchers to understand the concepts which lie on either side of, and delineate, this grey zone, and to reflect on the implications for their personal practice.

The remainder of this chapter introduces the key concepts for RCR. It defines and describes the concepts of *research misconduct* and *questionable research practice* through a series of illustrative cases, and explains the concepts of *responsible conduct of research* and *research integrity*, and places them all in context.

2. What is research misconduct?

The Soman case (Box 2) illustrates several aspects of research misconduct. For one thing, there appears to be a great unwillingness to accept that a scientist has intentionally engaged in fraud. The prestige attached to certain persons or their positions, and efforts that have been made to promote certain researchers or results, typically add to this difficulty. In addition, the case demonstrates that research misconduct concerns not only the individual researchers involved, but also the institutions at which they work, and the journals in which they publish. There might be a temptation to conceal a case of research misconduct, to make light of its importance, or even to shoot the whistleblower, in order to shield the university or journal from negative publicity. However, this is a gamble, as once a cover up is revealed the university or journal is likely to lose even more credibility.

Universities were traditionally viewed as self-regulating academic communities, and until the 1980s it was more or less left to universities themselves to deal with cases of research misconduct and questionable research practice. No universities had formal systems for doing this. Even in a very serious case, like the Soman incident described in Box 2, it was often a long while before the university involved reacted by setting up *ad*

hoc investigations; and whistleblowers were often put under pressure to dismiss their case or even threatened with sanction – in the Soman case the whistleblower was a young scientist without a permanent position.

During the 1970s and 1980s, several spectacular cases of misconduct in the US painted a picture of widespread incidents similar to the Soman case. The perception was that in many cases institutions were closing their eyes in the face of fraud to protect old friends and discredit whistleblowers. Where investigations were initiated, they appeared to be dragged out over very long periods and not to reach clear verdicts; and in many cases perpetrators were able to continue in their questionable practices at other institutions. The cases appeared to show the public that the scientific community was unable to deal effectively and convincingly with research misconduct itself.

In 1981 the first of a series of congressional hearings threw light on the problems and put more pressure on institutions to set up systems to deal with research misconduct, and to teach staff and students norms of responsible conduct of research. In the late 1980s, despite protests from the scientific community, the US was the first country to implement regulations that required universities receiving public funding to establish clear policies and procedures for handling misconduct.

Hence, a system developed in the US in which the main universities and other leading research institutions set up rules for RCR and appointed people to deal with offences. At the same time, large public funding agencies like the National Institute of Health and the National Science Foundation set up offices, including the Office of Research Integrity, to monitor and coordinate action. During this period the leading journals in medicine and science also gradually developed codes of conduct for responsible authorship and started to retract papers based on documented research misconduct (see the Wakefield case described in Box 1).

Thus, the first definition of misconduct was developed in US regulation. The current definition is known as the FFP definition, because it focuses on **F**abrication, **F**alsification and **P**lagiarism (see Box 3).

BOX 3: US OFFICE OF RESEARCH INTEGRITY DEFINITION OF RESEARCH MISCONDUCT

Research misconduct means fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results.

(a) *Fabrication* is making up data or results and recording or reporting them.

(b) *Falsification* is manipulating research materials, equipment, or processes, or changing or omitting data or results such that the research is not accurately represented in the research record.

(c) *Plagiarism* is the appropriation of another person's ideas, processes, results, or words without giving appropriate credit.

Research misconduct does not include honest error or differences of opinion.

(Source: Office of Research Integrity, n.d.)

Of course, the US was not the only country to encounter problems with research misconduct which called for regulation. Similar developments have occurred in many other countries and have spread from the medical and natural sciences to social sciences and the humanities.

The Hwang Woo-Suk case (Box 4) emphasizes the international character of much research and demonstrates that misconduct may have consequences all over the world. It also shows, like the Wakefield case, how hype about expected results can create strong expectations among not only patients and other potential beneficiaries, but also among funders. Strong expectations can create incentives to cheat in order to meet those expectations. And experience of success and hero status can sometimes seem to impair a scientist's ability to maintain a critical perspective on the integrity of their practice.

The Stapel case (Box 5) is an example from the social sciences. It shows the importance of openness in the handling of data and in particular allowing others access to raw data. Once again in this case, a senior researcher's success and status were instrumental in silencing critical questions for very long time. Maybe there is an indication here that the fear of losing one's status may be an even stronger temptation to cheat than the original gain of advantage without costs. The case also illustrates the importance of an environment in which procedures are transparent and there is ample space for questions and critique.

The Annette Schavan case is an example from the humanities. It is a case with many ironies. A person who writes about the way conscience is formed, and its necessity in education, does not appear to have been troubled by her own conscience when it came to plagiarizing the work of others. Also, as a government minister Schavan was responsible for research

BOX 4: THE HWANG WOO-SUK CASE

Hwang Woo-Suk is a South Korean researcher who became known as the King of Cloning. He appeared to be the answer to the South Korean hope of achieving industrial progress though biotechnology in spite of limited investment and a rather narrow scientific base. Following his claim to have cloned some cows (without providing verifiable data), media hype about the great promise of his research developed. He became a central figure in South Korean science governance and attracted a lot of Government funding. After Hwang's team claimed to have obtained stem cells from one out of thirty human embryos (published in *Science* 2004), and later, that it had established 11 embryonic stem-cell lines derived from the skin cells of individual patients (published in *Science* 2005), Hwang became the pride of South Korea. When the Bioethics and Biosafety Act came into force on 1 January 2005 it contained a clause that effectively exempted Hwang from the regulation.

Ironically, Hwang was charged with unethical conduct for having used eggs from paid donors and a junior member of his team. He admitted this and resigned, but he intended to continue his research. Then the Seoul National University opened an investigation into his research which concluded that both Science papers were based on fraudulent data. Science retracted the two papers, and Hwang was later sentenced to two years in prison (suspended) for embezzlement and bioethical violations. Apparently, he is still active as a researcher. Main source: Gottweis & Triendl (2006).

BOX 5: THE DIEDERIK STAPEL CASE

Diederik Stapel is a former Dutch Professor in social psychology. At the height of his career he was famous for several outstanding publications on human behaviour and considered a star member of faculty at Tilberg University. However, in 2011 three young researchers started to develop doubts about his activities, and eventually a committee was set up to investigate his work at three universities in The Netherlands. He was suspended in 2011.

A final report (Tilburg Univerity, 2012) concluded that Stapel had fabricated or manipulated data in at least 55 publications, dating back to as early as 2004. Early in his career, he manipulated data, but later he simply pretended to have run experiments and sent processed data to colleagues or PhD students for further analysis. No one was ever allowed to see the raw data. In all 19 PhD theses were prepared with data from Stapel, but the investigators advised that the PhD degrees should not be retracted, because Stapel had acted alone in the fraud.

In 2013, Stapel agreed to perform 120 hours of community service and to return income from his former position (at 1.5 x annual salary) in order to avoid further criminal prosecution. Main source: Tilburg University (2012).

integrity across the entire country, with her own integrity somewhat impaired. Finally, research misconduct did not damage Schavan's standing as a Catholic, and in particular her capacity to represent Germany to the Catholic Church itself.

Initially, the US definition of misconduct contained, in addition to fabrication, falsification, and plagiarism, a fourth clause: "other practices that seriously deviate from those that are commonly accepted within the scientific community". However, this clause was criticized by many scientists and scientific bodies, including the National Academy of Science, because it could have been used to punish creative or novel science. It was therefore later removed, leaving us with FFP. The fact that research misconduct does not include differences of opinion has been explicitly confirmed in Denmark. This happened as a result of the case against Bjørn Lomborg (see Chapter 3). However, in contrast with the US definition, which only mentions FFP and excludes "honest error" from research misconduct, Denmark, like many other countries in Europe, and like Australia, previously adopted a wider definition. The Danish definition (termed 'scientific dishonesty') was open-ended; it included a clause on "other serious violations of good scientific practice" and also included acts that are "grossly negligent". However, the new law (Ministry of Higher Education and Science (2017), see Chapter 3) has adopted the FFP definition. National differences in definition and regulation may create problems for researchers participating in the international world of science.[1]

3. The competitive nature of today's science

Why do people engage in misconduct? The many spectacular cases of misconduct have forced the scientific community not only to set up institutions and procedures to handle cases of misconduct, but also to look at the causes. Perhaps unsurprisingly, the usual motive behind research misconduct is self-interested pursuit of an advantage over others in the competition for funding, positions and overall recognition "without incurring the cost of effort" (Fang & Casadewall, 2013).

Back in 1942, the sociologist of science Robert K. Merton tried to describe the values adhered to by the scientific community (Merton, 1973). He identified what later became known as the CUDOS norms: **C**ommunalism (new results are the common property of the scientific community), **U**niversalism (scientists can all contribute to science regardless of their race or gender or social

1 The account in this section is mainly based on LaFolette (2000) and Steneck (1994).

BOX 6: THE ANNETTE SCHAVAN CASE

Annette Schavan is a German politician and member of the Christian Democratic Union. She studied education, philosophy and catholic theology, earning her doctorate at Düsseldorf University with a dissertation entitled *Person and Conscience*. In 1995-2005 she was Minister for Culture, Youth and Sport in Baden-Wüttenberg, and in 2005-2013 she was federal Minister for Education and Research. In 2012, a blog (Schavanplag, n.d.) claimed that 94 pages of Schavan's 325-page dissertation were copied without reference to sources. Schavan asked the university to examine the allegation. In an interview, Schavan said that she could not claim never to have made mistakes out of carelessness, but she refuted the claim that she had plagiarized or cheated. However, the faculty concluded in 2013 that, throughout the dissertation, she had wilfully committed fraud by plagiarism, and her degree was revoked. Schavan announced immediately that she would file a complaint over the verdict to the Court of Administration (Verwaltungsgericht). A few days later, she stepped down from her post as a federal minister.

Her complaint was rejected by the Court of Administration in 2014. But in the same year she received an honorary doctorate from the University of Lübeck, and later in 2014 she became German ambassador to the Vatican.

Main source, which among other things contains all the official documents: Schavanplag (n.d.).

background), **D**isinterestedness (scientists are not driven by personal interests in their pursuit of science), and **O**rganized **S**kepticism (scientific claims are critically scrutinized by the scientific community before being accepted). Merton's description was influential for the scientific community's perception of itself.

Interestingly, Merton did not attribute the norm of disinterestedness to the scientific community because he believed scientists to be morally better than ordinary people; rather, he found that the frequency of severe fraud in science was lower than that in other areas of human endeavour and concluded that an institutional norm actively deters scientists from research misconduct. Outside of explicit research misconduct, Merton also considered that the norm of disinterestedness could be violated by misusing science for various political purposes (e.g. in making claims about race or history not driven by the pursuit of truth).

At the end of the twentieth century the physicist John M. Ziman described the institution of science rather differently using the PLACE norms (Ziman, 2000): **P**roprietary (results are proprietary rather than communal), **L**ocal (researchers focus on local puzzles rather than general understanding), **A**uthority (there is a hierarchical structure of authority rather than the equality implied by Merton's universalism), **C**ommissioned (research is often commissioned and therefore not disinterested), and **E**xpert (scientists are valued as experts who can give advice on action rather than for their originality; Merton later included 'originality' in the CUDOS norms). Clearly, the shift from CUDOS (Merton, 1973) to PLACE (Ziman, 2000) signals a dramatic development in the perception of how science works, how it is organized and how it relates to society. And this raises questions about how science can retain its integrity if its traditional norms, as described by Merton, are indeed this deeply challenged. However, a closer look at the actual development of science between the 1940s and today gives a more nuanced picture. One aspect of the development of science is the *sheer increase in volume*. Already in 1963, the historian of science Derek John de Solla Price had argued in his book *Little Science – Big Science* that the amount of scientific activity, measured by the number of journals and results etc., had been growing exponentially, doubling every 10-15 years (De Solla Price, 1963). Solla Price warned that this growth could not proceed indefinitely, but the expansion still continues. A more recent follow-up study of the number of journals (Olesen Larsen & von Ins, 2010) has concluded that "[t]here are no indications that the growth rate has decreased in the last 50 years" (p. 600).

Another aspect is the increasingly prominent *role in society* that science has gained during the twentieth century and the first years of the twenty-first century. Following WWII, it became clear to politicians and the general public alike that science-based inventions and technologies had the potential to create prosperity and solve problems for society on a large scale (whilst of course also raising anxieties about the destructive potential of science and technology). Society has come to expect that 'expert' scientific knowledge will guide governments, public and private bodies, and individual citizens in making informed decisions on almost any issue in modern life, from dietary choice and medical treatment to energy saving initiatives and computer safety.

With high expectations about the advances science can bring, governments all over the world allocate substantial amounts of money to scientific research and to the education of scientists. Public funding agencies have thus been created in many countries, and across national borders, most notably perhaps in the EU. Governments then expect returns from their investment. In order to optimize quality and the efficient use of resources, many governments allocate large parts of public research funding through free competition between applicants. Many, moreover, have encouraged collaboration and co-funding between universities and industry, hoping to see greater economic returns from research investment. As a result, researchers have become much more dependent on proving scientific success, not least in terms of publications, and they increasingly collaborate with the private sector, where financial and other interests may conflict with the traditional values of academic freedom and disinterestedness (see Chapter 7).

Another development, sometimes described as the move from Mode 1 to Mode 2 Research,[2] is the funding of large, temporary, interdisciplinary projects designed to address specific problems. These problems are defined not by academia (as in Mode 1), but by a wider group of stakeholders in society, often including representatives of industry. Contemporary research is also characterized by greater internationalization. This is typically encouraged by funding agencies in the hope that synergies across borders will increase the quality of outputs and promote capacity building. In order to meet the evolving demands of governments and other funders, it has been necessary to organize science in increasingly large units with a high degree of specialization and division of labour.

Science has no doubt over the years developed higher scientific standards and more rigorous methods. Current requirements on clinical trials and statistical rigor are important examples of this. Also, the increasing demands for openness and accuracy in reporting across large, often international consortia have halted some of the research misconduct practices that big scientific names in the past managed to get away with. Clearly, however, the developments describes above raise some challenges. The modern scientist has left the ivory tower and has become a member of ordinary society, subject to its demands and trends in a way that may conflict with the most direct pursuit of scientific knowledge. Funders of research make strong demands on researchers, and obtaining funds from a variety of sources places the modern scientist in a field of conflicting interests that have to be managed. Conflicts of interest are discussed in more detail in Chapter 7. Increasingly, patents are the expected outcome of today's collaborations, which means that some scientific results are no longer common property as Merton (1973) insisted. The issue of intellectual property rights (IPR) is discussed in Chapter 6.

Again, scientists are not only providing the public good of shared knowledge; they are also involved in fierce competition for funding and positions. With such keen competition, researchers are highly dependent on proving their continued success. Since most funders employ various bibliometrics (e.g. journal rankings and citation indices) as a measure of quality in scientific performance, researchers often feel they are under increasing pressure to publish as much as possible, as quickly as possible, and in as high-ranking journals as possible. The competitive environment provides an incentive for each individual to gain advantages relative to others; and in this climate some people are likely to be tempted into misconduct.

4. Questionable research practices

Just how widespread is research misconduct? Clearly, this is difficult to assess accurately, in part because underreporting is highly likely. Martinson et al. (2005) (see more below) report estimates that 1%-2% of all scientists have been engaged in misconduct. These figures indicate that very many cases go undetected when compared to the number of reported cases. Thus, institutions and procedures need to be in place to bring cases to light and handle them when they do occur. Moreover, universities need to develop a culture which provides access and protection for whistleblowers and at the same time offers protection from false accusations, which may also be part of a competitive environment.

Compared to the more serious cases of research misconduct, *questionable research practices* are much more widespread (Martinson et al., 2005; Fanelli, 2009). Such practices are defined as research which undermines research integrity – breaching principles of honesty, transparency, and accountability – without amounting to research misconduct, and commonly arise within some of the areas discussed later in this book, like authorship and publication (Chapter 4), data handling and management (Chapter 5) and conflicts of interest (Chapter 7). To the extent that questionable research practices are much more widespread, they may have serious consequences for both the reliability of scientific results and public trust in them.

Some people wish to bring failure to live up to accepted standards for scientific methodology under the umbrella

2 These terms were coined in A. Gibbons et al. (1994).

of questionable research practices. For instance, there has recently been a debate over reproducibility that evolved in the medical sciences, but it is likely to spread to other areas. There is evidence to suggest that much basic and clinical research does not meet the fundamental requirement of reproducibility (e.g. see Begley & Ioannidis (2015) and The Lancet, (2014) for further discussion). Failure of reproducibility is, of course, a very serious problem. But whether it should be counted as a questionable research practice, as these are described above, is controversial. There is a distinction between being in good faith but failing to live up to standards because these have developed, and failing to live up to standards with the intent of cheating. Clearly, scientific standards develop over time, so it is arguable that historical research that would now be conducted differently need not have involved wilfully breaches of honesty, transparency or accountability. Hence, these questions are kept apart in this chapter.

FIGURE 1: A TABLE INDICATING THE PREVALENCE OF VARIOUS BEHAVIOURS IN THE US (FROM MARTINSON, ANDERSON, & DE VRIES (2005))

Percentage of scientists who say that they engaged in the behaviour listed within the previous three years (n=3,247)

Top ten behaviours	**All**	**Mid-career**	**Early-career**
1. Falsifying or 'cooking' research data	0.3	0.2	0.5
2. Ignoring major aspects of human-subject requirements	0.3	0.3	0.4
3. Not properly disclosing involvement in firms whose products are based on one's own research	0.3	0.4	0.3
4. Relationsships with students, research subjects or clients that may be interpreted as questionable	1.4	1.3	1.4
5. Using another's ideas without obtaining permission or giving due credit	1.4	1.7	1.0
6. Unauthorized use of confidential information in connoection with one's own research	1.7	2.4	0.8***
7. Failing to present data that contradict one's own previous research	6.0	6.5	5.3
8. Circumventing certain minor aspects of human-subject requirements	7.6	9.0	6.0**
9. Overlooking others' use of flawed data or questionable interpretation of data	12.5	12.2	12.8
10. Changing the design, methology or results of a study in response to pressure from a funding source	15.5	20.6	9.5***
Other behaviours			
11. Publishing the same data or results in two or more publications	4.7	5.9	3.4**
12. Inappropiately assigning authorship credit	10.0	12.3	7.4***
13. Witholding details of methodology or results in papers or proposals	10.8	12.4	8.9**
14. Using inadequate or inappropriate research designs	13.5	14.6	12.2
15. Dropping observations or data points from analyses based on a gut feeling that they were inaccurate	15.3	14.3	16.5
16. Inadequate record keeping related to research projects	27.5	27.7	27.3

Note: Significance of X^2 tests of differences between mid- and early-career scientists are noted by **(P<0.01) and *** (P< 0.001)

On the basis of a meta-analysis of available studies of the prevalence of research misconduct, Fanelli (2009) found that almost 2% of researchers admitted to having "fabricated, falsified or modified data or results at least once" (p. e5738), while a much larger proportion, 33.7%, admitted to other questionable research practices. When participants were asked about the behaviour of their colleagues, the numbers rose, and 14% reported that they had witnessed colleagues engaging in falsification and 72% reported that they had witnessed colleagues engaging in questionable research practices.

One of the studies include in Fanelli's (2009) meta-analysis was the survey by Martinson et al. (2005), which was completed by over three thousand US researchers (see Figure 1). The "top ten behaviours" in their table are behaviours that are likely to be sanctionable. The "other behaviours" are less serious or careless.

Martinson and his colleagues found that 0.3 % of the scientists who replied to the survey had, by their own admission, engaged in the falsification of data, and that 1.4 % had used the ideas of others without obtaining permission or giving due credit (plagiarism). However, a number of behaviours in the domain of questionable research practices had far higher frequencies. Of the respondents, 6% reported that they had failed to present data that contradicted their own previous research, 12.5% had overlooked others' use of flawed data or questionable interpretation of data, and 15.5 % had changed design, methodology or results in response to pressure from a funding source. Bias in the face of pressure from funding is examined in more detail in Chapter 7, author-ship and publications issues are examined in Chapter 4, and the handling and storage of data is discussed in Chapter 5.

These behaviours can make research results look more credible than they really are. Policymakers, companies, clinicians or other stakeholders who make decisions on the basis of this kind of exaggerated credibility may then end up making unwarranted and in some cases damaging decisions. Scientists who base their research on misplaced confidence in others' results may waste their time, and are at risk of producing further connected errors.

One of the drivers of questionable research practices is the intense competition for funding, positions, and so on, with researchers under constant pressure to 'improve' their CVs. Martinson et al. (2005) suggest that bad practice by some researchers trying to 'get ahead' may in turn encourage wider adoption of questionable practices, because people who see others appearing to get away with such practices without sanction (and who therefore see a skewed distribution of positions, publications and funding) may follow suit so as not to lose out in a competition perceived as unfair.

Considerations such as these suggest that research misconduct is not just a matter of individuals with "bad traits", or of local contexts (departments, laboratories) with a "bad culture". Widespread questionable research practice appears to be associated with general institutional and structural features of the research environment. As outlined above, recognition of this distribution of responsibility for both good and bad scientific practice has gradually led to a stronger focus on research integrity.

5. Research integrity

The notion of *responsible conduct of research* refers to conduct conforming with published rules or guidelines. This notion looks at behaviour from the outside, so to speak: did the individuals perform the right actions? Did they, for example, report findings accurately and objectively?

Research integrity is a notion which expresses, and emphasizes, the importance of the underlying values and norms of research – norms which the whole research community should not only display through their behaviour, but internalize as ideals they believe in. The hope is that when researchers sign up to norms in this way, they become motivated to comply with rules and guidelines, and to take responsibility for the trustworthiness of their and colleagues' research.

Within the last decade, agencies around the globe have worked towards international dialogue on how to understand and promote research integrity, and how to eventually harmonize standards and regulations.

A series of World Conferences on Research Integrity, from 2007 onwards, has been prominent in this work. The 2nd World Conference in 2010 produced the Singapore Statement on Research Integrity (World Conferences on Research Integrity, 2010). This international statement outlines "the principles and professional responsibilities that are fundamental to the integrity of research wherever it is undertaken". These are summarized as:

- Honesty in all aspects of research
- Accountability in the conduct of research
- Professional courtesy and fairness in working with others
- Good stewardship of research on behalf of others

This statement was followed, at the 3rd World Conference, by the 2013 Montreal Statement on Research Integrity in Cross-Boundary Research Collaborations (World Conference on Research Integrity, 2013). This outlines the responsibilities of individual and institutional partners in cross-boundary research collaborations, including general collaborative

BOX 7: PRINCIPLES OF RESEARCH INTEGRITY IN THE DANISH CODE OF CONDUCT FOR RESEARCH INTEGRITY

Honesty

To ensure the trustworthiness of research, researchers should be honest when reporting objectives, methods, data, analysis, results, conclusions, etc.

This requires accurate and balanced reporting when:

- presenting and interpreting research
- making claims based on findings
- acknowledging the work of other researchers
- applying for research funding
- reviewing and evaluating research

Transparency

To ensure the credibility of scientific reasoning, and to ensure that academic reflection is consistent with practice in the relevant field of research, all phases of research should be transparent.

This requires openness when reporting:

- conflicts of interest
- planning of research
- research methods applied
- results and conclusions

Accountability

To ensure the reliability of research, all parties involved should be accountable for the research carried out.

This requires that researchers and institutions accept responsibility for the research they are conducting, in terms of:

- accuracy and reliability of research results
- adherence to all relevant regulations
- fostering and maintaining a culture of research integrity through teaching, training, and supervision
- taking appropriate measures when dealing with breaches of responsible conduct of research

responsibilities, responsibilities in managing collaboration and in collaborative relationships, and responsibilities for the outcomes of research. The statements acknowledge that there are many national and disciplinary differences in the way research is organized and conducted, but they nonetheless seek to formulate basic principles and professional responsibilities that are fundamental to the integrity of science in general terms. Detailed interpretation of the general principles and their specific legal implications are often spelled out, however, in national and local regulations.

All existing Danish guidelines refer to these international statements. In a collaborative operation initiated in 2013, the Ministry of Higher Education and Science and the organization Universities Denmark worked together on The Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014), which was published in 2014. This Code now serves as the primary point of reference for researchers working in Denmark. It will of course need to be implemented by the universities, at which point it will be elaborated in more detailed local policies. According to the Code, three basic values should guide all research, inspired by the Singapore Statement (see Box 7):

The Code goes on to specify in detail the responsibilities of individuals and institutions across a wide range of areas, including research planning and conduct, data management, publication and communication, authorship, collaborative research, and conflicts of interest. It also outlines principles for research integrity in teaching, training and supervision. Finally, it states: "Institutions and researchers share a responsibility for addressing and taking appropriate measures when encountering breaches of responsible conduct of research", and this includes research misconduct as well as the broader range of questionable research practices.

It seems appropriate to end this chapter with the statement: "**Researchers** and **institutions** are responsible for creating and maintaining an environment where it is acceptable to bring forward well-founded suspicions of breaches of responsible conduct of research in good faith." This helps to bring out the idea of a shared, personal *and* institutional, duty to create an environment for research in which the incentives to indulge in questionable practices are minimized because individuals regard the system as fair, and because it is hard to gain an unfair advantage without cost to oneself. In Chapter 3, we move on to discuss how to handle breaches of responsible conduct of research in Denmark.

6. Test yourself questions

- How do "research misconduct" and "questionable research practices" differ?
- What are the main reasons why people engage in scientific misbehaviour?
- How do "responsible conduct of research" (RCR) and "research integrity" differ?
- What are the basic values underlying research integrity?

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3
How are breaches of RCR handled in Denmark?

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Summary

This chapter describes Danish procedures for handling breaches of RCR as they have developed over the years and explains how researchers encountering problems with RCR can navigate in the system. The following institutions, regulations, and official recommendations are covered by the chapter: the Danish Committe on Research Misconduct (DCRM) – until 2017 called the Danish Committees on Scientific Dishonesty (DCSD), the Practice Committee at the University of Copenhagen, Named Person arrangements, and the Danish Code of Conduct for Research Integrity.

1. Introduction

What can and should you do if you come across colleagues or collaborators who engage in scientific practices you find problematic? If you decide that you need to act, what are the possibilities and where can you seek guidance? The answers to these questions to a large extent depend on answers to the following questions, to be addressed in this chapter: What systems are set up in Denmark to deal with research misconduct and questionable research practice? And what official rules and norms apply within these systems?

Over the last few decades, following the developments in the US as described in Chapter 2, most Western countries have set up systems to deal with research misconduct. Most countries have followed a model in which the primary responsibility for investigating and dealing with allegations of research misconduct lies with the individual research institution. However, in Denmark, a system for dealing with cases of research misconduct at the *national* level was developed from the start of the 1990s. This system was later supplemented with institutional procedures for dealing with less serious cases of questionable research practice at the university level. Since 2012 this has been further supplemented with so-called Named Persons who serve as the point of contact for researchers and students who are unsure about how to handle alleged cases of research misconduct or questionable research practice. At the University of Copenhagen, there is one Named Person appointed for each Faculty.

In the following sections we describe the Danish system for handling violations of RCR, as it has developed over the years. We give some key pieces of information and pointers to help researchers who are facing problems with RCR to use the system. We begin by looking at the DCRM, the central national committee handling Danish cases of research misconduct. The body from which the Committee developed was first established in 1992, and the Committee is still the backbone of the system for handling cases of alleged research misconduct in Denmark.

2. The Danish Committee on Research Misconduct – Outline of the system

The committee system grew out of an initiative taken by the Danish Research Council for Medical Sciences. In 1992, an initial committee of eight members was established, including seven medical scientists and a high court judge as Chair. This committee covered health and medical sciences only and was established as a temporary initiative. In many ways it served to define the later terms and workings of the system.

In 1998 a permanent system with a committee system covering the full spectrum of scientific enquiry was established by an executive order issued by the Minister of Higher Education and Science. (This system is currently based on *Lov om videnskabelig uredelighed m.v. (Research Misconduct etc.), Act no. 383 of 26 April 2017* passed by the Danish parliament). This meant that from 1998 onwards the committee system was founded on Danish legislation, and that the definition of research misconduct was now laid down in law. For a reference to the current rules, see Box 1 and Box 2; and for a description of the 1998 rules see the 1999 report (in Danish) issued by the DCSD (2000).

The Committee is chaired by a court judge and the other 8-10 members must be recognized scientists representing different research areas. All the scientific members of the Committee are appointed by the Minister of Higher Education and

Science, based on an open call followed by a consultation with the Independent Research Fund Denmark.

The starting point of a case is normally that someone files a written complaint. Complaints can be filed by an individual or an institution. With the procedural setup introduced by the new law from July 2017 all individual complaints must be filed at the relevant research institution. The institution will then screen the case to see if some formal requirements are met (is there a scientific product, is the person complained about a researcher, and does the compliant concern research misconduct) and forward the case to the Committee for processing. The Committee can raise cases at its own initiative, but typically cases rely on someone being willing to come forward and make the complaint. Here it is important to notice that according to the law, every Danish university or other public research institution is obliged to raise cases for the Committee if there is a grounded suspicion of research misconduct committed at the institution in question. So the managament of the University of Copenhagen is under the legal obligation to pursue and report cases of research misconduct. The name of the person who makes the complaint will be issued to the person(s) complained about: the system does not allow for anonymous whistleblowers.

When someone makes a complaint it will in most cases be about alleged research misconduct by another researcher. However, sometimes cases are raised by researchers who want

BOX 1: THE DANISH COMMITTEE ON RESEARCH MISCONDUCT

The Danish Committee on Research Misconduct is a national committee consisting of a high court judge and 8-10 recognised researchers and it operates under the Ministry of Higher Education and Science.

The Committee deals with written complaints about research misconduct. It cannot punish offenders but may inform the institutions to which an offender is attached and the institutions may then invoke disciplinary actions. A complaint cannot normally be sent directly to the Committee but must be sent to your own research institution which will then pass it on. At the University of Copenhagen a complaint about research misconduct should be sent to the Practice Committee at the University of Copenhagen (see box 5).

You can read more about the Commitee on its web page (DCRM, 2017a) where it is also possible to read anonymized decisions taken by the Committee. You can also find an overview of the current regulatory framework (DCRM, 2017b).

BOX 2: THE DANISH DEFINITION OF RESEARCH MISCONDUCT

Lov om videnskabelig uredelighed m.v. (Act on Research Misconduct etc.), Act no. 383 of 26 April 2017, § 3:

"3.-(1) For the purposes of this Act:

1) Research misconduct shall mean: Fabrication, falsification and plagiarism committed wilfully or with gross negligence when planning, performing or reporting on research.
2) Fabrication shall mean: Undisclosed construction of data or substitution with fictitious data.
3) Falsification shall mean: Manipulation of research material, equipment or processes as well as changing or omitting data or results, thus making the research misleading.
4) Plagiarism shall mean: Appropriation of other people's ideas, processes, results, texts or specific concepts without giving due credit."

Excluded from the definition are

1) cases of fabrication, falsification and plagiarism which have only had minor importance when planning, performing or reporting on the research;
2) matters relating to the validity of scientific theories; and
3) matters relating to the research quality of a scientific product.

According to the remarks of the law authorship issues and so-called self-plagiarism are not normally considered cases of research misconduct.

to be cleared of allegations of research misconduct against themselves. For example, in 1994 the newly elected rector[3] of the University of Copenhagen, Kjeld Møllgård filed a case to exonerate himself of allegations of research misconduct going back more than 20 years. In this case the Committee, based on a report from a subcommittee with external members, concluded that the allegations were baseless.

The wording describing what counts as research misconduct has changed since the rules for the first committee were defined, but the substance is more or less the same – see Box 2 for the latest version.

When a case is presented to the Committee, the first thing it should do is to decide whether or not to deal with the case. For the Committee to accept a case, it must fall under its remit, as defined by the rules set out in Box 2, i.e. by concerning "fabrication, falsification or plagiarism in planning, performing or reporting research". The case also has to concern research conducted with full or partial Danish public funding or research conducted at a public research institution in Denmark. If the research in question is strictly privately funded and does not involve a public research institution the Committee can only deal with the case if the enterprise etc. consents. A number of formal requirements must then be satisfied. First, the case must concern a scientific product, i.e. a product generated by means of scientific methods applied in research typically in the form of a research paper or funding application. Secondly, the person concerned must be a researcher which is defined as any person who is a PhD student or who has a PhD degree or similar qualifications.

For the Committee to deal with a case it must be one of alleged research misconduct, not just scientific disagreement. From the beginning, the committee system has drawn a distinction between scientific disagreement over the validity of scientific theories or the quality of the research being conducted, and claims about research misconduct. The Committee only deals with the latter. Disagreements about what constitutes good science and the validity of specific scientific claims are left for the scientific community itself to deal with through peer review and via public critique of others' work.

Many of the cases put before the committee system so far have been rejected during the initial phase, typically because they do not concern a scientific product. For example, if a researcher engages in a public debate and makes claims that are not supported by facts, this is usually not covered by the rules.

If a case is complicated and requires expertise not found among the members of the Committee, it may decide to obtain expert assistance as specifically required, e.g. by including an external expert in the Committee's processing of the case. In other cases, the Committee may obtain an external statement from an expert giving an opinion on (parts of) the case.

When the Committee finds that a case meets the formal requirements and therefore should be taken under active consideration in the Committee, the next step is to procure all relevant information for processing the case. This will always involve a hearing of the person subject to the complaint, so

3 These were the days when rectors were elected by university staff and students.

BOX 3: REQUIREMENTS THAT MUST BE MET FOR THE ACTIONS OF A RESEARCHER TO BE DEEMED A CASE OF RESEARCH MISCONDUCT:

1) It must be a case of falsification, fabrication, or plagiarism.
2) It must be done wilfully or with gross negligence.
3) It must be about a researcher's product brought forward by means of scientific methods as part of research.
4) It must be about research related to a Danish public institution or based on public funding.

that she/he gets a chance to bring forward his view on the matter in question.

After this, the case is investigated by the Committee. In the process of investigation additional material going beyond that originally submitted by the complainant, the relevant research institution, and the person being complained about may be asked for. If the material contains factual information, the person subject to the complaint will be given an opportunity to comment on this information.

In Box 4 below is a sketch of a case dealt with by the committee system.

BOX 4: A CASE OF RESEARCH MISCONDUCT HANDLED BY THE DANISH COMMITTEE SYSTEM

The committee system was contacted by a Danish university which filed a plagiarism complaint. A member of a hiring committee, set up for recruiting candidates for a scientific position, suspected that an applicant had enclosed an article which they had not written. The hiring committee confirmed its suspicion by tracking down the original article.

During the hearing of the facts in the case, the respondent admitted having enclosed an article which he had not written although he had supplied it under his own name. The respondent then stated that the plagiarized article should be regarded as a test of whether the university was sufficiently thorough in its processing of applications for scientific positions.

The Committee did not find the respondent's argument to be credible and found the respondent to exhibit misconduct by intentionally plagiarizing the results of others and wrongfully alleging to be the author of a scientific publication which the respondent had not written …

The case can be retrieved from the 2009 annual review of the activities of the DCSD (2010).

This case was simple. Others are much more complicated – they have often been protracted and prolonged as a result of numerous hearings and complaints from the parties. As a result, one of the ideas behind the procedural setup in the new law is to give the research institutions a bigger role in treating individual cases while simultanously diminishing the role of the person bringing forward the complaint and not automatically make this person a party to the case.

In recent years there has been, on average, around one case a year where a researcher has been found guilty of research misconduct. The Committee is not able to punish offenders, but it can do a number of things which may have serious consequences for a researcher who is found to have acted dishonestly. The most important thing it can do is inform the researcher's employer. Using this information, the employer may choose to apply sanctions, the most drastic of which would be to terminate the researcher's employment. Also, if the case concerns an application for a grant from a public funding body, the Committee may inform the funding body. The Committee may also inform the editor of a scientific paper or book about its decision.

In the case described in Box 4 the effects on the convicted researcher are likely to have been minimal. Since the decision is only made public in an anonymous form, the name of the researcher will not be publicly announced, and the case will therefore not affect the person's possibility to apply for future jobs. However, the activities of the Committee fall under Danish legislation on access to public information, so the press and other interested parties may seek access to non-anonymized versions of the Committee's decisions. The researchers most affected by a verdict of research misconduct are those who already have a strong public profile, and hence a reputation that can be badly damaged. A bad reputation may, among other things, affect the researcher's ability to attract funding and obtain invitations to give lectures at conferences and the like.

So it is no small thing for an established researcher to be found guilty of research misconduct. This is why the Committee is headed by a high court judge, and why

safeguards based on public administrative law are in place. In many cases the Committee reaches a conclusion that research misconduct has not occurred, either owing to lack of evidence or because the practice involved, although questionable, does not qualify as research misconduct.

During their first ten years, the committee system would adjudicate on both research misconduct and questionable research practices. In other words, they could reach the conclusion that a person was not guilty of research misconduct, but was still open to criticism for questionable research practice. In this way the system was to some extent able to deal with the grey zones lying just beyond the borders of what had been defined as research misconduct. However, this came to a dramatic end in 2003 following the case of Bjørn Lomborg.

3. The Lomborg case and the establishment of the Practice Committee at the University of Copenhagen

In 1998 Bjørn Lomborg, who was then Associate Professor at the Department of Political Science, Aarhus University, published a series of short pieces in the Danish newspaper *Politiken,* in which he accused many of the scientists dealing with environmental risks, not least concerning global warming, of overstating the case and creating unnecessary fear. He also claimed that many of the solutions offered to deal with environmental problems were not optimal from a cost-benefit perspective. Later he turned his ideas into a book entitled *The Skeptical Environmentalist*, published in English by the prestigious academic publisher Cambridge University Press. His claims and arguments had a wide uptake both in Denmark, where in 2002 he was made director of the newly established Environmental Assessment Institute, and internationally.

Many of the scientists accused of scaremongering by Lomborg were unhappy, and some of them reacted by writing critical responses to Lomborg's claims and arguments. Thus Lomborg's views gave rise to a huge debate which took place both in popular media and in scientific circles. For example, the *Scientific American* invited four experts to comment on different aspects of *The Skeptical Environmentalist*, and Lomborg then provided responses to these commentaries. A number of the frustrated scientists also reacted in the beginning of 2002 by filing three separate complaints against Lomborg to the committee system. Here it was claimed that in *The Skeptical Environmentalist* Lomborg was guilty of, among other things, falsification of data, deliberately misleading use of statistical methods, and deliberately skewed representations and reports of other people's scientific findings.

From the start, the allegations gave rise to disagreement among the members of the committee system. Some members believed the case should be rejected at the initial phase because, as they saw it, *The Skeptical Environmentalist* was not a research publication and therefore did not meet the third of the three requirements listed in Box 3. Other members disagreed, and in the end a decision was made to establish an ad hoc group to review the case.

The working group delivered its report in September 2002. The report presented the strongly critical comments on *The Skeptical Environmentalist* made by other scientists in *Scientific American* and indirectly used these as evidence. It also referred to a number of highly defamatory statements about Lomborg made by prominent scientists in an issue of *Time Magazine.* Furthermore, it criticized Lomborg for not submitting his controversial claims to international journals for peer review. The report claimed that it was not in accordance with the norms of good scientific practice for a researcher to communicate research results to a wider public before these results have been reviewed by scientific peers.

On the question of whether *The Skeptical Environmentalist* could be considered a research publication, the working group delivered a divided decision. This disagreement continued when the report from the group was discussed in the commitee system. However, an agreement was reached that the complaints should not be dismissed simply on the grounds that the work complained about was not a scientific

publication (see Chapter 9 for further discussion about the relationship between scientific and popular publication).

In the final decision, which was accepted unanimously, it was decided that Lomborg satisfied the first of the three requirements of research misconduct (at the time called 'scientific dishonesty') in that his book misrepresented the scientific content of the studies reviewed to such a degree that it could be classified as a case of falsification. However, the committee members also agreed that it was not possible to prove that the falsification was wilful or grossly negligent – in other words, that they could not prove that Lomborg had intended to falsify results, and thus the second requirement for a case to count as one of research misconduct was not fulfilled. At the same time the Committee chose to leave the question whether *The Skeptical Environmentalist* should be classified as a research product unanswered.

On this basis the Committee decided on the following wording of its decision:

"*Objectively the publication falls under the concept scientific dishonesty. Viewed in light of the subjective requirements regarding wilfulness or gross negligence Bjørn Lomborg's publication cannot be said to fall under this term. However, the publication is clearly seen to violate the norms of good scientific conduct."* (DCSD, 2003)

Although Lomborg was formally acquitted of research misconduct, in practice the Committee's conclusion could be, and was, viewed as a serious attack on his scientific credentials. The decision was controversial and divided the scientific community, with strong reactions from groups of Danish researchers who were both for and against the decision made by the committee system. On the critical side, there was an outcry among many social scientists, who felt that norms of good scientific conduct originating in medical science were being superimposed on social science and the humanities. Thus many argued that it is common practice in large parts of social sciences and humanities to publish books without basing these on prior publications in international journals with peer review – which was one of the points of criticism underlying the decision.

Lomborg himself complained to the Ministry. It was not possible to appeal the full decision of the Committee, but it was possible for him to complain that the relevant legal procedures had not been complied with. Some of his key points were: a) 'Objective dishonesty' cannot be treated as a separate entity in a decision from the Committee. b) The Committee cannot base its assessment of research misconduct simply on the decisions of others, as it did here by referring to the papers in *Scientific American,* but must assess the publication in question itself. c) The Committee cannot make a decision on violations of the norms of good scientific practice (as distinguished from research misconduct). d) The book was not a scientific publication, as defined by the law, and it therefore did not fall under the remit of the Committee to assess it.

The Ministry accepted Lomborg's complaint on all four counts and made it clear that the Committee should only consider the scientific activities of scientists, not their communication with the wider public. The Ministry also said that the assessment must be undertaken by the Committee, possibly with the help of expert members of ad hoc groups, and that the Committee's decisions should only conclude whether or not an accused scientist is guilty of research misconduct in the full sense of the word; it may not draw conclusions on the issue of whether an acquitted scientist is nonetheless guilty of improper or questionable research practice.

Following the Ministry's decision, the Committee decided not to re-consider the case. But after the Lomborg case the committee system changed its practice, and it no longer includes possible violations of the norms of good scientific practice that do not strictly qualify as research misconduct in its decisions – something which has also been written into the latest version of the legislation regulating the committee system where the Committee now has explicit legal basis for refering such matters to the relevant research institution.

This left a hole in the system. It meant that the Committee could no longer adjudicate on matters lying in the grey zone between responsible conduct of research and research misconduct. To rectify this situation, it was decided by the Minister that questionable research practices should be dealt with at university level, and indeed it was written into the contracts between the Ministry and the universities that universities should ensure that good scientific practice is promoted and protected. As a consequence of this, in 2004 the University of Copenhagen established a Committee for Good Scientific Practice, also known as the Practice Committee. This additional Committee was set up to deal specifically, and only, with potential cases of questionable research practice. (For more details of the remit of the Practice Committee, see Box 5.) The new law on research misconduct from July 2017 specifically obliges research institutions to have a system in place and published guidelines for handling questionable research practice at the institution. With the law the Danish research misconduct system has a clear distinction of task: All cases of research misconduct are handled at the central level by the DCRM and all cases of questionable research practice are handled at the institutional level.

Another outcome of the Lomborg case was a change in the regulatory framework which made the decisions of the DCRM final, i.e. not subject to appeal to the Ministry. The reasoning was that the committee members are experienced and recognized researchers lead by a High Court judge as chairman. With this level of legal and academic expertise, it was felt that there was no need to allow decisions to be appealed at ministerial level.

In its first decade the Practice Committee examined one or two cases a year, but since 2014 the number of cases has gone up. Most cases have involved disputes over authorship (see Chapter 4).

4. Recent developments

Since 2010 there have been significant changes in the handling of RCR in Denmark and at the University of Copenhagen. These changes were made in response to a spectacular case, involving the University of Copenhagen: the Penkowa case. This case led to general strengthening of the mechanisms supporting RCR, including mandatory courses for PhD students, as mentioned in Chapter 1. It also led to the establishment of Named Person arrangements at the University of Copenhagen. Around the same time, a Danish Code of Conduct for Research Integrity was issued. The latter appears to have influenced recent efforts to limit and clarify the remit of the committee system, and to draw a clear distinction between research misconduct and questionable research practice resulting in a new law on research misconduct etc.

Milena Penkowa received her degree as medical doctor at the University of Copenhagen in 1998 and then began a stellar research career at the same university. She received her PhD degree in 2000, and less than a year later she handed in her doctoral thesis (a thesis for a second doctoral degree beyond

BOX 5: THE PRACTICE COMMITTEE AT THE UNIVERSITY OF COPENHAGEN

The Practice Committee was first established in 2004. It consists of associate and full professors at the University of Copenhagen who are appointed by the academic councils, with two from each of the Faculty of Health and Medical Sciences and the Faculty of Science, and one from each of the other faculties.

The Committee deals with written complaints about failure to adhere to good scientific practice (questionable research practice). It does not deal with complaints about research misconduct, which should be referred to the DCRM (see Box 1).

The Committee is also responsible for helping to clarify the existing norms of good scientific practice, and it may propose rules and guidance. Finally, the Committee takes steps to ensure public discussion of different aspects of good scientific practice, typically by means of a yearly meeting for all employees and students at the University of Copenhagen. You can find more information on the Practice Committee's web page (n.d.).

the PhD). However, this doctoral thesis was rejected, and suspicions were raised about research misconduct. After an internal review, part of which was conducted by the then Dean of the Medical Faculty and later Rector of the University of Copenhagen, Ralf Hemmingsen, it was concluded that there was no basis for raising a case about research misconduct at the committee system.

Penkowa continued her career at the University of Copenhagen. She became associate professor in neuroanatomy in 2004, and later the same year she submitted a revised version of her doctoral thesis on the basis of which she received her doctoral degree. In 2009 she received the prestigious EliteForsk Prize from the Ministry of Research, and later that year she was given the title of full professor.

However, in 2010 Penkowa was suspended following a conviction for financial fraud. Around the same time, and in large part as the result of investigations pursued by a journalist from the national newspaper *Weekendavisen*, it became clear that Penkowa had probably been involved in research misconduct dating back to her doctoral thesis of 2001. A series of investigations were conducted at the University of Copenhagen, and a number of cases concerning research misconduct were presented to the committee system. In some of these cases Penkowa was convicted of research misconduct; in others it was not possible to prove misconduct. In 2016 Penkowa was acquitted of 'document forgery of a serious nature'. The High Court judges deciding the case agreed that documents had been forged, but only three of the judges considered it document forgery of a serious nature. The remaining three judges held that the conduct, though questionable, could not be considered document forgery of a serious nature. This meant that the case was subject to the statutory period of limitation regarding less serious forgery and statute-barred. Since Penkowa could not be convicted of document forgery of a serious nature she was acquitted.

The conclusion of the Penkowa case was that research misconduct and other forms of fraud had taken place, that this had been going on for more than a decade, and that despite a number of warnings and signs that there were problems, things had been allowed to go on. So there was a feeling, both at the University of Copenhagen and nationally, that more needed to be done to prevent research misconduct and to deal with issues of questionable research practice.

Two of the many initiatives taken in the wake of the Penkowa affair have had a direct impact on the way breaches of RCR are handled and should therefore be mentioned here.
The first is that new arrangements in which so-called Named Persons are nominated were established at the University of Copenhagen, in the Faculty of Health and Medical Sciences in 2012, and then in the other faculties in 2014. The Named Person is a professor or associate professor in the relevant faculty to whom employees or students at the university can apply for advice and help, and for mediation in disputes. The Named Person is not part of the management, and she or he does not take initiatives alone. Rather, the main role of the Named Person is to assist people who are concerned about activities in their faculty which may involve questionable research practice or research misconduct.

There are small differences between the Named Person systems in different faculties; we shall describe the system as it works in the Faculty of Health and Medical Sciences. Here, whenever the Named Person is contacted, she or he must make a record of the contact. If allegations are raised about a specific person, that person must be informed. When contacting the Named Person, it may therefore be advisable not to mention any names initially and start by describing the problem in general terms. If it turns out there is no reason to pursue the issue, the accused person will not know about it. But if a name is mentioned, the individual in question will be informed about the inquiry even if it doesn't lead any further.

If accusations relate to issues that fall within the mandate of the DCRM or the University of Copenhagen Practice Committee, the Named Person can advise the complainant on how to present a case there. However, in reality many cases concern matters which can be dealt with through mediation, and here the Named Person plays a central role.

In public lectures, the first Named Person in the Faculty of Health and Medical Sciences, Professor Jørn Hounsgaard, has described the work he was required to do over a four-year period in office from October 2012 to October 2016. A few cases were passed on to the relevant Committee, and some were dealt with by giving advice in general terms. But in 46 cases Professor Hounsgaard took on a more active role as mediator. Of these cases, 31 concerned authorship disputes (i.e. discussions about who should be included as co-authors and in what order). Nine cases involved an element of personal conflict.

The second development following the Penkowa case was that the Danish Ministry of Higher Education and Science and the organization of Danish Universities decided, in 2013, to develop a Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014) (see also Chapter 2). A working group led by a representative of the Ministry and with representatives from major Danish research institutions drafted the Code. After revisions based on a broad hearing process the Code was published in November 2014. The main aim of the Code is "to support a common understanding and common culture of research integrity in Denmark". The Code is intended to guide both individual researchers and institutions. Institutions are expected not only to promote the principles and standards of RCR found in the Code, but also to develop policies that will integrate these principles and standards in their daily work.

The Code has received widespread support throughout the research community. All universities, including the University of Copenhagen, all of the major public and private foundations, and all research councils and institutions have signed up to

BOX 6: THE NAMED PERSON

Since 2012 there has been a Named Person in the Faculty of Health and Medical Sciences, and since 2014 there have been Named Persons in all faculties in the University of Copenhagen. The role of the Named Person is to serve as an advisor and point of contact for people who are concerned about possible research misconduct or questionable practice at their faculty.

The Named Person must inform the individual accused if she or he is named. However, it is possible to obtain advice from the Named Person on the basis of a general description of a case in which no names are provided.

The Named Person can advise on the procedure for passing on cases to the relevant Committee, but she or he is also authorized to mediate in less serious cases.

The Named Person also promotes awareness of RCR in her or his faculty.

For more information about the Named Person in the Faculty of Health and Medical Sciences you can visit the faculty's web page (n.d.).

For more information about the Named Person in the Faculty of Science you can visit the faculty's web page (n.d.).

BOX 7: DANISH CODE OF CONDUCT FOR RESEARCH INTEGRITY

The Code sets out principles of research integrity and makes recommendations on the standards defining RCR. It is not a legally binding document, but it aims to provide a framework within which institutions and researchers can further promote research integrity.

The Code outlines standards in the following six areas:
1. Research planning and conduct. 2. Data management.
3. Publication and communication. 4. Authorship.
5. Collaborative research. 6. Conflicts of interest.

Together these standards address the most common areas where questionable research practice may arise. In most cases the Code recommends that more specific policies must, where relevant, be defined by universities and other research institutions.

The Code also gives advice on teaching, training and supervision relating to RCR, and it emphasises the need for a system to handle research misconduct and breaches of RCR. (Ministry of Higher Education and Science, 2014)

the Code. These signatories are in the process of implementing the Code's recommendations by defining policies on various aspects of RCR. At the University of Copenhagen, the Practice Committee assists University management in developing such policies. The policies will eventually cover most of the issues presented in the following chapters of this book. A final development worth mentioning is the new Danish law on research misconduct etc. which came into effect on July 1. 2017. The new law aims to create a Danish system with an adequate and effective framework for handling both cases of research misconduct but also questionable research practice.

5. How to handle RCR issues

When a researcher at the University of Copenhagen has questions about research, and is in doubt as to how to behave, or about the behaviour of colleagues or students, there are a number of things she or he can and should do:

1) A good starting point would be to look at the Danish Code of Conduct (see Box 7), to look through the present book, and to consult the web-page of the Practice Committee, for guidance.
2) If doubts remain, a logical next step would be to contact the Named Person in the relevant faculty. The Named Person can give advice, and in cases of disagreement she or he can try to mediate. It is also possible to seek advice from colleagues, the head of section or head of department.
3) If the case concerns questionable research practice, and if the Named Person is not able to mediate, the next step may be to file a written complaint to the University of Copenhagen Practice Committee.
4) Finally, if the case is about research misconduct a complaint should be submitted to the Practice Committee, cf. Box 1. For younger researchers, it may be a good idea to ask a senior colleague, the head of section or the head of department, to file the complaint.

So the key to dealing properly with issues regarding RCR is to seek information and help in deciding where, when, and how to bring forward your concerns.

6. Test yourself questions

- What requirements must be satisfied if the actions of a researcher are to amount to a case of research misconduct?
- In a collaborative project you become aware that a colleague reporting results has omitted a number of data points which, if they were retained, would affect the statistical validity of the study. How should you handle this situation?
- Can you approach the Named Person with allegations about a colleague and remain anonymous?
- If a case similar to the Soman case (see Chapter 2) were to occur today in Denmark, how would the Danish system for handling violations of RCR make a difference?

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4
Authorship and other publication issues

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Summary

In this chapter we describe the Vancouver Recommendations' requirements for authorship in detail. We also mention some alternative guidelines and address some of the issues authorship raises. After this, we discuss various ways in which authorship can be wrongly claimed. We explain the consequences of different forms of undeserved authorship, indicate how widespread they are, and highlight some other publication issues. The chapter concludes with some recommendations to PhD students on how to manage publications and minimize problems and conflicts.

1. Introduction

In most scientific fields peer-reviewed publications are the primary means of communicating research results. It is fundamental to science that new findings are shared with the scientific community, both to enable critical assessment and, if the findings stand up to scrutiny, so that others can learn from them and build on them in their own research (see Chapter 2 and Chapter 9 for more discussion). At the same time, publications have become one of the primary measures by which scientists are ranked – e.g. when they apply for positions or for research funding. Scientists are compared via bibliometric measures based on the individual researcher's number of publications and citations The commonly used phrase "publish or perish" reflects how crucial this is to scientists careers, meaning that they are always striving competitively to have the most, and the most influential, publications.

Hopefully, you have not been in a situation like the one described in Box 1. But crediting authorship to someone who does not qualify as an author is unfortunately not a rare practice. In this chapter, we shall present the most influential international and Danish guidelines on authorship and explain in detail what they mean for researchers. We also discuss various other publication issues of importance for the PhD student. In the final section, we discuss what one can do to avoid engaging in questionable authorial practices.

2. Requirements for authorship

2.1 The Vancouver Recommendations

There are no globally accepted rules on academic authorship; different disciplines and different cultures have varying perspectives and traditions. However, in 1978 an influential group of editors of medical journals known as the International Committee of Medical Journal Editors (ICMJE) met in Vancouver and formulated a set of recommendations now widely known as the "Vancouver Recommendations" (ICMJE, 2015). Originally, these recommendations were called *Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Writing and Editing for Biomedical Publication*. They have since been updated several times, most recently in 2015, and now go under the official title *Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals.*

BOX 1

Imagine that you are about to finish the first article for your PhD thesis. Together with your main supervisor and one of your co-supervisors, who works at another university, you decided on the subject area and methodology.. You gathered the data, though a postdoc at the other university performed some measurements for you. You wrote the first draft of the paper, and you have discussed possible interpretations of the data with your supervisors. Both have commented in detail on the first draft. Having revised the manuscript, you have circulated it again, and then received an e-mail from your co-supervisor who declares it ready for submission – but who also requests that you add the postdoc as a co-author. You ask your supervisor what to do, and he advises you to do as requested, as the co-supervisor is coordinator on a research application that your research group needs to be involved in if they are to obtain a share of the grant. Declining the request will just antagonize the co-supervisor, whom your main supervisor knows very well.

Although the Vancouver Recommendations were formulated in the medical sciences, the principles they express are widely adopted today across the natural sciences and, to a lesser extent, beyond. In Denmark, they have become highly influential because various guidelines refer to them. Thus the former Danish Committees on Scientific Dishonesty (DCSD) (now replaced by Danish Committe for Research Misconduct (DCRM), see Chapter 3) used them as the basis of their "Guidelines on publication matters" in Chapter 5 of their 2009 *Guidelines for Good Scientific Practice* (Ministry of Higher Education and Science, 2009).[5] At the University of Copenhagen, the Practice Committee also refers to the Vancouver Recommendations as an expression of valid standards for authorship. Finally, the more recent *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) states in Section 4.1: "Attribution of authorship should in general be based on criteria adopted from the Vancouver guidelines".

BOX 2: THE VANCOUVER RECOMMENDATIONS (ICMJE, 2015, P. 2)

The ICMJE recommends that authorship be based on the following 4 criteria:[4]

1. Substantial contributions to the conception or design of the work; OR the acquisition, analysis, or interpretation of data for the work; AND
2. Drafting the work or revising it critically for important intellectual content; AND
3. Final approval of the version to be published; AND
4. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

In addition to being accountable for the parts of the work he or she has done, an author should be able to identify which co-authors are responsible for specific other parts of the work. In addition, authors should have confidence in the integrity of the contributions of their coauthors.

All those designated as authors should meet all four criteria for authorship, and all who meet the four criteria should be identified as authors. Those who do not meet all four criteria should be acknowledged […].

These authorship criteria are intended to reserve the status of authorship for those who deserve credit and can take responsibility for the work. The criteria are not intended for use as a means to disqualify colleagues from authorship who otherwise meet authorship criteria by denying them the opportunity to meet criterion #s 2 or 3. Therefore, all individuals who meet the first criterion should have the opportunity to participate in the review, drafting, and final approval of the manuscript.

We shall now discuss each of the four Vancouver requirements in more detail.

1) Contributions to the research process

The first requirement is to have provided a substantial contribution to the research process, anywhere from the conception of the idea to the analysis of the data. As the term 'substantial' is vague and open to interpretation the ICMJE list a number of examples of contributions that are *not* sufficient to merit authorship: acquisition of funding, general supervision of a research group, and general administrative support.

The publication *Guidelines for Good Scientific Practice* issued by DCSD (Ministry of Higher Education and Science, 2009)) used the word "significant" instead of "substantial" and specifies that the key to understanding what is meant by a significant contribution is the term *creative*: "It is internationally acceptable that right to authorship is acquired by creative efforts and only thereby". On this interpretation, authorship is not merited where an individual has not

4 We have used capital-lettering to emphasize the logical connectives.

5 DCSD decided in 2015 that these guidelines will no longer be updated because the publication of the new Danish Code of Conduct for Research Integrity makes this unnecessary. The new DCRM still keeps the guidelines available as a historical document, however, and because of their greater detail, we have referred to them where relevant in this chapter.

participated in the creative part of the scientific process. It is, for example, insufficient to have performed routine laboratory work, even if that work was very labour intensive. However, if the laboratory work involved the development of new methods, adjustments in the design of experiments, or the like, it may count as creative.

2) Contributions to the written text
The second requirement states that all authors must have participated in producing the written text. This may be through participation in preparing a draft manuscript or through critical revisions of important intellectual content in the final text. As a minimum this will require a careful reading of the manuscript where comments and suggested amendments are added. As examples of contributions that are *not* sufficient to merit authorship, the ICMJE group lists: writing assistance, technical editing, language editing, and proofreading.

3) Approval of the final manuscript
All co-authors need to read and approve the final version. DCSD *Guidelines* stated (Ministry of Higher Education and Science, 2009 p. 32) that:

> *an author shall be able to indicate in detail his or her own contribution and must have participated to such degree in the entirety of the work that the relevant party is able to indicate the full contents of the manuscript and be able to discuss fundamental aspects of the remaining contributions.*

The *Guidelines* then point in the direction of the fourth requirement:

> *Furthermore, all authors of an article – within the limits of what is possible and fair – are co-responsible for it being based on honest research so as for the risk of fraud to be minimised. If irregularities or dishonesty are proven in the research, it will be difficult for the co-authors of such work to disclaim co-responsibility.*

4) Agreement to be accountable
The fourth requirement was added in 2013. The ICMJE (2013) explains it this way:

> *Authorship involves not only credit for the work but also accountability. The addition of a fourth criterion was motivated by situations in which individual authors have responded to inquiries regarding scientific misconduct involving some aspect of the study or paper by denying responsibility ("I didn't participate in that part of the study or in writing that part of the paper; ask someone else"). Each author of a paper needs to understand the full scope of the work, know which co-authors are responsible for specific contributions, and have confidence in co-authors' ability and integrity. When questions arise regarding any aspect of a study or paper, the onus is on all authors to investigate and ensure resolution of the issue. By accepting authorship of a paper, an author accepts that any problem related to that paper is, by definition, his or her problem. Given the specialized and myriad tasks frequently involved in research, most authors cannot participate directly in every aspect of the work. Still, ICMJE holds that each author remains accountable for the work as a whole by knowing who did what, by refraining from collaborations with co-authors whose integrity or quality of work raises concerns, and by helping to resolve questions or concerns if they arise.*

The new element here appears to be the duty to help in resolving issues of potential misconduct if they arise. It is not possible for an author to deny responsibility for this by claiming that she or he is not responsible for parts of the paper he or she did not participate in. A further implication is that authors need to assess the integrity and trustworthiness of all of their co-authors. This helps to ensure that authors who engage in questionable practices will end up in a position where others refrain from collaborating with them on publications.

The *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) states: "In addition to being accountable for the parts of the work he or she has done, an author should be able to identify which co-authors are responsible for other specific parts of the work." However, it is later clarified that responsibilities may be variable among co-authors:

All authors are responsible for the content of the publication. However, the responsibility of each author should be assessed subject to their individual role in the research by considering their area of expertise, their experience and seniority, a possible supervisory role, and other relevant factors. Thus, in some cases an author may have a wider responsibility than others for ensuring the integrity of the publication or specific parts of the publication.

2.2 Deviating Practices

In some fields, particularly those involving very large teams of researchers, the Vancouver Recommendations are not considered adequate. Alternative guidelines, not least for these areas, are used by the journal *Neurology* (2017) and have been accepted, among others, an editorial in the *British Medical Journal* by Baskin and Gross (2011), and these also seem to be echoed in *The European Code of Conduct for Research Integrity* (ALLEA, 2017, 2.7).

These requirements are less demanding than the Vancouver Recommendations. The crucial difference is that a co-author does not need to be involved in the actual writing of the text. In a large team, it is accepted that one or just a few authors may do the writing. Moreover, taking part in the writing is considered a sufficient intellectual contribution, in line with the Vancouver Recommendations. However, the requirement of full transparency about the role of each author is more demanding than the corresponding accountability rules in the Vancouver Recommendations.

Since the *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) refers to the Vancouver Recommendations as its standard, one might think it would be a violation of the *Code* to follow *Neurology*'s authorship policy. However, the foreword of the *Code* says: "The Recommendations of the Code should always be understood in accordance with established practices predominant within the individual fields of research". We see this as an indication that substantiated reasons based on practices within a certain research field may be justified as exceptions to the general policy.

2.3 Order of authors

When submitting a manuscript for publication, it is necessary to decide not only who is to be listed as authors, but also the order in which order the authors should appear in the by-line. In some fields, authors are ordered according to the importance of their contributions, and special academic merit is therefore indicated by the authorial positioning. The author listed first (the 'first author') is selected for having contributed most significantly and for drafting the first manuscript. The last position on the by-line (often referred to as the 'senior author') is reserved for the (typically senior) principal investigator who had overall responsibility for the project. The remaining authors are ordered according to the estimated significance of their contributions. Both first authorship and last authorship can be allocated to two people if their inputs were comparable; this should then be noted in the paper and can later be recorded in an explanatory footnote in the authors' CVs. However, again, these principles are not observed universally. In some fields, often with large teams of researchers, authors are simply ordered alphabetically.

BOX 3: *NEUROLOGY'S* AUTHORSHIP POLICY

Criteria for qualification (intellectual contributions):

- Design or conceptualisation of the study
- Or analysis or interpretation of the data
- Or drafting or revising the manuscript

All authors acknowledge all versions.

Those who do not qualify as authors are listed as co-investigators or contributors.

Any paid medical writer who wrote the first draft or responded to the reviewers' comments must be included in the author byline.

All authors must complete and sign authorship forms with roles and contributions, disclosure forms listing all sources of potential bias, and copyright transfer agreements; author contributions and disclosures are published in the journal.

See Marusic et al. (2011) for a review of the meaning and practices of authorship across different disciplines. Typically, either the first author or the last author will be responsible for internal communication among all authors. Likewise, one of them will serve as the corresponding author who makes sure that the journal's guidelines are properly followed and communicates with the journal about responses to referees' reports and revisions of the manuscript. In some fields the senior author is normally expected to assume a special responsibility for the validity of the work, and he or she should therefore take extra care in reviewing the contributions of the other authors.

The ordering of authors in the by-line, especially where the positions of first and last author are concerned, can of course create conflicts. It is therefore advisable to prepare a draft statement when initiating a collaboration that specifically addresses this issue (see Box 4).

2.4 Authorship declarations

DCSD recommended: "Prior to submission of the manuscript, a common authorship declaration ought to be prepared, which precisely indicates the nature and volume of each author's contribution". Today, an increasing number of journals require all co-authors to submit a signed statement that they have read and approved the final version of the manuscript before it will be considered for publication. Some journals also require contribution statements that specify what each author has contributed, and some even ask to know what percentage of the work was done by each author.

For PhD students enrolled at a Danish university, the Ministerial Order #1039 of August 27 2013 on The PhD Degree Programme at the Universities and Certain Higher Artistic Educational Institutions (Ministry of Higher Education and Science (2013), sometimes referred to simply as "the PhD Order") specifies that where a dissertation includes articles written in collaboration with others, a written declaration, or co-author statement, describing the PhD student's contributions to the work must be submitted. Standard forms for these declarations can be found on Danish university websites. The co-author statements must be submitted with the dissertation, and if they are not completed correctly, the university may not accept the dissertation. At the University of Copenhagen, the Faculty of Science requires: "The co-author statement should always be signed by the first author, the corresponding-/senior author and the PhD student. If there are two or three authors the statement must always be signed by them all." At the Faculty of Health and Medical Sciences, where there are six co-authors or fewer, all must sign. If there are more than six, the corresponding author, the senior author and the principal supervisor must sign as a minimum.

These co-author statements are not to be confused with the co-author statements that journals require researchers to fill out when they are submitting papers for publication. Where the latter are concerned, specific requirements may differ from one journal to another.

2.5 Acknowledgements

If other researchers have contributed to the article in ways that do not merit co-authorship, their contribution can still be noted, and appreciated, in the acknowledgement section of the article. Admittedly, there is limited formal academic recognition in such an acknowledgement, but it nevertheless serves important functions. First of all, it is a question of expressing gratitude where it is due and thus increasing the likelihood that people will be willing to assist again in future. In some institutions the ability to demonstrate that one has assisted in a piece of research, even if not as a co-author, may itself be treated as a parameter of success. Finally, acknowledgements also help to make transparent who actually contributed to the work presented in the paper.

Acknowledgement does not imply responsibility for the content of the publication, but it may still be seen as an endorsement of the paper; and on some occasions a person who qualifies for acknowledgement may not want to be seen as endorsing the work. The ICMJE group therefore recommends that "[b]ecause acknowledgment may imply endorsement by acknowledged individuals of a study's data and conclusions,

editors are advised to require that the corresponding author obtain written permission to be acknowledged from all acknowledged individuals" (ICMJE, 2015, p. 3).

3. Undeserved and ghost authorships

In cases of undeserved authorship, a paper's author by-line will name an individual whose contributions do not merit authorial status. This questionable research practice can arise in a number of ways. The *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) states (4.1 viii): "Guest authorship (i.e. listing authors who do not qualify as such) or ghost authorship (i.e. omitting individuals who should have been listed as authors) should not take place."

3.1 Gift authorship

Gift authorship (also sometimes known as *honorary authorship*, or, when asymmetric power relations are involved, *coerced authorship*) is an authorship that has been granted to, and accepted by, a person who does not fulfil the requirements for authorship. The reasons for granting gift authorships vary. At some institutions, and in some fields, the head or director of a unit (e.g. a department, laboratory or research group) has traditionally been added routinely as co-author of all articles published by the unit. However, if he or she does not satisfy the requirements of authorship described above, this is gift authorship and therefore undeserved. The *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) states (4.1 vi): "Participation solely in the acquisition of funding, in the collection of data, or in general supervision of the research group does not justify authorship."

DCSD explicitly mentioned "the head of institute's provision of framework conditions, specialist departments' services of routine data or mere help in collection of data" as examples of non-creative contributions which do not in themselves merit authorship status. DCSD also said: "The guidelines [i.e. on publication matters] may give rise to problems for supervisors accustomed to gift-authorships. However, the right to authorship must follow the usual rules, also in this relation, and accordingly, only supervisor(s), who meet the above three requirements[6] [for authorship] should be co-author(s) (Ministry of Higher Education and Science, 2009)."

Sometimes authorship is granted to a person who does not satisfy the requirements for authorship because one of the other authors owes him or her a favour; or authorship may be granted in order to strengthen a relationship through the exchange of a gift. Sometimes, however, this exchange can involve coercion – e.g. when a lab whose assistance is needed for some routine services request co-authorship in return, even though this is not merited by their contribution.

Gift authorships are also sometimes swapped among researchers as a way to artificially inflate their publication lists. But note that, according to the Vancouver Recommendations, in receiving a gift authorship one becomes accountable for work that one has not been involved in – and may not even know about.

3.2 Planted authorship

A planted authorship is a gift authorship that the recipient was not informed about. In such cases, the intention is normally not to benefit the recipient, but to strengthen the impression that the article has a good pedigree (and perhaps also to facilitate passage through the peer-review process) by including a highly ranked or well-known scientist as co-author. This is problematic for several reasons. First of all, it obviously gives a false impression of the real authorship, and thereby of who is responsible for the content of the article. And, unknown to him or her, the recipient of the gift may end up being held responsible for research which turns out to be of low quality or perhaps even an example of misconduct. To the extent that journals require signed co-authorship statements from all authors, planted authorships are likely to become extinct.

6 The 2009 DCSD guidelines mentioned only three requirements, corresponding to the first three Vancouver Recommendations.

3.3 Ghost authorship

Ghost authorship is the opposite of gift authorship. In it, despite deserving authorship, one or more authors are hidden by being omitted from the by-line. This may be done to hide a possible conflict of interest. A typical case is an author from a private company who fears that a paper will lose in credibility if she or he appears as author, thereby signalling that the research involved a collaboration with industry. However, the Vancouver Recommendations state clearly that authorship is not only a right, but also a duty. If a person satisfies the criteria of authorship, she or he should figure as an author. More and more PhD projects are undertaken in close collaboration with industrial partners who have a direct commercial interest in the results. In these cases, transparency about authorship and funding is very important. For more on conflicts of interest, see Chapter 7.

A number of cases have been uncovered in which medical companies have managed to get drug studies published with the authorship of seemingly independent researchers who downplayed the risks or overstated the benefits of a drug, but did not in fact participate in the research. This is of course highly questionable practice, as it makes someone responsible for research they didn't conduct and at the same time can hide commercial interests. Wislar et al. (2011) found that more than 20% of the articles in six high-impact medical journals had gift authors, ghost authors, or both.

4. Negative impacts of undeserved authorships

4.1 How widespread is undeserved authorship?

According to the International Association of Scientific, Technical and Medical Publishers (Ware & Mabe 2015), in late 2014 there were about 28,100 English-language (plus a further 6,450 non-English) journals in the fields of medicine, science, and technology. Together these journals were publishing more than 2.5 million peer-reviewed articles a year. It has also been found that the number of authorships has increased at a much higher rate than the number of articles (Plume & van Weijen, 2014). In the decade from 2003 to 2013, the number of articles grew from 1.3 to 2.4 million; in the same period, the number of authorships went from 4.6 to 10 million.

A study of research misconduct and questionable research practices in general (Martinson et al., 2005) based on anonymous self-reporting by several thousand early- and mid-career researchers funded by grants from the US National Institute of Health (NIH) showed that 12.3% of mid-career and 7.4% of early-career researchers had engaged in "[i]nappropriately assigning authorship credits" within the last three years. In another study, this time of German universities, Böhmer et al. (2011) found that by far the most common questionable research practices related to authorship. More than half of the respondents reported that they had experienced such issues.

Yank and Rennie (1999) examined contribution statements published with articles in the medical journal *The Lancet*. Analyzing descriptions of the contributions of individual authors, they found that 44% of authors did not satisfy the Vancouver Recommendations.

Focusing specifically on authorship, the study by Wislar et al. (2011) mentioned above surveyed six general medical journals with high impact factors. Corresponding authors of a randomly selected sample of articles were asked about the contributions and roles of all authors. On the basis of the replies, it was investigated whether all of the authors of each article had complied with the Vancouver Recommendations on authorship. The results showed improper authorship affected 21% of the articles. Comparing the results to those of a similar study from 1998 by Flanagin et al., which had found improper authorship in 29% of articles, Wislar et al. concluded that increased efforts by both journals and academic institutions would be important for maintaining integrity in scientific publishing.

Thus, although the Vancouver Recommendations are widely accepted, authorship issues remain widespread. This is confirmed by the fact that most of the cases handled by the Practice Committee and the Named Persons in the University

of Copenhagen's Faculty of Health and Medical Sciences and Faculty of Science concern authorship issues.

4.2 What's the problem?

The reasons why undeserved authorship and ghost authorships are considered a questionable research practice or, in very serious cases, research misconduct relate to the impact of these practices on colleagues, science as an institution, and society.

For one thing, boosting your publication list with false authorship gives you an unfair competitive advantage. You are simply cheating or, as it is sometimes put, participating in "academic doping". Secondly, incidents of guest, planted and ghost authorship may harm science as an institution. For one thing, they make it unclear who is responsible for what in the scientific literature. Knowing who is responsible for what is important when questions or criticisms relating to methods, data or the interpretation of results are raised. Further, public knowledge of undeserved authorship practices damages the reputation of science and scientists, and may in the long run undermine society's trust in results. Finally, from the perspective of society, a practice of crediting undeserved authorships, and not crediting qualified authorships, implies that resources may not be being allocated optimally. Many countries invest a great deal in scientific research in the hope that this will help us to solve the grand challenges facing the global community today (from climate change, to cancer, to famine), or simply to promote economic competitive advantage. Since authorship is the most important parameter for obtaining academic positions and funding, its mis-representation means that the resources spent on science will not necessarily end up with the best-qualified scientists, but rather with those who are best at appearing to be strongly qualified, perhaps via undeserved authorship, false citations and the like.

Given these impacts of undeserved authorship, it is not surprising that increasing attention is being given to it – both with respect to how authorship can be made more transparent through better implementation of, for example, the Vancouver Recommendations, and with respect to the question of how to evaluate the qualifications of individual scientists more accurately and thereby discourage the negative consequences of a "publish or perish" climate.

5. Other publication issues

5.1 Prepublication

Different disciplines operate very different practices of pre-publication. In physics, mathematics and related disciplines, where peer-review may take several years, it is common to submit papers to a publicly accessible pre-publication archive. For example, www.arXiv.org holds papers from physics, mathematics, computer science, quantitative biology, quantitative finance and statistics. When the paper is finally published, the author should notify arXiv; the arXiv publication should at this point be deleted from the author's publication list and give way to the journal version.

In complete contrast with this approach, many journals will *not* publish results based on data that have already been presented publicly – e.g. in conference proceedings. This is especially common policy in biomedical sciences. Before engaging in prepublication, it is therefore wise to check whether it would preclude later publication in the relevant journals. It is also necessary to be careful about when and where to present data and results at conferences. A PhD student should check with his or her supervisor before presenting work in any public forum, to avoid problems of this kind.

Secondary publications – republishing data in a different journal – is generally considered an acceptable way of reaching different audiences (e.g. a national audience, or researchers from different fields), but they normally require the agreement of both the original and secondary journal, and must be made fully transparent by inserting a cross-reference to the original version of the article. As a general principle, the *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) states (3.1 ii): "Publishing the same results in more than one publication should only occur under particular, clearly explained and fully disclosed circumstances."

The guardians of the Vancouver Recommendations, the ICMJE (2015), lists the following conditions:

1. *The authors have received approval from the editors of both journals (the editor concerned with secondary publication must have access to the primary version).*
2. *The priority of the primary publication is respected by a publication interval negotiated by both editors with the authors.*
3. *The paper for secondary publication is intended for a different group of readers; an abbreviated version could be sufficient.*
4. *The secondary version faithfully reflects the data and interpretations of the primary version.*
5. *The secondary version informs readers, peers, and documenting agencies that the paper has been published in whole or in part elsewhere—for example, with a note that might read, "This article is based on a study first reported in the [journal title, with full reference]"—and the secondary version cites the primary reference.*
6. *The title of the secondary publication should indicate that it is a secondary publication (complete or abridged republication or translation) of a primary publication.*

Undisclosed duplicate publication is in general discouraged. It is likely to be treated as questionable research practice, and even as research misconduct (so-called "self-plagiarism"). It may distort the scientific record by giving undue weight to the results, as they are reported several times. For example, if the same data from a study of the side-effects of a medical treatment are published several times, review studies will be skewed and ultimately, this may place patients at risk (see Tramer (1997) for a case study).

5.2 Inappropriate recycling of material

When sections of the same text appear in several of an author's publications, this is referred to as "text recycling" and is another form of self-plagiarism. Attitudes to text recycling have developed within disciplines over time and vary from field to field. Unfortunately, there is no well-defined boundary indicating when a textual overlap between two articles is so substantial as to be classified as a case of recycling. See, for example, Bretag and Mahmud (2009) as well as Bruton (2014) for more detailed discussions of the definition of text-recycling.

The Danish Code (Ministry of Higher Education and Science, 2014) has the following policy (3.1 iii): "Recycling or re-use of primary materials, data, interpretations or results should be clearly disclosed." In some fields, a certain degree of recycling is difficult to avoid, especially in sections such as methods and materials. In these cases, recycling may even be encouraged to ensure a precise and easily recognizable description of, for example, a technique. However, such recycling should be made transparent in a cross-reference to the earlier article in which the material, method or technique was first described. Similarly, previous work may be recycled to serve in the introduction to a new article, but again such recycling should be made transparent in cross-references.

5.3 Manuscripts based on the same database

With regard to multiple publications based on the same dataset, the ICMJE (2015) states that:

> *Editors might consider publishing more than one manuscript that overlap in this way because different analytical approaches may be complementary and equally valid, but manuscripts based upon the same dataset should add substantially to each other to warrant consideration for publication as separate papers, with appropriate citation of previous publications from the same dataset to allow for transparency.*

Lack of transparency is problematic because readers can be led to believe that the reported results derive from different studies or samples, distorting the scientific record.

Data fragmentation occurs when available data is partitioned so as to produce multiple articles, where they could instead have been published together. Sometimes, this is done deliberately with the purpose of creating more publications – a ploy known as "salami publiation". In some cases, data fragmentation is considered a questionable research practice because it gives the author an unfair advantage in building

his or her list of publications and citations, and because it wastes time and resources, e.g. the time of the researchers who peer review or revise the papers. However, it is difficult to pin down exactly when the practice is dubious, because word limits and other restrictions imposed by journals may actually prohibit publication of the material in one paper. In all cases, transparency and the ideal of contributing to the scientific record with as much value as possible should be the guiding principles.

5.4 Plagiarism versus proper attribution

In science, researchers almost always draw on previous work by others, whether data, results, or other text. Unless this work has become so established that it is considered common knowledge, the use of another researcher's work should always be clearly attributed, and references to the original work should be sufficiently detailed to enable readers to find the relevant passage. Verbatim text taken from the work of others must always be marked as quotation, and paraphrases as well as translations must always be accompanied by a reference to the original. Failure to do this is plagiarism, which may be considered a form of scientific misconduct (see also Chapter 2).

Authors writing in a language other than their native tongue may find it tempting to use phrases they have read in the publications of native speakers (see Yilmaz (2007), for such a case). However, while this may be a good strategy for language learning in everyday conversation, it is a questionable practice in academic publications, where it counts as plagiarism. Software developed to detect similarities between multiple texts, including programs that compare a submitted text to all publications available in a particular corpus (e.g. arXiv, MedLine abstracts, etc.), has revealed many cases of plagiarism in the literature (e.g. see VroniPlag (n.d.) or Déjà vu (n.d.)). In addition, more and more journals are now running new submissions through plagiarism detection software like iThenticate or Turnitin. All PhD dissertations at the Faculty of Health and Medical Sciences, University of Copenhagen, are routinely checked by iThenticate before being accepted for further assessment.

5.5 Publication of negative results

It can be difficult to get negative results published. To attract readers, journals generally seek to publish new and exciting findings, and grant-giving agencies and foundations have a similar leaning, since they need to demonstrate that their money is being well spent. This has led to an environment where positive results are much easier to publish than negative ones, even though negative results can be of high scientific value. Just imagine the time that you could save if you did not have to go through a laborious research process to find out that your hypothesis is wrong, but could rather read that others had already provided the relevant disproof. In recognition of this, journals specifically aimed at publishing negative results have appeared, such as *The Journal of Negative Results in Biomedicine*. Such journals are very valuable to the scientific community, but usually they have a low impact factor and are thus less attractive to publish in.

Plainly, failure to publish negative results may lead to publication bias. If it is easier to publish studies with positive than negative results, there is a risk that reviews of the literature will show a false picture of the world, with the positive results being given disproportionate weight. However, as is stressed in the *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014), researchers have a responsibility to be transparent about their results, which must imply being open about negative results as well as positive.

5.6 Non-academic publications

The Vancouver Recommendations apply to academic publications only. These include peer-reviewed articles in journals, but also chapters in collections and monographs published by academic publishers, as well as publications without peer-review that are nevertheless research publications. However, most scientists also publish other kinds of writing, such as popular articles for the general public. Often such non-academic publications are based on previously published academic papers.

There are no formal academic guidelines for non-academic publications, but the general rules and guidelines covering

publishing apply to them – e.g. copyright regulations. Although the Vancouver Recommendations ignore non-academic publications, it may still be wise to consult others and discuss how their contributions should be recognized when you are considering non-academic publication.

6. How to manage your publications as a PhD student

As a PhD student you will need to manage your authorship and publication issues yourself, since you cannot expect anyone else to take responsibility. However, this may involve difficult situations. On the one hand, you are responsible (in part) for decisions about who is added as a co-author to the by-line of your articles. On the other hand, you might work in an environment where you come under pressure to accept a questionable practice; and whistleblowing may give rise to conflict with your collaborators.

To minimize the risk of unpleasant conflict we suggest that you follow the advice given in the "Guide to minimizing authorship issues" (see Box 4) below.

If you ever come under pressure to grant co-authorships in return for access to technical equipment or routine services, you should ask your supervisor to assist you in the negotiations. In the unfortunate circumstance that your supervisor turns out not to be helpful, you may contact the Named Person designated for your faculty and seek advice.

In the last resort, after consulting the available guidance, the question is: Do you want to make a complaint because you cannot agree to engage in a questionable practice? Or is the prospect of repercussions by making a complaint so serious that, under the circumstances, you would prefer to accept a questionable practice? This is not an easy choice, since both alternatives may lead to negative consequences. But in the end, only you can decide.

7. Test yourself questions

- What are the Vancouver Recommendations' requirements on authorship?
- What should you do if you observe someone being credited with unwarranted authorship?
- What should you do if someone requires to be a co-author of your paper?

BOX 4: GUIDE TO MINIMIZING AUTHORSHIP ISSUES

Arrange a meeting with your supervisor on publications for your PhD. One of the items on the agenda should be authorship issues.

If it is relevant, make it clear that you intend to follow the *Danish Code of Conduct for Research Integrity and DCSD's Guidelines for Good Scientific Practice*, Chapter 5, and/or The Vancouver Recommendations; and discuss at the meeting how you will manage your publications in the light of these documents.

When you are initiating collaboration with others on an article, always make a draft statement that specifies who is to be included as a co-author and how the workload will be distributed, and seek to ensure that the parties involved accept and sign up to it. Encourage people seeking co-authorship to make suggestions as to how they can contribute to qualify as co-authors – this applies equally to heads of department and fellow PhD students. Keep a record of agreements to consult in cases of doubt. Of course, initial agreements may need to be revised as the work progresses, and initial agreements may include a list of areas where the relative contributions are yet to be determined, but changes and clarifications should be recorded explicitly. Make sure to have the co-authorship statements that are required for submitting your dissertation ready and signed by all relevant parties before submitting a manuscript.

If a co-author wants to withdraw because of disagreements over the final manuscript, the guiding value should be transparency. For example, it might be advisable to briefly explain the withdrawal in the acknowledgements.

See more in Richard et al. (2014)

- Who can you approach for help with conflicts over authorship?
- Should a researcher who participates in data acquisition and analysis, but who lacks the skills in English to engage in the writing process, be credited as a co-author?

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5
Research data management

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Summary

Good research data management is the foundation of transparent and trustworthy research. It is therefore increasingly becoming a priority for funders, journals, universities and governments to invest in improving data management. But what is 'good' research data management, and how do we define data and primary materials in the first place? In this chapter we provide an overview of research data management; we describe the regulations that govern it and the tools available for data handling at the University of Copenhagen and elsewhere. We also discuss aspects of the research environment that encourage researchers to be good data managers, and aspects that have the opposite effect.

1. Introduction

Most research is based on a set of data and its analysis (some mathematical and philosophical studies are exceptions to this generalization). Of course, other things are required to make a good study apart from data and data analysis; typically, a research question, a review of existing findings in the field and critical discussion of the findings are also essential components of scientific work. However, if the data are not in order, these other components will usually have little scientific merit.

Two of the three main forms of research misconduct presented in Chapters 2 and 3, falsification and fabrication, relate to the way researchers obtain their data. When these forms of misconduct occur, data are either wholly made up or partly supplemented with fictitious data, and therefore the entire study or research product must be deemed fraudulent. It is easy to see why such practices must be condemned and policed: they waste precious time and funding, threaten to undermine the image of science and the public's trust in research, and in some cases may even cause harm to those whose actions are guided by spurious research findings. However, when it comes to setting out exactly what good data management looks like, a long line of questions present themselves, which cannot be simply answered by saying that researchers should document and report data obtained in a truthful way. What permissions are required before data are collected? In what way should data be collected or recorded? How should data be digitized, transcribed, processed, or in other ways treated? In what form should data initially be stored, where, by whom, and for how long? How should access to data be controlled? What further information should accompany data? How should data be analyzed? To what extent, and in what way, should data be shared after the completion of a study? How, and for how long, should data be archived?

These questions are to a large extent methodological and their answers are therefore partly to be found within the research discipline in which a specific study is conducted. However, the questions also raise general ethical and regulatory issues going beyond technical questions about methodology. Consider, for example, the issue of data sharing. In 2009, the leading scientific journal *Nature* published an editorial with the heading "Data's shameful neglect". It began with the following words:

> *More and more often these days, a research project's success is measured not just by the publications it produces, but also by the data it makes available to the wider community. Pioneering archives such as GenBank have demonstrated just how powerful such legacy data sets can be for generating new discoveries – especially when data are combined from many laboratories and analysed in ways that the original researchers could not have anticipated. All but a handful of disciplines still lack the technical, institutional and cultural frameworks required to support such open data access – leading to a scandalous shortfall in the sharing of data by researchers. This deficiency urgently needs to be addressed by funders, universities and the researchers themselves* (Nature, 2009).

In this editorial, *Nature* called for a change in what is considered RCR when it comes to data sharing. Following the call, many funders and journals have begun to impose requirements in line with those suggested by the *Nature* editorial, and in some fields of study they are today commonplace, although there are other fields in which they certainly are not. An example of a large funder imposing requirements of this kind is the European Commission.

The Commission was among the stakeholders adopting the *'FAIR Guiding Principles for Scientific Data Management and Stewardship'*. The so-called FAIR principles are a set of guidelines to help researchers make their research data Findable, Accessible, Interoperable and Reusable. Among other things, these guidelines advise on and illustrate how to write a Data Management Plan (see 5.3), focusing on reusability. Adherence to the FAIR principles when publishing research data will ensure that machines can find and make sense of data sets, which should improve the reusability of data (Wilkinson et al., 2016).

Despite these efforts, there are no common standards of aspects of data management such as data sharing. So, what RCR requires when it comes to data sharing and other aspects of research data management is clearly up for discussion, and views on the appropriate practices will develop over the coming years. It is likely that what today may be seen as part of a burning ethical debate may in the future be a normal part of what in the various disciplines is taught as proper methodology.

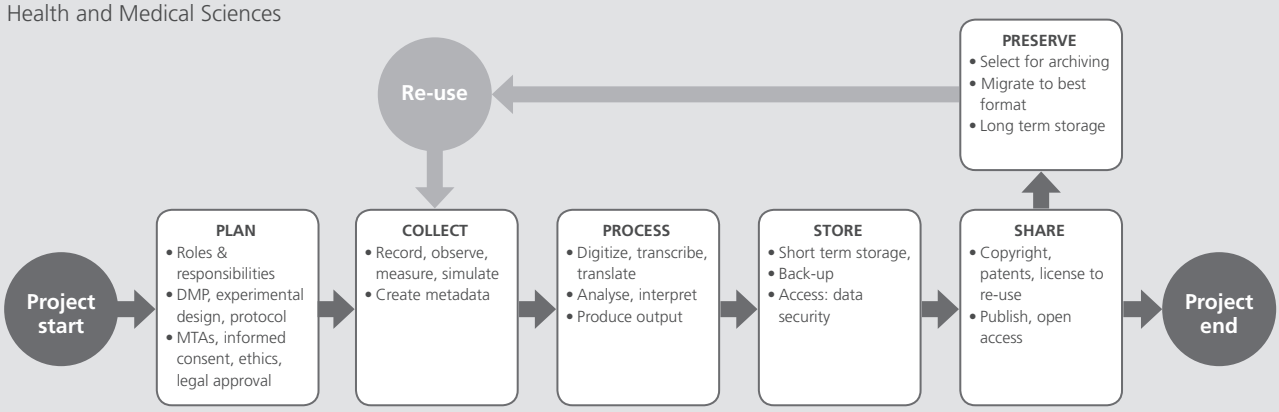
Before we go into more detail, we need to define what we actually mean when we are talking about 'data' and 'research data management'. The *Danish Code of Conduct for Research Integrity* (Ministry of Higher Education and Science, 2014) (see Chapter 3) presents a general definition in which data are defined in relation to primary material:

> "*Primary material* is any material (e.g. biological material, notes, interviews, texts and literature, digital raw data, recordings, etc.) that forms the basis of the research. *Data* are detailed records of the primary materials that comprise the basis for the analysis that generates the results."

There are many different types of data (e.g. observational data, experimental data, simulation data, processed data) and what constitute data may vary across research disciplines. For an anthropologist, primary material could be videos or interviews, and research data could be the transcripts of these videos or interviews. For a geneticist, primary material could be tissue samples, while research data could be the digital DNA sequences obtained from these samples.

By 'research data management' we refer to the entire process involved in getting from primary material to research data and on to research results; it is a collective term for the planning, collecting, processing, sharing, storing, protecting, archiving and, if necessary, destroying of research data and primary material. A schematic overview is presented in Figure 1, which lays out what we call the research data

FIGURE 1. THE RESEARCH DATA LIFECYCLE. The blocks represent the various phases in research data management and contain keywords appropriate for each phase. Illustration taken from the research data management policy of the Faculty of Health and Medical Sciences



lifecycle. The aim of this chapter is to outline generic norms of good data management and to discuss how these norms can be implemented across disciplines. In the sections below, we will look at each phase of the research data lifecycle in turn, highlighting some of the most important issues to be considered. As a starting point, we refer to the policy on research data management formulated by the Faculty of Health and Medical Sciences (2016) at the University of Copenhagen. We recommend that all PhD students familiarize themselves with the policies of their own faculties.

2. Planning research projects

Research data management starts before any primary material or data have been collected, in the form of project planning. In this phase you determine your experimental design and set-up your protocols. You should decide who will have rights to access the data you will generate, during and after the project (e.g. will/can you share your data set?) and who will be responsible for the data in the future (e.g. after you have left the university). If you work with big data sets, it is important to plan where you will store your data, and who will pay for this storage.

2.1 Data Management Plans

During the planning phase, you should set up a data management plan (DMP). A DMP is a document in which you describe actions to be taken at all stages of the research data lifecycle (Figure 1). A DMP is not just a handy tool. It is now a required component in funding proposals for many funders abroad, each of which has its own specific DMP template. The European Commission requires DMPs to be created in all funded Horizon2020 projects, and the expectation is that in the near future all major research funders (including those in Denmark) will require a DMP. Researchers are therefore strongly advised to write a DMP for each research project. If you are a PhD student, it is a good idea to discuss the DMP with your supervisor before you start collecting data, to check that you and he or she have the same expectations when it comes to managing your data. For example, what statistical test will be best suited to the analysis of your data? Are there any standards for data formatting in your discipline, and what will happen to your data at the end of your project? Discussing all of this beforehand will save you time (and possibly trouble) once you have started to collect data.

The Faculty of Health and Medical Sciences has prepared a DMP template for researchers to use (Faculty of Health and Medical Sciences, n.d.). In Box 1, we show a summarized version of how to fill in the DMP template in four different research disciplines. For the first three disciplines, we have selected three research articles and filled in the DMP template as we imagine the authors of the articles might have done. The fourth DMP is fictional, designed by the authors of this chapter. Box 1 clearly illustrates the considerable variation in data management practices across disciplines. For example, analysis differs greatly between qualitative and quantitative research; projects dealing with personal data will require more permissions before the commencement of data collecting, and big data projects will involve some special data storage considerations. The research articles used in Box 1 are:

1. *Lassen, J. and Sandøe, P. (2009) GM plants, farmers and the public – A harmonious relation? Sociologia Ruralis 49: 258-272.*
   In this qualitative research paper, the authors study attitudes of farmers to herbicide-resistant, genetically modified (GM) plants. Using a series of semi-exploratory focus group interviews that were audio-recorded and transcribed, the authors examine the farmer's willingness to adopt GM plants, as well as the way in which they manage the plants.
2. *Den Boer, S. P. A., Baer, B., Boomsma, J. J. (2010). Seminal fluid mediates ejaculate competition in social insects. Science 327: 1506-1509.*
   In this quantitative research paper, the authors address sexual selection theory by examining the mating biology of social insects, including tropical leafcutter ants. The authors combine fieldwork in Central America with laboratory research. Their research involves the collection and dissection of ants and bees, cell staining techniques and microscopy.
3. *Vinther-Jensen, Larsen, I. U., Hjermind, L. E., Budtz-Jørgensen, E., Nielsen, T. T., Nørremølle, A., Nielsen, J. E.,*

Vogel, A. (2014). A clinical classification acknowledging neuropsychiatric and cognitive impairment in Huntington's disease. Orphanet Journal of Rare Diseases 9:114.
In this clinical research paper, the authors propose a new clinical classification for the diagnosis of Huntington's disease. For this purpose, the authors conduct neurological examinations, psychiatric evaluations and neuropsychological tests in a large cohort of patients recruited from a Danish outpatient clinic.

4. This 'big data' project collects data from a large number of fixed and mobile observatories from around the world. The data collected will be analyzed and used to simulate how the climate develops over time in order to provide estimates of the likely impact of climate change on the planet. The project is fictional, but based on articles by Bernholdt et al. (2005), Lee and Kumar (2016) and Middleton et al. (2006), as well as the German Climate Computing Centre's website on long term archiving (n.d.).

All the DMPs were written for the purpose of illustrating this chapter and prepared after the actual research on which they are based had been concluded. The authors of the original research articles are not responsible for the DMP content.

BOX 1: EXAMPLES OF DATA MANAGEMENT PLANS

	DMP 1: Qualitative research	**DMP 2: Quantitative research**	**DMP 3: Clinical research**	**DMP 4: Big data research**
Short project description	Examining Danish farmers' perception of GM-crops as part of their agricultural practice.	Examining sexual selection theory in social insects, by examining whether the seminal fluid of male A harms the survival of sperm in male B.	Examining to what extent neuropsychiatric symptoms and cognitive decline may be early manifestations of Huntington's Disease.	Simulating the development of the Earth's climate on a long time scale.
1.1 Do you have the appropriate ethical approvals, legal approvals and agreements in place?	No formal requirements for approval exist.	Work on insects does not require ethical approvals, but permits to collect and export all Panamanian ant species involved in the project to Denmark will be applied for from the Panamanian authorities.	The study was approved by the Ethics Committee of the Capital Region of Denmark. Written informed consent was obtained from each participant before enrolment. The Danish Data Protection Agency gave permission to gather, store and share the data.	No ethical approvals are necessary.

1.2 Who will have the rights and responsibilities for the data that you will collect or generate?	The lead researcher has responsibility for the data both during data production and in the following years (i.e. during reporting and storage).	The lead researcher has responsibility until the project ends; the research group leader is the main person deciding how, where, whether to share data after the project.	A senior clinician (the corresponding author) has responsibility for the data. Rights to use the data (in pseudo-anonymized form) are shared via a designated, password protected subpage of the web-page, Enroll-HD.org.	The lead researcher is responsible for data creation and management. After the project, the principal investigator and his/her institution retain control over and responsibility for the data.
2.1 How are the data collected?	Using qualitative sociological methods; six focus group interviews involving in total 36 farmers carried out in 2005.	Through fieldwork, dissections, cell staining, fluorescence microscopy.	Through clinical and psychometric tests undertaken at the hospital facility.	The data are created using an advanced model simulating changes in the Earth's climate under different pre-set conditions.
2.2 What data will you collect?	Interviews are digitally tape-recorded and stored as VMF-files. Tapes are transcribed verbatim, and stored as RTF-files. Both formats are durable; neither relies on specific software.	Data on % sperm survival are recorded in a paper lab book; a copy is saved digitally in .xml and .prn. Photos of reproductive organs are saved as .jpg files. The total volume of all data in the project will be < 1GB.	Data include UHDRS-motor scores to classify patients as motor manifest HD gene-expansion carriers, the Symptom Checklist-90-Revised, and Hamilton Rating Scale for Depression-17 to assess neuropsychiatric symptoms.	The data consist of existing information such as air/water temperature, air pressure, humidity, wind speeds and water currents. Advanced algorithms will model how these will change when subjected to certain changes in e.g. CO_2 content over time. The project will produce > 500 TB of data.
2.3 How will you control consistency and quality of the data?	Random samples of the interviews are compared with transcripts to validate the quality of the transcripts.	Preliminary experiments to fine-tune the protocol. Sperm viability analysis is performed blind, so data recorder is unaware of sample identity (treatment category).	By selected double checks. Physical/neurological examinations and neuropsychiatric evaluations are conducted in 2 separate visits, and performed blinded to one another.	The data collectors will repeatedly check the sensors' operation, note uncertainty ranges and calibrate the equipment if necessary.

2.4 How will descriptive documentation and metadata be created?	A detailed methodological protocol documents the production of data and subsequent handling.	File name format: experiment name_ species_version. DMP and protocol stored with data, all files cross-linked and with the same keywords.	Descriptive documentation and metadata are an integral part of Enroll-HD. org. Local records are linked to unique patient identifiers.	A flexible, hierarchical schema is used to capture climate model metadata, describing logical concepts such as model ensembles, simulations and datasets, with all associated detailed information. These data are stored in a central metadata catalogue maintained in a relational database.
3.1 Describe how your data will be processed to produce the final data set that underlies the research results.	Transcripts are coded and analyzed using the qualitative software Atlas-ti.	Data are analyzed in SAS using Generalized Estimating Equations (GEEs), with binomial errors, correcting for over-dispersion, to analyse the effect of treatment on sperm survival.	All patient records are pseudo-anonymized. The key to de-anonymizing the data is kept with the corresponding author and the director of the local biobank.	Observational data can be analyzed to produce predictions of weather patterns by running algorithms on an institutional HPC centre. Data for analysis are also published to allow for external analysis or simulations.
4.1 How and where will the data be stored and backed-up during the project?	Master copy of all data, including rtf files with the codes are stored at lead researchers' H-drive on university server. Hard-copy printouts of the interviews and the analysis are stored in the lead researcher's office.	Master copy of data, DMP, protocol on the lead researcher's H-drive on the University of Copenhagen server.	Data are uploaded to Enroll-HD. Backups will be made on a password-protected server at the hospital.	Output data from the simulator will be stored in steps in a working directory on an array of Network-Attached Servers controlled by SDS (Software-defined Storage) for two months, after which they will be moved to grid storage.
4.2 Who will have access to the active data set?	The lead researcher only.	The lead researcher only.	The corresponding author, the lead author (PhD student) and the statistician.	The consortium group.
4.3 How will you ensure data security?	Electronic (master copies) are secured by passwords. Printouts are kept in a locked office.	Lab book and laptop are kept in a locked drawer. Laptop is password protected. Samples are kept in a locked lab.	Through password-protected, closed data-folders.	Through an authentication procedure prior to access.

5.1 How will you share your data?	Data will not be made publicly available; it is impossible to anonymize the data, as farm and personal details are revealed during interviews. Permission can be given to specific researchers to see the data if they sign an agreement.	Data will be shared through a repository requested by the publisher, alternatively via the DRYAD repository, which includes a DOI.	Access to data will require the permission either of the administrators of the Enroll-HD web page or of the corresponding author.	Via the data portal which consists of a distributed Grid system spanning multiple data centres across the country. The system provides authenticated, access-controlled, seamless access to Climate Model data and related analysis and visualization software, stored on online disk farms and deep archives across a number of centres.
5.2 Will there be a period of exclusive use of the data for the project team after project end?	Not applicable.	Data are shared automatically upon publication of any manuscript.	Due to the sensitive nature of the data limited access to data will continue indefinitely.	No.
5.3 Are there other conditions/ restrictions for the sharing of the data set?	Not applicable.	No restrictions exist.	A credible institutional setting and a legitimate purpose. Access is granted case-by-case.	No restrictions exist.
5.4 Who will make decisions concerning access to data sets?	The lead researcher.	The research group leader, after consultation with the lead researcher and collaborator.	The corresponding author.	The consortium group.
6.1 Which data will you archive?	Files and hard-copy records of primary data (interviews), secondary data (transcripts and notes) and the analysis.	All data underlying the publications plus those difficult or costly to replace.	All.	All created data will be archived.
6.2 What is your long-term preservation plan for the data set?	The data will be stored as described above until considered of no value for further studies.	After the project, the data will be archived in the Institutional repository ERDA for min. 5 years.	There is no defined expiration date for the designated web-page.	Data will be archived for at least 10 years at the German Climate Computing Centre on tape.

2.2 Ethical and legal approvals

During the data planning process it is often necessary to obtain permissions or approvals of various sorts. There may be requirements set by the research community or wider society for the collection of certain kinds of primary material and data. For example, legislation is in place to protect human research subjects, both in their safety and in their privacy. Rules and regulations also govern the use of live animals in experiments, and there are a number of measures in place to guarantee safe use of techniques such as genetic modification. Some key requirements and regulations are listed in Box 2. As these are not the subject of this chapter, what we present here is meant merely as a reminder that, where relevant, you have an obligation to acquaint yourself with the relevant legislation and ensure that all necessary permissions are in place before embarking on data collection.

2.3 Rights and responsibilities relating to research data and primary material

Before starting a research project, researchers should try to clarify their rights to, and responsibilities for, the data and primary material collected or generated by the project. This

BOX 2: SOME REQUIREMENTS THAT NEED TO BE SATISFIED BEFORE EMBARKING ON DATA COLLECTION

Research involving human beings and/or human materials:

1. Health research projects in Denmark involving human beings or any kind of human material (cells etc.) need permission from a *regional ethics committee*.
   See more on the website for the National Committee on Health Research Ethics (2017).
2. Research projects involving sensitive personal data may require permission from the *Danish Data Protection Agency (DDPA)*. This applies, for example, to social science projects outside the field of human health based on interviews, surveys and similar methods that typically do not require permission from a regional ethics committee. Application for permission proceeds via a single registration at each faculty involved. Even if no permission from the DDPA is required, researchers must comply with the requirements of the *Danish Act on Procession of Personal Data*.
   See more on the website for the Danish Data Protection Agency (2010).
3. In some countries (e.g. the UK and the US) all projects involving human subjects require permission from an *Institutional Review Board*. Such permissions may also be required by international funders and by journals. Therefore, the Faculty of Health and Medical Sciences and the Faculty of Science at the University of Copenhagen have set up a Review Board where researchers can ask to have their projects reviewed even if this is not required by Danish law.
4. Typically, it is a requirement for all projects involving human subjects that participants give their *informed consent* to the research. Part of the basis for the informed consent is the provision, to participants, of information on measures to protect their privacy.

Research involving other organisms:

5. Where laboratory animals are used, permission is required from the *Danish Animal Experiments Inspectorate*.
   See more on the website for the Danish Veterinary and Food Administration (2017).
6. Experiments involving the release of genetically modified organisms or other applications of advanced technology may also require permission.

Researchers engaging in international collaborations should be aware that requirements may vary across countries.

helps researchers to prepare for, and ideally avoid, many of the issues that can arise in collaborations, and to know who will do what with the data during and after the project. Unfortunately, determining rights and responsibilities is not always a straightforward exercise. For one thing, rights to data are defined by a number of legal rules (e.g. personal data law, law protecting patients, copyright law, design law, property law, and general contract law). We cannot cover all relevant legislation here, and we therefore recommend that you talk to your supervisor(s) and/or project collaborators before embarking on your project, and as a starting point determine:

1. *To what extent you will have access to, and are permitted to get a copy of, the research data and/or primary materials collected.* For example, if you obtain data sets and materials from external sources, it is important to know what you can and cannot do. There may be agreements in place that regulate access, such as material transfer agreements. If you work with industry partners, there may be contracts with these partners that define how data can be used.

2. *To what extent you may (re)use the primary materials and/or research data in other projects and for other purposes.* This includes agreeing on which rules apply if you or your collaborators leave the project prematurely, or when you finish your employment. At that point, would it be acceptable for you to use the data and/or materials in the new project, even if you are then working in a different team, lab, or at a university? Primary materials of a physical nature, such as tissue samples, geological samples, and paper laboratory notebooks, are subject to common property rights, which means that by default they belong to the institution at which you work. Thus, you cannot take them with you at the end of your employment, or project, without seeking permission first.

3. *Whether there are terms that regulate the above, and what disciplinary measures will be applied if these terms are violated.* For example, if you work with personal data, you should be aware of and able to state whether there are rules concerning data confidentiality and how these rules limit access to data by you, your collaborators, and also by others. How will you make sure these rules are followed, and what penalties can be expected when this does not happen?

You should also be conversant with:

4. *Intellectual property rights* (see Chapter 6).

5. *All data management and sharing requirements of funding bodies and partner organizations.* For example, many funders require data to be made publicly available at the end of a project (Open Access).

6. *Any local regulations on rights to data and primary material.* It is important to note that faculties may have different regulations on rights to data. If in doubt, check your faculty's policy and any existing regulations within your department or research group, as well as the (PhD) contract you signed at the start of your employment.

3. Collecting and processing primary materials and research data

It is essential that you provide a thorough and clear description of the primary materials and research data you collect, and how you process them. Doing this as you go along will save you a lot of time and effort later on. Please note that you should aim to provide records of your research that are transparent to others as well; your supervisor may wish to replicate your study, or one of your peers may be enthused by your work and ask to use your sampling design or protocols in their own research. In this section, we will make some suggestions as to things to consider when you record and process your primary material and research data.

3.1 What should you record?

Your research plan

You will have written a summary of all data management steps in your DMP. However, it is also a good idea to describe the background of your research project in more detail. For example, what is the current state of the art in your research field? What theory inspired your work? What is the overall

aim of the project, and what are the specific research questions you would like to answer? This can then be followed by a description of your project plan, your methodology. What techniques will you use and why? What is the sampling design, how many replicates will you include, and what equipment will you need to collect your data? In other words, you should provide a description of the overall project, and this description should be kept with the research data as long as they exist. The description will come in handy when the time comes to write up your results at the end of the research project.

The nature, quantity and location of your primary materials
You should keep clear records of the primary materials used to generate research data. It is the duty of the research institution (and therefore your research group) to provide proper storage facilities, such as freezers and secure storage cabinets. However, it is your responsibility, in collaboration with your supervisor, to draw up a storage/documentation plan in which you make informed decisions on what to keep in storage, where, and for how long. What is most important is that you provide thorough records, to allow research data to be traced back to the primary material they were generated from. You should therefore make sure that your primary materials are labelled properly (e.g. with a sample ID, date of collection, short description of the material/sample, person in charge of the project), and that this information is recorded in your data file, together with your research data.

One case where incorrect or incomplete labelling and recording of primary materials led to problems arose at the Royal Ontario Museum in 2007. The Museum's new curator was on the hunt for a skeleton of one of the largest dinosaurs that ever existed, the Barosaurus, to display in the new exhibition. He spent months and considerable resources investigating where to obtain such a skeleton (digging one up, purchasing a cast, and the like), until by chance he found a reference in a research paper stating that there was a complete skeleton of the kind he was looking for in the museum's own basement. It turned out that the previous curator had stored the bones individually in separate cabinets and failed to record these samples in the museum's database. In this way, the previous curator made this large dinosaur skeleton virtually invisible, reuse of the material by others very difficult, and storage of the bones was almost rendered pointless.

Research data generated or collected
Researchers working in a laboratory will often use a paper or electronic *lab notebook* to record their research data, and some institutions require it. These notebooks have been used as the basis of claims to intellectual property (e.g. rights to patents), to show who invented something first, and can be offered as evidence to defend researchers against accusations of research misconduct (e.g. Ledford, 2016; Nickla and Boehm, 2011). It is therefore important that you use lab notebooks appropriately, by recording data directly in a way that cannot be altered at a later stage, as well as adding dates to your records and signing the pages. Researchers in other disciplines may not use a lab notebook. However, they are still required to keep electronic records of their data on a designated drive on the university's server (see Section 5.5), and annotated so that they can be understood and used by other people if needed.

Another consideration is the format of your digital research data. Data should be accessible and readable for a suitably lengthy period (The *Danish Code of Conduct for Research Integrity* and The University of Copenhagen policy for data management require a minimum of 5 years after project end, but aim for longer). Is the data format you are using accessible by others using standard programs and equipment? Is it reasonable to expect that the computer program you are using will still be available and readily accessed ten years from now? If your research data were generated with specific software, codes and calculations, you should always keep information about these with the data, and you should save an additional copy of the data in an accessible format (e.g. *.csv, .rtf, .tif, .mp3, .mp4, .pdf*).

If you will generate multiple datasets within a research project, it is a good idea to keep an overview of all of the databases or files in a single document and describe how they relate to one

another. Also carefully consider file names. What will make most sense to you five years from now (e.g. *Fig1B.ai* or the more explicit *Fig1B_EffectSleeponMood_PeterPetersen_Jan16.ai*)? The same goes for version control: How will you keep track of multiple versions, the changes made in these versions and the members of the team who made these changes? What titles will work best (e.g. *Finaltext.doc, absolutelyfinaltext.doc, reallyabsolutelyfinaltext.doc* or *textonsmoking_16Jan16_Susanne.doc, textonsmoking_18Jan16_Asger.doc, textonsmoking_22Jan16_Lars.doc*)?

Metadata

In the examples above we have briefly touched on the collection and storage of metadata. Metadata are data describing your primary material, research data, and project, which enable you and others to identify, understand, and search the work you have created. The term comes from computer science but is widely applicable to any scenario where data need to be traced back to their source. Metadata elements can be divided in a number of categories:

Descriptive metadata consist of information about the content and context of a piece of primary material, a dataset or the like ("the object"), which will help you discover and identify it. Examples are title, creator/author, subject, keywords, and description/abstract.

Structural metadata provide information about the internal structure of the object, e.g. page number, chapter, and table of contents. Structural metadata can also tell you something about the relationship between elements, e.g. 'Figure Z is part of Article B' and 'PhotoB_FilterX was created using original PhotoA'.

Administrative metadata describe information needed to manage the object. Examples are creation date, file type, copyright permissions, required software, provenance (history), and file integrity checks.

Ask yourself carefully what metadata are best suited to describe your research project. There may be differences which depend on the research discipline, and you should note that some discipline-specific metadata standards exist (e.g. see the UK's Digital Curation Centre's website on Disciplinary Metadata (n.d.)).

3.2 Quality controls to improve accuracy and reproducibility

Good practice in the collection and recording of primary material and research data, as well as use of the appropriate metadata, enable researchers to attain better standards of reproducibility. Reproducibility can be defined as the ability to re-do, i.e. duplicate, an entire research project, with the aim of either reproducing similar results or disproving their reliability. Reproducibility is at the heart of science, but unfortunately failure to reproduce published research is relatively common (see *Nature's* special issue 'Challenges in irreproducible research', 7 October 2015). For example, a large consortium of researchers in psychology collaborated to reproduce 100 published empirical studies. While significant results could be found in 97% of the original studies, this was the case in only 36% of the reproduced studies (Open Science Collaboration, 2015). In pharmacology, recent research showed that only 20-25% of a sample of 67 medical studies were reproducible (Prinz et al., 2011). Some degree of irreproducibility is inevitable – e.g. because two tumour samples are unlikely to look exactly identical under a microscope, because animal behaviour cannot always be predicted, or because the composition of geological samples may depend on very local conditions.

4. Storing data during the project

Losing research data can be disastrous, especially when the data have been generated over a very long period, were costly or difficult to collect, or cannot feasibly be replaced. Every researcher has probably gone through a 'data storage scare' at some point: a misplaced USB stick or laboratory notebook, a laptop that crashed before a back-up was made, or a camera that was stolen (search #lostUSB and #datadramas on Twitter for some real life examples). It is easy to imagine how this could have severe consequences, e.g. if all data generated during a PhD project was lost, or if sensitive personal data was lost, signalling lack of compliance with regulations for data handling.

Below we describe some general things to consider when storing active data (data used in on-going research projects). Note that there is likely to be a stronger regulatory framework if you are working with personal data, if agreements for data use exist, or if commercial interests and intellectual property need to be protected.

4.1 Data storage and back-up

The risk of data loss needs to be considered when you are choosing the method and location of data storage. How stable is the storage solution? Could it easily be damaged or misplaced? Is the process of backing up data straightforward? Portable devices such as USB sticks and hard drives, and laptops and desktop computers, are not the best storage solutions. One way to prevent data loss is to store the master copy of your active data on your personal drive on the university's servers, because data stored there are automatically and regularly backed-up. For data to be shared with your research group members, consider using the research group's common drive on the university's servers. This option may become especially important at the end of your employment: your personal drive is not accessible by others, so crucial lab data may disappear from the research group if you do not migrate data to the common drive before leaving.

4.2 Data security

You will also need to ensure that data cannot be accessed by third persons who are not part of the project team, and prevent data sets being tampered with. It is necessary to plan this carefully at the start of the project, especially when you are one of several researchers collaborating on the same project and active data need to be shared. As required by PhD contracts and other contracts, all employees should adhere to UCPH's IT security guidelines (University of Copenhagen, n.d.). If you use private IT equipment (e.g. mobile phones, tablets, and so on) for checking work emails and other project-related items, bear in mind that the security guidelines apply to these units as well – perhaps especially so.

Data security can operate on various levels:

Security of data files and computers

Questions you should ask yourself include the following: Are my computer and data files password protected? How can I guarantee the secure removal or destruction of data? Will collaborators have controlled access to the data? Are changes made by my collaborators logged somewhere? Will I be able to see whether unauthorized persons have tampered with my data? If you need to share data in an on-going research project with collaborators at the University of Copenhagen, you can request password protected folder sharing at your faculty's IT department. Alternatively, you could set up a group room on KU-net in which you deposit a copy of the files. Care should be taken when distributing data over email. Such transfers should only be made via the University email system (not Gmail and the like), and personal or sensitive information should always be encrypted.

Security of storage networks

If you cannot avoid using storage networks outside the university's servers to store your data, you should investigate whether these services sufficiently protect your data against vira, malicious codes, hacking attempts, and so forth. Commercial cloud-based file sharing services such as Dropbox, Amazon and Google Storage can be used for backing up research data, but they should never be used when the data are confidential, sensitive or valuable. These services are very popular because of their ease of use, but they often store data in countries with privacy and data protection laws that differ from those in Denmark. Note that the Danish Act on Processing of Personal Data (§ 50, stk. 2) states that in many cases transfers of sensitive personal data to countries outside the EU requires permission from the Danish Data Protection Agency.

Physical security

What about the physical security of your primary materials – that is, materials such as tissue samples, laboratory notebooks, soil samples, or photographs? Can someone simply walk into your office and take or tamper with these? Do you store your computer in a locked cabinet? Have you had an alarm set up in case the freezer holding your samples breaks down? If you do not take these precautions, you might discover

that a laptop has been stolen from the office, that samples have accidentally been defrosted, or that chemicals have been spilled over a lab book rendering it unreadable. Where it makes sense, consider making copies of your research materials at regular intervals.

5. Sharing data after the project

In the previous section, we looked at data sharing with collaborators within an on-going research project. In this section, we address the sharing of data with the wider scientific community after a project has concluded.

5.1 Why share research data?

As mentioned in the introduction to this chapter, sharing of data sets has become more and more common and is expected to become standard in most disciplines in the near future. But why would you share data? A paper in PLoS ONE (Federer et al., 2015) outlined attitudes to the sharing of data sets in biomedical research and found that social and professional barriers hinder data sharing more than technical ones. For example, researchers were concerned that they might lose their competitive advantage in getting future papers accepted for publication or in obtaining funding if they made their data sets available. They also feared that others might scrutinize their data and find errors in their research, or would misuse their data sets in new research projects. If these concerns exist in other research disciplines as well, how is the general shift towards data sharing to be explained? In the next two sections and Box 3 we give an overview of the benefits of data sharing, which fall under both rewards for sharing (the carrot), and sanctions or negative reactions for not sharing (the stick).

Reasons for data sharing – the stick

One reason for data sharing is the fact that other stakeholders demand it. Among these stakeholders are some funding agencies, who are seeking to maximize their 'return-on-investment'. They require data sets to be made publicly available, among other things, to increase transparency in research, but also so that data can be re-used by other researchers and more results can be generated from a single funded project. As mentioned in Section 5.3, many of these funders require a data management plan to be drawn up. Many high impact journals nowadays also require data sharing, at the point when research results are published. Some journals have specific requirements relating to the format in which data sets are submitted and the repository in which they are deposited, so check the publisher's policies carefully. This is especially important because publishers' policies may also require authors to comply with the publisher's Copyright Transfer Agreement (CTA). The CTA may influence an author's rights to reuse not only the

BOX 3: WHY SHARE DATA?

There are many reasons why research data should be shared with the wider research community whenever possible:

Impact on your research profile:

- It leads to new research collaborations.
- It increases the impact and visibility of research.
- It provides credit to the researcher.

Impact on the (scientific) community:

- It enhances scientific enquiry and debate.
- It enables innovation and new data uses.
- It increases the efficiency of research due to reusability.
- It provides a great resource for education and training.

Ethics:

- It encourages the improvement and validation of research methods.
- It enables scrutiny of research results.
- It facilitates transparency and accountability or research.

Compliance with requirements:

- It meets journal, institution, and/or funder requirements for data sharing.
- It meets standard practices within the research community.

particular publication, but also the raw data. Lastly, some universities also regulate data sharing. No Danish universities do so yet, but some have stated their intention to require a certain fraction of their publications to be held in open access as part of a general movement towards open science reflected in data management policies (e.g. at the Faculty of Health and Medical Sciences, University of Copenhagen (2016)).

Reasons for data sharing – the carrot

Another reason to make your data publicly available is that data sharing may add value to your research profile. Work by Piwowar and colleagues (Piwowar et al., 2007; 2013) has found that studies in which data were deposited in public repositories received more citations than those in which the data sets that were not made available, and that 20% of data sets are reused at least once within four to eight years after data deposit. In many cases, re-use leads to additional co-authorships, with the original authors being asked to collaborate on a new project using their deposited data.

Data sharing also benefits the scientific community as a whole. For example, it improves both the discoverability of research (Niyazov et al., 2016) and the reproducibility and transparency of research in general (Ascoli, 2015; Sturges et al., 2015), and it stimulates collaborative efforts to effectively analyze massive data sets (Ferguson et al., 2014).

5.2 Can any data set be shared?

While some data types can readily be shared after a project has ended, others cannot. Conditions may exist that need to be fulfilled before data can be shared with the scientific community, or with industry. As mentioned in Section 5.3, it is therefore essential that you examine existing policies and agreements for data use and reuse. Cases where data sharing limitations may exist include:

1. Research projects involving personal data
   Personal data, such as views expressed in questionnaires, patient level data from health registers, certain types of tissue sample, photos, x-rays, scans, and video and sound recordings, cannot be shared straightforwardly. Anonymization of data sets can sometimes remove information that would otherwise enable people to be identified, but this may be difficult or impossible when data sets are small, or when a combination of general characteristics would allow reasonable guesses to be made about a person's identity. In Denmark, all research projects involving sensitive personal data need to be registered at the Danish Data Protection Authorities (DDPA, Datatilsynet – see Box 2 above). The DDPA has policies on data sharing that researchers need to follow, and projects that involve personal data which are not sensitive and therefore do not need to be registered may still need to comply with these policies.

2. Research collaborations across national or institutional boundaries
   Collaboration across institutional or national boundaries can present challenges where the publishing and sharing of data is concerned. Some national laws and institutional policies may disallow the sharing of data for reuse while others do not, so conflicting regulations must be resolved during the planning phase, possibly through an agreement, and described in the DMP of the project.

3. Research collaborations with industry
   When collaborating with industry partners, researchers must examine whether restrictions exist on the sharing of research data as a result of industrial intellectual property (see Chapter 6).

4. Data obtained from third parties
   If you do not collect the primary material or data yourself, but instead obtain them from third parties (registries, other researchers, etc.), you need to adhere to any sharing restrictions imposed by the third parties. In most cases, Material Transfer Agreements (MTAs: contracts that govern the transfer of research materials between two parties) will be set up to regulate the use and re-use of material and data, mediated through the University's Tech Transfer Office.

5.3 Defining other people's use of your data

When you prepare your data set for sharing, consider whether you should describe the terms and conditions for the re-use of data by others. This could include credit or attribution conditions or a description of how others may use your data. For example, are they permitted to alter the data set? Are they permitted to redistribute it? You could also specify whether commercial exploitation is allowed. An agreement on conditions modelled on the Open Data Commons or the Creative Commons (although the latter is not specifically designed for data or databases) will ensure that the users know what they may and may not do with your data.

6. Preserving data after the project

Research data management does not stop with the end of a research project and the publication of the obtained results. The last step in the research data lifecycle is the long-term preservation of research data (archiving). Unfortunately, this step is often overlooked – e.g. because researchers move on to another place of employment and start on new and exciting research projects. Research groups sometimes lack standard procedures describing what should happen to primary materials and research data after a project ends, and so it may be unclear who will have responsibility for the materials and data in five, ten, or twenty-five years' time. As a result, data sets are often left unmanaged on computers or university drives, rendering them inaccessible or difficult to interpret by others. In reality, this means that data sets are lost to the scientific community.

In this section we briefly describe why you should thoroughly consider data preservation, what you should preserve, and where and how to do so.

6.1 Why preserve data?

The Danish Code of Conduct for Research Integrity states that researchers must preserve their data for *at least* five years after the project's conclusion. Publishers and funders that require open access to data sets will also require that the data you make publicly available remain available long-term. Vines et al. (2014) showed that, despite these demands, the availability of research data declines rapidly with article age. They showed that the odds of a data set remaining available drop by 22% every year after the publication of the data set. You should thus choose a stable solution to preserve your data over the long term (see below). This may help you defend yourself against future challenges raised by peers in connection with your published work, but may also benefit your future work, especially if your preserved data are accompanied by metadata allowing easy searches.

6.2 What data to preserve?

Should every single data point be preserved for many years? The answer is: "No". Indeed, for some types of research data and primary material there are formal restrictions on preservation. For example, materials may need to be destroyed at the conclusion of the research in projects dealing with personal data (unless anonymization is imposed and agreed upon). For data that can be archived, you should make some informed decisions on what you should preserve for at least five years. First of all, you will need to preserve all data underlying any publications. However, note that this does not mean that unpublished data should not be preserved, as it may be of value to you or others in the future. Second, we recommend that you preserve all data that are costly or difficult to replace. For example, think of data sets generated in big collaborative projects, data derived from primary materials that were difficult to obtain (e.g. soil samples collected in the Amazon rainforest), and data generated with specialist equipment not standardly present in every research group. On the other hand, the preservation of primary materials will only be advisable where the quality of the material allows it and it is financially feasible. Because long term storage may be costly, it is necessary to determine who will cover these costs, as well as who will have responsibility for the data and primary materials in the years ahead.

6.3 How to preserve data?

Data preservation involves transferring your data set from storage media designed for the relatively short-term storage of active data (e.g. your laptop or your personal drive on the university servers), to a storage repository specifically

intended for long-term data preservation (a data archive). Care must be taken when selecting the repository. Some repositories specialize in storing data sets that underlie research publications. They allow data sets to be made publicly available, and they can attach a digital object identifier (DOI, a form of persistent identifier which does not change over time, as opposed to a URL, which may go out of date) to your data sets. However, these repositories may not necessarily be suitable for preservation over decades or longer, and those maintaining them may not be interested in storing data that did not result in a publication. But repositories specializing in very long-term preservation may not give you the option of making your data sets publicly available and may not be set up for all types of research data and materials. It is therefore important to consider carefully what you need from a repository, and what is possible. In addition, you will need to check any regulations the repositories impose on how data sets should be formatted and what metadata must accompany the data set.

Repositories can roughly be divided into institutional repositories, national and international repositories, discipline-specific repositories, research output-specific repositories, and general data repositories. The website www.re3data.org (a database of data repositories) is a good place to start if you are considering using a repository. In Box 4, we briefly illustrate the advantages of three archive types.

BOX 4. THREE TYPES OF ARCHIVES

Institutional repositories

Advantages: Includes support function for local users, and may contribute to branding the content.

Example: The Electronic Research Data Archive (ERDA) at the Faculty of Science, University of Copenhagen. The ERDA is accessible to all researchers in this faculty and will be accessible to researchers in other faculties in the near future. It can also be used to make data sets publicly available for data sharing.

Discipline-specific repositories

Advantages: Will have collections of similar types of data, potentially making it easier to combine data sets, since they will be using the same metadata schemes and vocabulary.

Examples: NASA's Space Physics Data Facility, Archaeology Data Service, the DRYAD repository.

The National repository

Advantages: Very long-term and stable preservation of high quality research data.

Example: The Danish Data Archives (DDA, Rigsarkivet). DDA is the only national repository where personal data can be archived. Personal data archived at DDA can be re-used with the permission of the Danish Data Protection Agency (Datatilsynet). Data stored at DDA are intended to be preserved indefinitely.

6.4 Data destruction

Some data and primary material will need to be destroyed after the project end, instead of being archived. This may be because they are of low value or quality and not worth preserving, or because an agreed retention period has ended, or because legal or ethical regulations require destruction. As with data archiving, data destruction needs to be especially carefully considered when dealing with confidential or sensitive data. Use irreversible methods; the 'simple deletion' of files may not destroy the data but merely remove the reference to them at the user-interface. This means that if you lend out your USB stick, or throw away your old laptop, someone may be able to access your data.

7. Getting help with research data management

For help with research data management related issues, researchers at the Faculty of Health and Medical Sciences can contact researchdata@sund.ku.dk or visit the Faculty's Research Data Management Website (Faculty of Health and Medical Sciences, 2016). Researchers at other Faculties can find information on the University's central intranet page for data management (University of Copenhagen Intranet, n.d.).

8. Test yourself questions

- While conducting your research project, what actions are covered by the term 'research data management'?

- What should you consider when starting a new research project, and why is it important to consider this before collecting the first data point?
- Who are the main stakeholders interested in good research data management, and why?
- How will good research data management benefit your own career in research?

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6
Commercialization of research results and intellectual property rights

Niels Lysholm Engelhard

Summary

Universities have become increasingly engaged in collaboration with industrial companies, and intellectual property rights (IPR) play an important role in this kind of collaboration. This chapter begins by introducing the legal background to transfers of technology from universities to industry. It then describes the two most important forms of intellectual property right used to regulate this transfer; patents and copyright. There follows a detailed description of how technology transfer works at the University of Copenhagen, through the involvement of the Tech Transfer Office at the University. Finally, a short account of experiences with technology transfer at University of Copenhagen is provided.

1. Introduction

Industry depends on access to the results of university research in order to develop new products and processes, and thereby remain competitive. Mechanisms to support technology transfer from academia to industry have been embedded in innovation policies by almost all governments across the globe. Direct industry participation in publicly funded research projects has become a tool widely used by the various funding bodies to encourage technology transfer, both in national and EU research programmes, especially as part of the EU Horizon 2020 programme. More and more, universities and other public sector research institutions are involved not only in providing education and scientific discoveries, but also in collaboration with industrial companies.

On the face of it, this seems to conflict with the traditional role of publicly funded universities as institutions which provide knowledge as a public good for the benefit of all. The potential conflicts of interest the wider role gives rise to need careful management (see Chapter 7). At any rate, it has become part of life on universities all over the world. Technology transfer can take many forms, but this chapter will focus on technology transfer based on the commercialization of research results protected by IPR.

2. Technology transfer

The transfer of technology from universities to industry really took off with the 1980 Bayh-Dole-Act in the US, which stated that the *universities* have the right to take ownership of inventions made by their researchers. Before 1980, in the US, researchers themselves had ownership to any inventions made as part of their work. This was called "Professor Privilege". Denmark's own "Bayh-Dole-Act" – the Act on Inventions at Public Research Institutions – was passed in 2000 (Ministry of Higher Education and Science, 2009). Before then researchers at Danish universities and other public sector research institutions had ownership of their own inventions.
Why should universities protect inventions, rather than allowing researchers to just publish new knowledge so that anyone can benefit from its application? Imagine having invented a new molecule that could be the key ingredient in a wonder drug for the eradication of HIV or tuberculosis. Would it not be more ethical to publish the findings so that anyone can use them?

The problem is that it takes years, and vast funds, to develop and market a new drug or other high tech product. Therefore, no investor or company would take on the risk of developing and commercializing a new product or technology without the protection offered by a patent to secure a return on that investment. Hence, if technology is to be made commercially available, a property right to the invention may be necessary. Companies also want to invest in products for which there is likely to be a demand – there's no point developing a drug that no-one wants to buy. However, there are also areas which are not commercially interesting, but where new knowledge may be beneficial – e.g. to people living in impoverished parts of the world. Universities also have an obligation to benefit these people, and publish results deemed not to be worth patenting.

Hence, there are important scientific, economic, and societal priorities involved in technology transfer and how it is managed. Governments encourage technology transfer, because it is a way to supply innovation to industry and create new jobs. For universities, industrial collaboration offers

opportunities for extra funding; and for researchers to gain access to otherwise unobtainable knowledge and equipment. However, universities have obligations that go beyond what can be achieved through commercialization – e.g. finding cures for very rare diseases of little commercial interest, or helping people to find healthier ways of living. Therefore, a reasonable balance between research focused on commercial applications and other kinds of research is called for. Where industry collaboration does occur, the freedom of research must nonetheless be protected.

The effective technology transfer process is in essence about people interacting so that innovation can occur. Intellectual property rights may be viewed merely as tools, and legal agreements can be seen as a framework to support collaboration between academic scientists and industry. The process is not always easy, as academia and industry belong to different worlds. Understanding the viewpoint of the other party is the key to success. The primary mission of a university is education, and the creation and dissemination of new knowledge for the sake of knowledge itself, with publishing as a fundamental condition. Industry's mission, by contrast, is to make a profit by providing services and offering products to the market. The knowledge lying behind these services and products is for the most part developed confidentially in-house.

3. Intellectual property rights

Intellectual property rights confer ownership on ideas and creations and grant the inventor/creator exclusivity for a certain period of time. They are instrumental in driving forward the development of technology and innovation. IPR divide into two categories:

1) *Industrial Property Rights* include patents and utility patents, trademarks, industrial designs and geographical indications.

2) *Copyright* covers literary and artistic works such as articles, theses, films, photographs, musical compositions, drawings and paintings, sculptures, and architectural designs. The rights related to copyright include those of performing artists in their performances, and those of producers of phonograms and broadcasters in their radio and television programmes. This chapter will focus on patents, utility patents and copyright, since these are the most relevant types of IPR for public sector researchers.

3.1 Patents

A patent covers the technical aspects of an invention – it is, in other words, a technical solution to a problem. The owner of a patent can block others from commercial exploitation of the invention; at the same time anyone is permitted to perform research on the invention for non-commercial purposes. Patent rights are territorial rights. If a patent has only been granted in Denmark, anyone can exploit the invention in other countries outside Denmark, although they cannot export products or semi-manufactured products that are based on the invention to Denmark. But there is no "patent police" – it is the owner of a patent who must protect his or her rights against infringement.

Criteria governing the issuing of a patent are:

1) Novelty
2) Inventive step
3) Industrial applicability

Novelty means that the invention has to be novel at the date the patent application is filed. Meeting the novelty criterion is an objective and a global matter. If an invention has been presented in a public forum, described in a paper, journal, or on the Internet, or in any other way, it is not possible to obtain a patent unless the patent application is filed before the invention was published. Discussing the invention in a closed circle – e.g. with a supervisor and close colleagues – does not destroy the novelty of the invention, nor will the submission of a manuscript to a journal provided the manuscript is kept confidential during the review process and a patent application is filed at least one day before the paper is published. Thus, patenting will not hinder or prevent publishing – it is only matter of timing.

Inventive step means that the solution presented by the invention must not be obvious to a person with knowledge within the technical field of the invention who has all of the relevant published information at hand. The combination of two or more already published documents, such as a scientific paper combined with a text book or a patent, may not qualify as an inventive step, and render the invention obvious.

Industrial applicability means that it is possible for the invention to be made and used.

A patent provides protection for 20 years from the date the patent application was filed. Anyone can exploit an invention freely after expiry. Twenty years is a long time in some technological areas, but not in the pharmaceutical or pesticide industry, where it takes 10-13 years from initial filing of first patent application to the product's being ready for launch in the marketplace. The long development phase leaves the company with only 7-10 years to get a return on its investment before the patent expires. An annual fee is paid for each country in which the patent is in force. The patent protection will lapse in a country if the fee is not paid.

A patent application can be filed for four types of item:

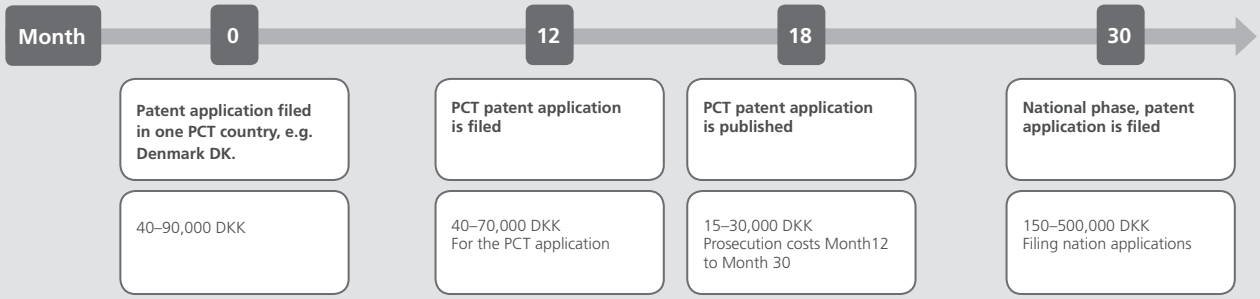
- Subject matter (e.g. a compound, herbicide or drug)
- Process or method (e.g. a process for the extraction of specific compounds, or for manufacturing a product)
- Machine or article of manufacture (e.g. a new tool)
- Use (e.g. a drug developed against one disease may show effectiveness against another disease)

A plant or animal that can be found in the wild is not patentable. However, a transgenic animal such as the Oncomouse may be patentable in certain countries such as US; the same is true of genetically modified (GM) plant varieties – e.g. a GM wheat. Inventions contravening public policy or morality (e.g. a torture instrument) cannot be patented.

It is very costly to file the first patent application in many countries, and this imposes a heavy burden on companies and institutions. This could be detrimental to innovation, either preventing the filing altogether or imposing further delay on top of the frequently long journey between the first filing and the final product. Thus, several regional and global patent treaties make it possible to postpone costs while working to obtain a patent. This allows an inventor or company several years to complete prototyping and business planning before the application process becomes costly, as outlined in Box 1 below. One of the most widely used systems is the Patent Corporation Treaty (PCT) system, which is operated by the United Nations.

It usually takes 3-4 years from the date of the initial filing of the application, for the patent to be granted. The route from patent application to granted patent, including costs in DKK, is outlined below (Box 1):

BOX 1



This overview clearly shows the expense of the route from patent filing to granted patent. The precise cost depends on the complexity of the invention and field of technology.

Inventorship is credited to one or more individuals who have contributed intellectually to the conception of the invention and the technical means of the invention (the "how"). An individual cannot be an inventor if he or she merely follows a protocol designed by others, comments on the text of a draft patent application, provides funding for the research project leading to the invention, or has a senior or management role. Adding people to the list of inventors who are not really inventors, or omitting inventors from the list, can lead to problems for the patent owner and even result in the invalidation of a granted patent. In cases of doubt, inventorship can be determined with the assistance of a patent agent (see Box 2). This has some interesting similarities to questions of academic authorship, where a 'substantial contribution' is usually required (see Chapter 4), but is more formally regulated.

Knowledge created by companies is often not published in journals, but the information is available in the patent literature. Patent applications are published 18 months after the first filing date, and the patent literature offers researchers a rich source of knowledge and "how to" which can be used freely for research purposes as long as the research is *into* the invention and not using the invention as a tool in research project. For example, research into the Polymerase Chain Reaction (PCR) method would not infringe the PCR patent, but using the PCR method as a tool instead of buying the patented PCR product would constitute an infringement. Thus, by a search of the patent literature it is easy to carry out business intelligence on competing groups or companies.

BOX 2

More information on patents can be found here: www.wipo.org, www.epo.org and www.dkpto.dk.

There are several free databases available on the Internet. www.google.com/patents and www.espacenet.com both excellent databases.

3.2 Copyright

Copyright differs from industrial property rights (patents, trademarks and design registration) in many ways. The copyright symbol © is still widely used, but in fact it is not necessary, as copyright is automatically given by law without any application process. Copyright also differs from industrial property rights in that with it the creator of the copyrighted item, who is always an individual, holds the right to his or her work. Furthermore, a work has to represent "originality" to enjoy copyright protection.

The Danish Copyright Act ("Ophavsretsloven", Danish Ministry of Culture, 2014) regulates the protection of two categories of subject matter (or types of creation):

1) *Literature and artistic works* such as maps, drawings, computer programs, architecture, various expressions of art (fictional or non-fictional), applied art, works of fine art, and graphic works.

2) *Neighbouring rights* such as photographs, films, movies, sound recordings and music, and the performance of literary or artistic work such as theatre plays.

Copyright protection lasts for 70 years after the death of the creator in the first category and 50 years in the second category.

The creator has the right to reproduce (copy), alter, disseminate, and perform or show or display his or her work. These rights can be assigned to a third party such as a journal or publishing company. Researchers and teaching staff hold the copyright to any material (except computer programs) that fulfil the criteria for copyright protection. For example, I have copyright to the text in this chapter; but my employer has the right to use the text even if I leave my position.

Computer programs are protected by copyright. The protection relates only to the actual code (the binary sequence of "0" and "1") and to graphical representations such as the layout of the graphical interface, including icons and drawings – not to the algorithm in itself. Who owns a computer program made by a researcher at a public research institution in Denmark? Unlike inventions, the employer (institution) automatically has ownership here.

A work that enjoys copyright may consist of two individual works, e.g. a photo of a sculpture presented in PowerPoint. The creator of the sculpture still has copyright to his work, the photographer holds copyright to the photo, and maker of the PowerPoint holds the copyright to the PowerPoint slide. In this case, the last of these creators would need permission, or a license, from the photographer and artist, or from an organization to which the artist and photographer have assigned their right to reproduce or otherwise use the creation.

It should be emphasized that copyright protection only applies to the work itself, not to the idea or theory presented in the work – e.g. to a new theory in given scientific field. Box 3 presents some practical tips for navigating the complex world of copyright.

BOX 3: TIPS CONCERNING COPYRIGHT ISSUES

- Never use photos, drawings, or other copyrighted material in public without obtaining permission from the rights holders
- Do not assign all your rights to publishing companies or other organizations without having read the guidelines: *Copyright for researchers, students and teachers at University for Copenhagen* (http://kubis.kb.dk/copyright)
- UBVA (Udvalget til Beskyttelse af Videnskabeligt Arbejde, The Committee for Protection of Scientific Work) offers free guidance, an e-book on copyright (in Danish), and free online courses in copyright (www.ubva.dk)

4. How does technology transfer work at the University of Copenhagen?

Collaboration with external partners is often an integral part of working at a university or other public research institution. The collaboration can take many forms and is regulated by different types of legal agreement. Technology transfers are usually organized by specialized Tech Transfer Offices. In order to avoid problems employees should always consult the local legal advisor in their faculty, or contact the Tech Transfer Office for assistance.

The Tech Transfer Office at the University of Copenhagen operates from the Research & Innovation Department, in the university's Central Administration (Fælles Administrationen). All matters relating to the commercialization of IPR at the University of Copenhagen are handled by the Tech Transfer Office, which also assists researchers in entering all types of legal agreement.

As a junior researcher, you are not permitted to sign an agreement between the University of Copenhagen and external partners. The agreement must be negotiated by the Tech Transfer Office and signed by your head of department. If you need more information, there is a booklet introducing the overall principles of the university's collaboration policy at http://www.fi.ku.dk. The booklet is available in Danish and English.

Inventions made by researchers at Danish universities, university hospitals and other public sector research institutions are regulated by the Act on Inventions at Public Research Institutions (Lov om opfindelser ved offentlige forskningsinstitutioner, Ministry of Higher Education and Science (2009)). If an employee has made an invention as part of his or her work, the research institution has a right to transfer to itself the rights attached to the invention. All tangible materials – e.g. antibodies, seeds and microbial strains – belong to the institution and can in principle be commercialized under a license agreement or sold. However, the Act only gives the institution the right to inventions falling inside the researcher's field of work at the institution.

For example, if a cancer researcher invents a patentable new kitchen tool, that tool will not be considered an invention subject to the Act.

The inventor must report (disclose) the invention to the Tech Transfer Office by completing an Invention Disclosure Form, but how do you know if you've made an invention? The definition of "inventions" is stated in the The Patent Act (Patentloven, Ministry of Industry, Business and Financial Affairs (2017a)), and The Act on Utility Patents (Brugsmodelloven, Ministry of Industry, Business and Financial Affairs (2017b)). Under the Act on Inventions at Public Research Institutions (Ministry of Higher Education and Science, 2009) the research institution has a two-month period after the date of disclosure to decide whether to assume the rights to the invention. Inventors are not entitled to publish or otherwise disseminate information relating to the invention during this assessment period. If the Institution fails to notify an inventor of their decision within the two-month period, the inventor retains the rights to his or her invention as a private individual.

Where the institution decides to assume rights over the invention those rights become the property of the institution. If the invention is exploited commercially, the employee will be entitled to a reasonable payment from the institution. That payment is described by the Act, where details of how net income is to be calculated are given; but each institution has the right to decide how they distribute net income between the institution, the departments and inventors. Box 4 describes how this distribution is handled at the University of Copenhagen.

Sometimes an invention involves inventors from more than one institution, as well as inventors from a company. In such cases the invention will be co-owned and a patent co-ownership agreement will be signed between the parties. The proportion of ownership will, unless otherwise agreed, be based on the intellectual contribution of each inventor to the invention. It is highly advisable therefore that all inventors agree on the distribution rubric internally as soon as possible, and preferably at the time when the invention is disclosed to the institution.

Bachelor's and Master's students are not subject to the Act on Inventions at Public Research Institutions (Ministry of Higher Education and Science, 2009) in that the Act does not apply to inventions created as part of their studies as private individuals. If a Bachelor's or Master's student becomes a co-inventor by participating in a research project, the institution may enter an agreement with the student under which the student assigns his or her share of the rights to the invention to the institution in return for a share of the net income.

BOX 4: DISTRIBUTION OF NET INCOME FROM INVENTIONS AT THE UNIVERSITY OF COPENHAGEN

Net income is defined as gross income (e.g. royalties received) minus external costs incurred during the commercialization of an invention (including patent costs and travelling expenses). Once the total costs for commercialization of the invention have been recouped, the net income will be distributed in the following manner:

If the University of Copenhagen assumes the rights to an invention before the end of the two-month period:
1/3 to the inventor(s)
1/3 to the department(s) where the inventors are employed
1/3 to the University of Copenhagen

If the University of Copenhagen decides not to assume the rights to an invention within the two-month period and offers the rights of ownership to the inventors:
The University of Copenhagen is entitled to 1/3 of net income.

Where the University of Copenhagen offers the inventors to reclaim the ownership to an invention after having tried to commercialize it:
The University of Copenhagen is entitled to a share of the net income subject to individual agreement on a case by case basis.

If a University of Copenhagen Bachelor's or Master's student becomes a co-inventor through his or her participation in a research project, the Tech Transfer Office will ask the student if he or she wishes to assign his or her share of the invention to the University of Copenhagen as if he or she was an employee of the University of Copenhagen. It is recommended that an assignment and confidentiality agreement with the student should be set up as part of a research project involving industrial partners. Contact the Tech Transfer Office for help and guidance.

4.1 The two-month period

Each institution has its own procedures and forms for the disclosure of an invention. Once formalities are in place, the invention is assessed and evaluated before the institution decides whether to assume the rights to the invention and file a patent application. Essentially, the decision is based on answers to the following questions:

1) Is the invention new and patentable?
2) Does the invention have commercial potential?
3) Can it be commercialized (sold or licensed)?

The first question, relating to patentability, is assessed by an external patent agent who not only understands the specific field of technology, but is also a specialist in IPR and patent law. As outlined above, one of the prerequisites for obtaining a patent is that the invention must be novel. This means that the invention must not have been made available before to the public anywhere in the world. The patent agent conducts a search in the patent literature and the scientific literature to identify documents or other material that may destroy the novelty of the invention and thus prevent the invention from being patented. This process usually requires input from the inventors, who assist the patent agent in fully understanding the technology, defining the invention and setting up a proper search profile. The review and assessment of patentability is stated in a written report.

The Tech Transfer Office reviews the commercial potential of an invention by benchmarking it against similar technologies or products currently available in the marketplace, and by contacting relevant companies and other commercial players (without disclosing the invention) to assess its commercial potential. For some inventions, an examination of the regulatory landscape surrounding the technology may be necessary in order to identify potential barriers to the commercialization of the invention such as industry standards or customs in the trade. The inventors play an important role in assisting the Tech Transfer Office with any technical input needed in the evaluation of commercial potential.

To answer the question of whether an invention can be commercialized it is necessary to consider a number of issues: the stage of development of the invention, the internal resources (funding, capacity of potential inventors, and availability of equipment) it will require, the availability of relevant potential industrial partners, and time and funding constraints, both internal and external. The Tech Transfer Office investigates these issues in close collaboration with the inventors.

Following the investigations outlined above, the Tech Transfer Office will decide to either assume or decline to assume rights to the invention from the inventors. In the first of these outcomes, a patent application will be drafted and filed, and commercializing activities will begin. The patent applications are drafted by an external patent agent in close collaboration with the inventors.

4.2 The commercialization period

After the patent application has been filed commercialization activities begin. There are basically two routes to commercialization for university IPR:

1) License or sell the IPR to an existing company
2) Establish a spin-out company founded by the inventors or a wider group of inventors

Under the Act on Inventions at Public Research Institutions (Ministry of Higher Education and Science, 2009), an

institution may sell or license IPR to industry partners, license IPR to a spin-out company or receive shares in a spin-out company, or both, in exchange for IPR generated at the institutions. Each Danish university has its own business strategy (see Box 5 for the University of Copenhagen's strategy). Some institutions sell IP rights, some only out-license IPR, yet others receive shares for equity in start-up companies originating from the institution as the preferred strategy. Institutions may employ a combination of these strategies.

Although a given technology can in principle be sold or licensed to more than one company, the majority of commercial agreements involve one company obtaining exclusivity for the technology. The commercial partner (or licensee) pays the ongoing patent costs as part of the license agreement and will therefore almost always demand exclusivity in exchange. When commercialization of the invention is unsuccessful the institution will offer to hand back, or return, the rights to the invention to the inventors, including the right to make a patent application which will then no longer be supported by the university's Tech Transfer Office.

Luckily inventions from the University of Copenhagen do find their way to partners in industry. This can mean both some initial income, sometimes modest, for the inventors and an intensified collaboration with the industrial partners, often leading to more funding and greater access to skills and equipment in the industry.

The University of Copenhagen received 40 to 77 new invention disclosures a year between 2009 and 2013, and rights to the invention were assumed in 20-30% of cases, resulting in 15-26 license and sales agreements a year. In comparison, 291 to 498 new invention disclosures were filed across all Danish universities and other research organizations in the same time period, resulting in 103 to 120 license and sales agreements. As shown in Figure 1 below, while the number of invention disclosures and new patent applications has been rising, the number of the license and sales agreements has not gone up to the same extent. This is the result of the time-lag between an invention being disclosed and the license or sales agreement being signed.

Patent expenses are roughly equal to income between 2009 and 2013, but the net profit here does not represent the real value of technology transfer to the university. In most cases a license or sales agreement entails collaboration with the industrial partner which generates more funding and new equipment. In some cases, the inventors have raised double-digit millions in research grants, so it is a win situation for both the university and the individual inventor, even if the industrial partner does not succeed in commercializing the invention.

BOX 5: IPR AND BUSINESS STRATEGY AT THE UNIVERSITY OF COPENHAGEN

The University of Copenhagen:

1) only invests in patent applications with a likelihood of being commercialized
2) does not sell IPR or accept shares in spin-out companies in exchange for them
3) maintains ownership of IPR and licenses rights to external or spin-out companies

Before a potential industry partner is approached, a non-confidential description of the invention and business opportunity will usually be drafted by the Tech Transfer Office and the inventors in collaboration. There are several ways in which to identify the appropriate industry partner. The inventors may be familiar with relevant companies, or the Tech Transfer Office may be able to identify and contact relevant industry partners. Face-to-face presentation of the invention to a potential external partner is headed by the Tech Transfer Office with the assistance of the inventor(s).

5. Further information and sources of assistance

Visit www.fi.ku.dk
Contact the Tech Transfer Office by e-mail: techtrans@adm.ku.dk
Employed within Capital Region of Copenhagen? Visit www.regionh.dk/til-fagfolk/forskning-og-innovation

6. Test yourself questions

- Who owns innovations created at a Danish university?
- Is there a copyright to scientific work?
- How can a university innovation be patented?

References

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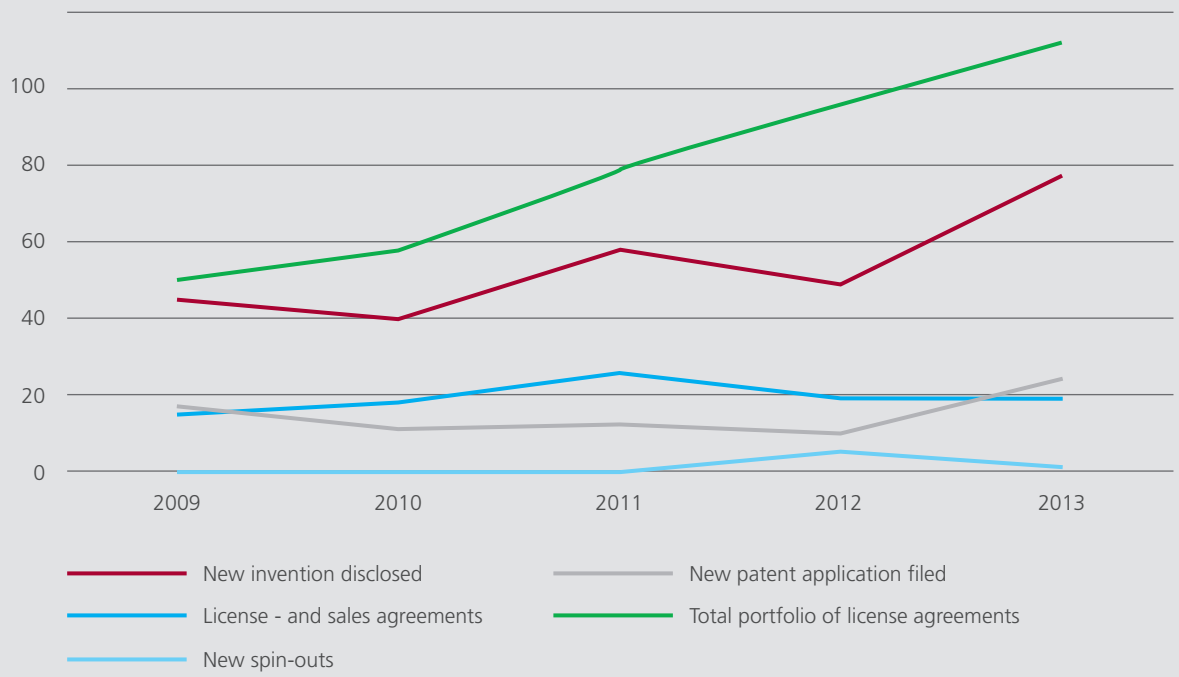
FIGURE 1. COMMERCIALIZATION STATICS, UNIVERSITY OF COPENHAGEN 2009-2013



7
Conflicts of interest

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* The authors would like to thank thank Peter Sandøe for his contributions to the content of this chapter.

Summary

Scientists are driven by many interests, ranging from the goal of doing good science to financial incentives, personal commitments, and career development and the pressure to publish. When these interests compete with each other, pointing towards different actions or decisions, the scientist may have a 'conflict of interest'. This chapter begins by looking at how 'conflict of interest' is defined in documents relevant to academic research. It then outlines possible consequences of conflicts of interest and asks how we can decide when conflicts of interest require a response. In the light of the rules and guidelines that apply, we go on to discuss how we can evaluate and manage conflicts of interest, and how this relates to young researchers' work.

The chapter lays out four main kinds of response to conflicts of interest: managing the potential consequences via disclosure, reducing financial conflicts of interest via formal restrictions, eliminating conflicts of interest via 'recusal', and adopting an open and reflective attitude to the existence of conflicts of interest and their possible effects.

Key take-home points include the following: conflicts of interest are widespread and often inevitable, but they do not always lead to improper conduct. Conflicts of interest need to be managed in order to protect both the integrity of scientific research and trust in science.

1. Introduction

Scientists do science for many reasons. Many are driven by curiosity, by a desire to advance our understanding of the natural world or its human inhabitants. For many scientists the quest for knowledge is also associated with a desire to improve the world, either directly through applied research or indirectly by contributing to 'blue skies' knowledge that may have practical applications in the future. But scientists also want to get paid at the end of the month, be recognized by their peers, pursue promotions and secure permanent employment, support their students, and obtain funding for their next project. They might also have personal interests in scientific questions such as the cause or treatment of a particular disease, and many would admit to a competitive streak – the rewards of being recognized in your field and in the public domain can be great, and can inspire great work. Thus science does not only consist in the intellectual work of designing, conducting, analyzing, and publishing experiments – being a scientist is a profession, embedded in the ordinary world of jobs, salaries and career prospects. Like other professionals, scientists pursue a great variety of interests and sometimes different interests clash with one another. For example, trying to be an independent scientist of unimpeachable integrity can sometimes conflict with the need to take into account the opinions and approval of funders. Clearly, where scientists' eagerness to please funders leads them to distort their findings, they are committing research misconduct. It is important to recognize, however, that having a conflict of interest does not *in itself* constitute misconduct. Nor do conflicts of interest always lead to improper conduct.

Conflicts of interest are thus all around us, and not just in high profile cases where a (typically financial) conflict of interest is cited to explain research misconduct. Conflicts of interest are also increasingly inevitable in today's scientific environment, where competition is intense and academic institutions are strongly encouraged to work with private and industry funders (see Chapter 4).

In this chapter we discuss how conflicts of interests can be defined, recognized, evaluated, and managed. As with many of the topics in this book, it is easier to state general principles than it is to apply them in practice. We therefore use fictional case studies to make abstract definitions and principles a little more concrete, and to explore grey areas. There is no one definitive document on conflicts of interest, but we discuss key local, national, and international guidelines. We also include some simple practical tools to help readers think through conflicts of interest in their own scientific lives.

2. What is a conflict of interest?

Some important definitions of a conflict of interest are given in Box 1.

BOX 1: DEFINITIONS OF CONFLICT OF INTEREST

1) According to the Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014), a conflict of interest is "a situation in which financial or other interests have the potential to compromise or bias professional judgment." (p.15)
2) According to Thompson, writing in the *New England Journal of Medicine* in 1993, a conflict of interest is "a set of conditions in which professional judgment concerning a primary interest (such as patients' welfare or the validity of research) tends to be unduly influenced by a secondary interest (such as financial gain)." (p.573)
3) According to MacDonald et al., writing in the *Journal of Business Ethics* in 2002, "We can define a conflict of interest as a situation in which a person has a private or personal interest sufficient to appear to influence the objective exercise of his or her official duties as, say, a public official, an employee, or a professional" (p.68)

These definitions all refer to the idea of a primary, professional, or official duty to act, or exercise judgment. However, it is not easy to define a single, primary interest for scientists – they have many different professional duties, and different scientists would probably pick different duties as the most important. For example, referring to Thompson's definition, a medical researcher might have both patient welfare and the validity of research as 'primary' interests. For the purposes of this book, we state broadly that the professional duty of a scientist is to advance scientific knowledge through accurate reporting of findings and valid scientific reasoning as defined by principles of good scientific practice. However, as should be clear to readers of this book, what exactly that means is continually debated, and this leaves room for interpretation of when exactly good scientific practice is compromised by other interests.

What kinds of interest or commitment could come into conflict with a scientist's primary professional duty? Common examples include:

- Personal financial gain (e.g. increased salary; increased value of personal investments in companies related to the research)
- Professional financial gain (e.g. funding for current or future research projects)
- Alternative professional commitments (e.g. commitments to a spin-off company)
- Career interests (e.g. achieving tenure)
- Professional relations (e.g. supporting students' or collaborators' careers)
- Personal relations (e.g. helping a friend)
- Religious, moral or political commitments (e.g. honouring a religious position by avoiding stem cell research; suppressing data on climate change until after a key convention of a political party with a sceptical agenda)

Among the diverse array of conflicts of interest, *financial* conflicts of interest have received particular attention – they are considered highly likely to influence a scientist's actions. We therefore consider them in a little more detail here.

Personally, scientists can have interests in direct financial gain – e.g. through stock ownership, consultancy work, spin-off companies, secondary employment, and so on. If returns on investment or payments are dependent on the results of the scientist's own research, there is a clear conflict of interest. There have been several studies showing correlations between financial investment and the results of research (see e.g. Bekelman et al., 2003; Ridker & Torres, 2006; Lesser et al., 2007; all cited in Goozner et al., 2008).

Outside of direct personal financial gain, scientists are continually faced with the challenge of securing funding, and the results they obtain can have a more or less direct influence on their chances of success. If a private sponsor has an interest in a particular result, the conflict of interest is very clear. But even if the research is paid for by a source that has no interest in the *direction* of the results, getting *some* results – and preferably important and novel ones – may well influence the likelihood that the scientist will obtain further grants. Even

less directly, all scientists have an interest in ensuring that political processes and public opinion favour the future supply of funding. Naturally, these pressures can affect decisions about such matters as how to target research resources and publications.

Box 2 contains three fictional cases illustrating different kinds of interest and how they might conflict in determining a scientist's actions. We will return to these examples throughout the chapter, and consider the consequences they might have and how these can be managed. For now, see if you in one sentence can summarize which interests or duties conflict for each case.

As the three examples in Box 2 show, conflicts of interest are highly diverse. They range from professional and financial interests to personal or moral commitments, including the drive for collegial respect (John), financial security (Anjali) or job security for one's colleagues (Lone).

To bring some order to this diversity, it is useful to clarify some of the key features of conflicts of interest:

- First, conflicts of interest span the entire research process, not just the results stage. They might arise when a scientist is conceptualizing and designing experiments; performing data collection, modelling, or analysis; preparing and publishing articles; or presenting results and their implications in professional and public forums. They can also arise in relation to the many other functions that a scientist performs, from acting as an expert reviewer to training and teaching students, contributing to decisions regarding recruitment and funding, and so on.
- Second, conflicts of interest are not just about the individual's self-interest. Many are about commitments to others, or duties to a group or collective such as a lab, a research field, or even to the wider society.
- Third, it is important to note that 'good science' can itself involve interests that point in different directions, leading to internal disagreement within the scientific community about where the boundaries of 'good conduct' lie. For instance, it is often unclear when the aim to publish results quickly in order to advance the progress of science trumps other aims such as ensuring that results are as solid as possible before publication.

BOX 2: EXAMPLE CASES

1) John, a final year PhD student, is eager to achieve recognition from his colleagues and maximize his chances of getting a good postdoctoral position. He has been advised by his supervisor that the one thing missing from his CV is a publication in a high impact factor journal. John has collected data suggesting that a hypothesis commonly accepted in his field is false – the kind of result likely to catch the attention of *Nature* or *Science*. However, there are a few data points that prevent the relevant comparison from reaching statistical significance, and John wonders if collecting more data would allow him to conclude that these data points are statistical outliers.
2) Anjali, who is a postdoc, is in a team of three researchers being paid to estimate the impact that building a new bridge would have on the local fauna. The results will help determine exactly where the bridge will be placed. Anjali and her partner own a summerhouse on the beach close to where the bridge may be placed, and very much hope that the bridge will be placed elsewhere, as it will decrease the value of their property. Anjali will be involved in making observations that cannot be fully automated and quantified.
3) Lone, an assistant professor, is part of a research group that receives a significant share of its funding from a large Danish medical company. They are currently testing one of the company's promising new drugs for diabetes. Their preliminary data indicate that the drug may have unforeseen side-effects that could significantly delay its market introduction. Lone worries that the company may discontinue the funding they have provided so far, which could lead to staff cuts in Lone's research group. Lone is the only one who has seen the preliminary data.

3. The consequences of conflicts of interest

Thompson's (1993) definition in Box 1 describes a conflict of interest as a set of conditions that *tend* to influence scientists to act against their primary duties – as we have seen, the existence of a conflict of interest does not in itself constitute, or necessarily lead to, misconduct. So when should we worry? If there is nothing inherently wrong with scientists being motivated both by their professional duties and their personal interests (Steneck, 2007; p.68), how do we know when this *is* a problem? Deciding when conflicts of interest are problematic requires us to consider both the potential severity of the consequences, and the likelihood of them occurring. We can then consider how to manage or eliminate conflicts of interest deemed to be problematic (see Section 4).

3.1 Conflicts of interest can lead scientists away from responsible research conduct

The most serious problems arise when scientists resolve the conflict between different interests in a way that departs from their professional duty to produce valid research. As mentioned above, many studies have shown correlations between authors' financial conflicts of interest and the outcomes of research. However, as earlier chapters have explored, there are more or less serious ways in which scientists may diverge from responsible research conduct. Thus, problematic consequences of conflicts of interest might range from relatively minor issues, such as sitting on data a little too long or letting the interest of a funder influence the direction of one's research, to forms of research misconduct such as fabrication or ethical violations.

To return to our cases (see Box 2), John's conflict of interest might lead him to discard the outliers in order to make the finding statistically significant, which would clearly constitute research misconduct. But he might also decide to run another experiment to see if that changes the conclusion, which could fall into a grey area.

If Lone hid data on dangerous side-effects to protect her research staff she could be charged with misconduct, but if the side-effects were not serious and she sat on the data just long enough for her staff's contracts to be renewed, an evaluator may decide that her actions stopped short of research misconduct.

Scientists whose decisions, judgments, or actions are biased away from responsible research conduct by a conflict of interest may not be consciously aware of the bias. For instance, in collecting and analyzing qualitative observations of the local wildlife Anjali might overstate the expected negative impacts of the bridge without realizing she is doing so. If Anjali was later accused of misconduct, whether she had *intentionally* biased the data would be an important question for an evaluator to consider. And even if they concluded that she had no intention to misrepresent, she would still have the duty to declare her conflict of interests (see Sections 4.1 and 4.3) or even remove or (in the technical jargon used here) 'recuse' herself from the project (see Section 4.4).

3.2 Conflicts of interest can undermine trust in science

In Box 1, MacDonald et al. (2002) state that a conflict of interest exists when a competing interest is sufficient to "appear to" influence a professional's ability to exercise official duties, highlighting the importance of appearance. Even if Anjali was *not* influenced by her conflict of interest, if she failed to disclose it and a newspaper picked up on the story, it could damage both official and public trust in the results of the study and the reputation of the researchers.

Across many parts of contemporary society, science has a special status as a source of knowledge about the world. Humanities and social science scholars have long questioned and investigated the degree to which science provides impartial, objective, and trustworthy knowledge (see Box 3), but it is widely believed that science tells us how things are rather than how someone wants to present them as being. This gives scientific results significant weight in relation to important societal decisions, as well as justifying the financial prioritization of scientific organizations and projects, and investment in applications and technologies based on scientific knowledge.

For science to maintain its status it is crucial to maintain or improve public trust, and nurture the belief that scientists

generally act responsibly and produce valid research (see more on the issue of public trust in science in Chapter 8). But conflicts of interest can undermine that very belief. The consequences can be local, as when an individual scientist is discredited. But they can also be more far-reaching. For example, if many studies of climate change were found to involve conflicts of interest, this could damage perceptions of the entire field and its ability to inform important societal decisions. This raises the question of whether conflicts of interest always should be made public (an issue we return to in Section 4).

3.3 When are conflicts of interest significant enough to require a response?

Above we have explored potential negative consequences of conflicts of interest for research integrity (Section 3.1) and for trust in science (Section 3.2). What this does not tell us is how to judge the likelihood and severity of these negative consequences. Or in other words, whether a conflict of interest is 'significant' enough to demand a response. Three considerations help to answer this question:

1) *Contextual requirements*: In some cases, there will be rules or guidelines that tell you whether a conflict of interest is serious enough to require that you respond to it, and how to respond (see below). There may also be local traditions or rules set down your employer. PhD students employed by the University of Copenhagen can read about conflicts of interest in University of Copenhagen (n.d.)
2) *Your personal judgment*: There are bound to be conflicts of interest that are not covered by rules or guidelines, or cases where it is not 100% clear how to apply the rules. Here, honest reflection on whether a conflict of interest is likely to influence you is crucial, and personal judgment can be cultivated over time, through private reflection and discussion with others.
3) *The judgment of others*: Colleagues, supervisors, the 'Named Person' at your faculty (see also Chapter 3), and professional independent advisors can all give useful advice on whether a conflict of interest is significant enough to require a response. This can also be a useful way of working out whether the mere appearance of conflict of interest would be damaging – how likely is it that others will suspect you have been unduly influenced?

BOX 3: THE NATURE OF SCIENCE

It is important to acknowledge that the idea of science as a source of totally impartial and objective knowledge is a simplification. What kind of knowledge is produced by scientific research is a central topic for philosophers, sociologists, ethicists, and historians of science, as is the degree to which scientific practice is influenced by social contexts, and the ways in which scientific knowledge does and should influence social and political decisions. Setting aside the more abstract philosophical discussions that can seem far away from the scientist's everyday work, many scientists themselves would acknowledge that the processes through which research is funded, how that research is then designed, and how the results are applied and understood, are rarely wholly impartial or objective.

These topics are dealt with in theory of science courses (good introductions can be found in Andersen et al., 2006 and Chalmers, 1999). But thinking about conflicts of interest reminds us that philosophical and sociological questions about scientific knowledge are partly about the concrete reality of scientific practice; the ways in which the world outside the lab is entangled with the work that goes on within it. This doesn't imply that scientists should continually challenge the norms, methods, and ethos of their research field – rather, sometimes reflecting on the social contexts of science can help illuminate the boundaries between bad methodology, research misconduct, and the inevitable shaping of research by its context.

4. How to handle conflicts of interest

In this section we consider what should be done when you, your colleagues, or the institution at which you are conducting your research decide that a conflict of interest demands a response. Responses range from managing potential consequences of conflicts of interest via disclosure (4.1) or discussion (4.2), to reducing them through financial restrictions (4.3) or eliminating them through recusal (4.4). This topic is also discussed (with a focus on US rules and legislation) in the US Office for Research Integrity (ORI) Introduction to the Responsible Conduct of Research (Steneck, 2007). Box 4 provides an excerpt from the Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014; p.15), stating the current position for researchers working in Denmark. Note that the Code focuses not only on what should be done, but also on whose responsibility it is to do so.

BOX 4: THE DANISH CODE OF CONDUCT FOR RESEARCH INTEGRITY (MINISTRY OF HIGHER EDUCATION AND SCIENCE, 2014) – EXCERPT ON CONFLICTS OF INTEREST

6.1. Responsibilities

i. All parties involved with the research in question should disclose any conflicts of interest.

ii. Assessors of research and research proposals (e.g. editors, reviewers, research councils, etc.) who have a conflict of interest should withdraw from any involvement in the process.

iii. All parties involved with the research in question have a joint responsibility for handling issues relating to conflicts of interest.

6.2. Division of responsibilities

i. **Researchers** are responsible for disclosing all conflicts of interest related to the research they are involved with.

ii. **Institutions** are responsible for addressing conflicts of interest, and for ensuring that all conflicts of interest are handled adequately. In this context **institutions** should have a policy for handling conflicts of interest, which includes information on:

a. Situations that constitute a conflict of interest

b. Disclosure of conflicts of interest, including how to handle confidentiality issues

4.1 Disclosure: Declaring conflicts of interest

The excerpt from the Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014) in Box 4 states that the main responsibility of researchers is to always disclose any conflicts of interest[7] and to withdraw from assessment processes when they doubt their ability to act impartially. It is primarily the responsibility of the various relevant institutions (e.g. universities, research institutes, journals) to *handle* conflicts of interest, although the code also emphasizes that 'all parties involved' have a 'joint responsibility'. For employees at the University of Copenhagen, the rules on external activities that might constitute conflicts of interest can be found on the intranet (University of Copenhagen, 2016).

The form of disclosure young researchers are most likely to have encountered is being asked by a journal to declare conflicts of interest when submitting a paper for publication. This is just one, albeit a key, way of stating your conflicts of interest in a public forum. The basic rationale behind disclosure is transparency: it should be left to the reader to judge whether the results appear trustworthy or unduly influenced by conflicting interests. As stated in the Vancouver Recommendations:

"Public trust in the scientific process and the credibility of published articles depend in part on how transparently conflicts of interest are handled during the planning, implementation, writing, peer review, editing, and publication

7 As discussed in Section 3.3 there are some conflicts of interest that are so small, or so generic to being a scientist, that they may be taken to lie outside of this protocol. In other words, in our terminology the code should be understood as reading 'any potentially significant conflicts of interest'.

of scientific work." (International Committee of Medical Journal Editors, 2013, p.3)

As we saw above (3.2), transparency is widely believed to promote public trust in science. If scientists lay their conflicts of interest on the table, the argument goes, they will be perceived as more trustworthy and will avoid the damage to trust that can result when an undeclared conflict of interest is later discovered.

But can we say for certain that openness about conflicts of interest always promotes public trust in science? Probably not. Raised public awareness of such conflicts may instead backfire and undermine the perception of science as an objective, trustworthy source of knowledge. Simple insistence on disclosure may also have the unintended consequence that scientists feel they have 'done enough' by disclosing a conflict of interest and do not consider its potential effects. Such uncertainties surrounding the effects of disclosure are reflected in the diversity of journal policies that exist (Goozner et al., 2008; Krimsky & Rotherbuerg, 2001). They are also regularly debated in journal editorials (e.g. Stossel and Lee, 2008). Regardless of your own opinion on these questions, you should of course check and carefully follow any policies on disclosure that apply to you and your work, particularly when submitting papers for publication.

In spite of the contested effects of disclosure on scientists' behaviour and public trust, transparency remains valuable. Letting your stakeholders – be they peers, funders, editors, patients, journalists, or other readers of your publications – know about your conflicts of interest is a way of respecting their ability to form their own judgments. It gives them the opportunity to judge whether the conflicts are insignificant, or warrant more detailed investigation of your work, or in their opinion, may disqualify you from participating in the research or academic activity in question. Disclosure also communicates your awareness of the existence and potential consequences of conflicts of interest, and it helps to share the responsibility for evaluating and monitoring conflicts of interest across the scientific community.

Journals are not the only place where you can disclose conflicts of interest. Researchers can choose to list their conflicts of interest online, for employees of the University of Copenhagen this can be done through the research information system CURIS (see University of Copenhagen, 2016), or in places where particular stakeholder groups will be able to access them: for example, in the case described in Box 2, Anjali's research team could have posted a conflict of interest statement on a local community website. It is important to consider whether your disclosure is easy to find: having a list of your conflicts of interest in a PDF on a subpage to your personal webpage on a university website may make the information available in principle, but no one is ever likely to see it. On the other hand, if you want to make a public disclosure, it is also important to check with your supervisor or legal office whether there any restrictions on whether and how you do so. Of course, some interests do not require disclosure, particularly those are just a part of being a scientist in today's world (e.g. see John's case in Box 2).

BOX 5: RULES OF THUMB FOR DISCLOSURE

- If you are uncertain whether an interest that you have presents a conflict, disclose it clearly. The Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014) requires all parties to disclose "any conflicts of interest".
- Deciding whether a financial conflict of interest is significant can be tricky. Journals may have clear guidelines on what should be disclosed, but otherwise the guidance is not entirely clear. A good rule of thumb is that you should disclose all interests except those that are so small or unrelated to your work that you cannot imagine anyone else (including a journalist) thinking they are relevant.
- In most circumstances, interests that apply to all scientists, such as the pressure to publish or obtain funding, need not be disclosed.

4.2 A Culture of reflection: Discussing conflicts of interest with colleagues

If you identify a potentially significant conflict of interest for you or your research group, try to find a way to bring it up with your colleagues, including your supervisor if possible. Ask colleagues: Do they agree that a conflict of interest exists, and could it threaten good scientific practice? How might the conflict of interest cause suspicion of undue influence? Does anyone see a straightforward way to eliminate the conflict or does it arise from elements of your situation that cannot easily be changed? Who else could be called in to assist or advise?

Preliminary discussions help to ensure that action is taken quickly – but they also give those involved a chance to respond and potentially correct misunderstandings before official procedures are brought into play or accusations are made. If official rules or guidelines cover the situation, open, preliminary discussions will also help to ensure that they are applied quickly and effectively. Where there are no clear rules, or where the potential consequences lie in the grey zone of questionable research practice, discussion with colleagues becomes even more advisable and will be a key way in which you can improve your own judgement (see also 3.3). In general, the habit of discussing the many competing interests that scientists deal with is a good one: it can help to raise awareness, empower people to raise specific cases, and potentially reduce the risk that conflicts of interest will have negative consequences.

To return to the case studies in Box 2, if conflicts of interest were regularly discussed in John's lab, his supervisor may have talked to him about the pressures that the need to get a high profile publication places on PhD students, preparing John to better handle his doubts. Or for Lone, if the research team had from the outset of the project discussed conflicts that might arise if preliminary findings failed to show what the funder hoped, others in the team might have been prepared to ask about the results and share the burden of deciding on next steps.

4.3 Restrictions on financial interests

As described in Section 2, financial conflicts of interest are considered highly likely to influence a scientist's ability to perform their primary duty and also to damage public trust in science. They therefore receive particular attention and need to be managed with care. Personal financial interests are sometimes managed by restricting the amount of money a scientist can invest in companies connected with their research, the amount of money they can make 'on the side', or the intellectual and financial ownership of research results (see also Chapter 6). But who sets these restrictions varies – there are both national guidelines and institutional frameworks, and researchers involved in international collaborations need to take particular care to check that they are satisfying all relevant guidelines. The University of Copenhagen's code of good scientific practice with regard to external partners can be found on the website for the Practice Committee at the University of Copenhagen (2016).

Professional financial interests, such as the need to obtain good, important or even specific results to satisfy funders or improve a scientist's chances of obtaining more funding, are less easily managed. Indeed, to some degree these pressures are ubiquitous. As John and Lone's case studies both show (Box 2), pressure to secure future financial support or employment can easily affect decisions about when and how to share results. In neither case is the *existence* of the conflict of interest something that could be eliminated – rather, in cases like these researchers must often rely on other modes of management such as discussion and reflection (4.2) and disclosure (4.1).

4.4 Recusal

The Danish Public Administration Act (Justitsministeriet, 2004) applies to all employees at the University of Copenhagen. It is a fundamental principle of this act that public employees must be impartial when they contribute to decisions on, for example, who should receive funding or be employed, taking only professionally relevant considerations into account. Where an employee has a conflict of interest – e.g. if a close colleague is on the shortlist for a job or grant – they are deemed ineligible and must step back or 'recuse' themselves from taking part (see also The European Code of Conduct for Research Integrity ALLEA, 2017; p.7). In practice, it can sometimes be difficult to find candidates

for membership of an evaluation or hiring committee with *no* conflicts of interest, particularly in small research fields (Justitsministeriet, 2014; §4). Other situations that may require recusal include certain types of additional or external employment, when these are deemed likely to interfere with an employee's main duties (for KU employees, see University of Copenhagen, 2016).

'Recusal' is a tool that can also be usefully applied to situations not covered by employment legislation, and indeed to any situation where a conflict of interest is considered highly likely to cause an actual or perceived bias in research. In the case studies in Box 2, Anjali could have decided to remove herself from the project, or at least to step back from any part of data collection and analysis where her private interest in the result could bias her work.

It is very important for PhD students trying to decide whether to eliminate a particular conflict of interest via recusal to get advice. You can discuss the matter with colleagues, your supervisor, with the faculty's Named Person, and, where relevant, with key stakeholders. In difficult cases, any decisions about the participation of individual researchers will ideally be taken by someone suitably qualified who is not involved in the relevant research project (Steneck, 2007; 78).

BOX 6: PRACTICAL TIP

Keep a record of the conflicts of interest you consider yourself to have, and of any financial interests outside of your primary employment, and update it regularly. A simple list saved on your computer will suffice.

This is a good way to stay aware of the issues surrounding conflicts of interest, and how they may be affecting you, and it can be a useful reference in any discussions with your supervisor about, say, publication schedules. A regularly updated list can also make it quicker and easier to prepare full replies if you are asked about conflicts of interest (e.g. by a journal or a funding agency). See Australian Code for the Responsible Conduct of Research, Section 7.2.1 (Australian Government, 2007).

5. Test yourself questions

- What is a conflict of interest, and what kinds of conflict of interest do you think are most relevant to PhD students?
- How can conflicts of interest be damaging to science or scientists?
- How can you determine which conflicts of interest are significant enough to require action to manage them (e.g. via disclosure or recusal)?
- Do you think scientists should disclose all conflicts of interest? Why, or why not?
- Describe three types of conflict of interest that scientists in Denmark often face, what the potential consequences might be, and how they could be managed or eliminated.
- Which conflicts of interest do you currently have, and what consequences could they potentially have for your scientific conduct if they are not managed correctly?
- For each of the three cases in Box 2, say what action you think the researcher should take.

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8
Public science communication

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Summary

This chapter examines the role of public science communication in responsible conduct of research. The chapter begins by asking what public science communication is (Section 1). It then explains why public science communication is integral to responsible conduct (Section 2), discusses various reasons for communicating (Section 3), asks whose responsibility it is to communicate (Section 4), and points to key factors in doing communication responsibly (Section 5). Responsible science communication is not just a matter of explaining scientific results in an accurate and balanced way. Communicating how science *works*, including the uncertainty that accompanies research findings, is crucial if we are serious about inviting public audiences to take part in conversations about scientific research and what it means for society. It is also crucial for researchers to be clear about their motives in communicating, and consider how these may differ from those of media professionals and the publics they communicate with. The diverse media available today – from social media to public lectures and participatory public events – make it easier than ever before to engage people in research, and allow researchers at every stage of their careers to participate. However, researchers still need to reflect carefully on when and how it is appropriate to communicate their own research, and about how they present themselves, their institution, and their expertise. The chapter reflects mainly on why, how, and when to communicate, but practical tips and links to further guidance are also included.

1. What is public science communication?

Before we start discussing public science communication as part of the responsible conduct of research (RCR), we will step back for a moment and ask what it refers to. One of the most prominent forms of science communication is reporting by journalists, including specialist science journalists such as Lone Frank in Denmark or Matt Ridley in the UK. Giving

BOX 1: A DIVERSITY OF MEDIA FORMS FOR SCIENCE COMMUNICATION

- Newspapers, news websites and news programmes, often featuring prominent scientists. Scientists on the news sometimes talk about their own research, but often comment on news stories related to their broader expertise. For example, a political scientist commenting on elections or a plant geneticist commenting on protests about GM crops.
- Science magazines, e.g., *Wired, Discover, New Scientist.*
- Popular science books, e.g., those by Richard Dawkins, Ben Goldacre, and Stephen Hawking.
- Documentary films and radio programmes, e.g., RadioLab (www.radiolab.org), Material World on BBC Radio 4 (www.bbc.co.uk/programmes/b006qyyb), or Hjernekassen on DR (www.dr.dk/p1/hjernekassen-pa-p1).
- Online videos produced by scientists, both serious and for fun.
- Live webcasts of public talks, e.g., TED talks (www.ted.com/topics/science).
- Social media including blogs, Twitter, Facebook, Q&A sites, e.g., Science Blogs aggregator (www.scienceblogs.com), Reddit Science (www.reddit.com/r/Science).
- Museums and science centres, e.g., University of Copenhagen museums such as Medical Museion (www.museion.ku.dk).
- Science fiction or novels with scientific or biomedical themes, e.g., *Frankenstein* by Mary Shelley, *Saturday* by Ian McEwan.
- Cafe Scientifique, public lecture and discussion groups, e.g., Science & Cocktails in Copenhagen (www.scienceandcocktails.org).
- Science festivals, e.g., 24 hours, Golden Days, ESOF public programmes.
- Guerilla Science (http://guerillascience.org/).
- Science comedy, choirs, and club nights, e.g., Copenhagen Science Slam (www.facebook.com/cph.science.slam).
- Theatre productions, e.g., Videnskabsteatret (www.videnskabsteatret.dk).
- Consensus conferences and political consultation, e.g. GM Nation (www.gmnation.org.uk).

an interview to a journalist can be a highly effective way for a scientist to communicate their research or to enrich news coverage with expert commentary, but there are also many other possibilities. Different media facilitate different communication goals – e.g. social media and public events can allow researchers to come into more direct contact with publics[8] and allow publics to get more actively involved.

This chapter will take a broad perspective on forms of public science communication. Box 1 lists different communication media with examples, and Box 2 gives case studies of scientists who do public communication. Both demonstrate the diversity of media available, and Box 2 also demonstrates the diversity of roles scientists can play – from writing personal blogs about their daily work, to being interviewed for TV, speaking at public events, and appearing on radio shows.

8 In the science communication research literature, rather than write about 'the public' scholars often write about 'publics' in the plural. This recognizes that there is not one homogenous public. Rather, there are groups with different attitudes, knowledge, and interests in scientific research. Many of these heterogeneous 'publics' (e.g. patient organisations) have significant if non-traditional forms of expertise.

For more examples, the University of Copenhagen's online newspaper *Universitetsavisen* published a series of articles in 2014 about the university researchers with the most media mentions (Zieler, 2014).

When thinking about public science communication, it is worth recognizing that many of the issues overlap with those of internal scientific communication. A peer-reviewed journal article can seem worlds apart from an article in a tabloid newspaper. However, both involve selecting what to include and in how much detail, and deciding whose perspectives are presented. Even when producing a peer-reviewed article, scientists inevitably omit a lot of what actually happened in the lab – such as failed experiments, changes in methodology, or alternative explanations of the findings. And unless publishing in a highly specialized or high profile journal, authors are often communicating to scientists from different fields and so have to simplify or explain technical terms. Whilst a lot *more* detail is omitted for a non-scientific audience, the job of translating from one 'language' to another is fundamentally the same. Gregory and Miller (1998, p.245) write:

BOX 2: CASE STUDIES OF SCIENTISTS DOING PUBLIC SCIENCE COMMUNICATION

1) Anja Cessi Andersen is a Professor of Astrophysics at the University of Copenhagen and does a lot of public outreach, particularly interviews for television and radio and at public events (Andersen, 2011). By speaking at length, she can often deliver her message in her own voice, rather than always being filtered through a journalist's lens.
2) Ben Goldacre is a British doctor and epidemiologist who often comments on news stories and writes a newspaper column and blog called 'Bad Science' (Goldacre, 2017) which exposes flaws in biomedical research and in media reports of research. In doing this, he communicates how epidemiological studies work methodologically, aiming to equip his readers better to evaluate other reports of clinical research in the future. You can also find Ben Goldacre on YouTube giving talks at public events such as TED and on Twitter as @bengoldacre.
3) Microbiologist Dr Rosie Redfield writes an 'open science' blog reporting the daily work in her laboratory at the University of British Columbia (Redfield, 2017). After reading a paper in Science claiming that a bacteria had been discovered that could live on arsenic rather than oxygen, Redfield was sceptical and repeated the experiment, failing to replicate the results. She reported the results on her blog, which was picked up by the scientific community and popular media, contributing to a retraction of the original study (Wolinsky, 2011).

"Scientists take for granted that the scientific paper is not literally true: it is not a blow-by-blow account … But the scientific paper is truthful even though it is written according to a formula which deliberately distorts the literal truth in order to make the research accessible to other scientists. So popular accounts of science should not be viewed as somehow 'untrue', merely because they, too, have to leave out a lot and simplify what they include to match the expectations and abilities of their audiences"

Bucchi (2004) argues that we should therefore think of science communication as a continuum with highly technical scientific publications at one end and popular media at the other – in-between lie media such as science magazines, textbooks and detailed documentaries. Thinking in terms of a continuum also highlights the fact that the boundary between popular and scientific communication is far from clear-cut, and reminds us that scientists consume popular media too.

2. Public science communication as part of the responsible conduct of research

In recent years, governments, universities, and funders have placed more pressure on scientists to do public science communication – or, in other words, to engage more closely with the society that supports and will be affected by their work. Indeed, societal impact is now generally seen as the third arm of the modern university, alongside research and teaching.

In Denmark, the University Law (Uddannelses- og Forskningsministeriet, 2015) and the Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014) both reinforce the message that communication and participation in public debate are central to good scientific conduct (see also Doubleday, 2009; Pickersgill, 2011; Meyer & Sandøe, 2012). However, courses and textbooks on RCR or research ethics rarely cover science

BOX 3: THE RESPONSIBILITY OF THE UNIVERSITY TO COMMUNICATE IN PUBLIC

1) Danish University Law (Uddannelses- og Forskningsministeriet, 2015), Chapter 1, Paragraph 2, Section 3 (translated by Jeppe Berggreen Høj):

   "The University must as a central knowledge and culture bearing institution exchange ideas and competences with the surrounding society and encourage employees to participate in the public debate."

2) Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014):

   "Publication and communication are essential for enabling the research community to scrutinize and discuss research results. Thus, researchers have a right and an obligation to publish and communicate their results to the research community, to professional practitioners, and to society at large. Research can be communicated through various channels ranging from strictly professional contexts aimed at peers to more popular research communication aimed at a broader audience.
   Although form, expression and level of detail may differ according to channels employed and audiences addressed, the standards for responsible conduct of research should always be respected when communicating research."

3) Excerpt from 'The Engaged University: A Manifesto for Public Engagement' (National Coordinating Centre for Public Engagement, 2010):

   "Twenty-first century universities make a huge contribution to the life and success of the nation –through their teaching, their research, their students and their relationships with other organizations. In recent years, with government encouragement, universities have worked hard to strengthen their mutually beneficial links with the local and regional economy and business community. Now there is increasing recognition that higher education institutions can play an equally vital role in the UK's community, intellectual and cultural life through their engagement with the public. It is a role that enables institutions not only to rediscover their roots as active contributors to positive social change but also to gain practical benefits of lasting value."

communication. This leaves researchers with little guidance on why they might want to communicate, when they have a responsibility to do so, and how to communicate responsibly (Meyer and Sandøe, 2012). The present chapter addresses this gap, focusing on early stage researchers.

One of the key norms of scientific research is that the knowledge it produces should be shared openly within the scientific community. This helps knowledge to advance by avoiding unnecessary repetition of experiments and opening research up to peer scrutiny. It also allows potential applications of basic research to be explored as early and efficiently as possible. In his 1942 sociological study of the principles under which scientific institutions operate, Robert Merton describes openness or 'communalism' as one of four central norms; the idea that scientists should feel a sense of common ownership of the products of science (Merton, 1973 [1942]). Contemporary formulations based on Merton's work (e.g. Ziman, 2000) still include communalism, and whilst scientists often keep new results or novel techniques under wraps until they are published, the importance of publication in scientists' lives indicates how central a principle communalism still is.

Meyer and Sandøe (2012) argue that this principle of openness should extend further, encompassing not just scientific publications read by other scientists but also communication via popular media. Or in other words, common ownership of research results should include those outside scientific institutions. If we fail to share research in public, we leave people unequipped to deal with scientific controversies when they arise and exclude them from discussions about the future of research. Openness between scientists and publics can also help to facilitate the progress of research. For example, the translation of research into real world applications can be improved when the people who will use those applications are involved from an early stage. It is also worth noting that as science becomes ever more interdisciplinary and international, popular media are an important route for scientists themselves to learn about each other's work and thus focus their efforts most efficiently (Research Councils UK, n.d.).

3. Benefits of public science communication

Public science communication is an integral part of RCR (see Section 2) because it comes with potential benefits on societal, institutional and personal levels. This section breaks down these three levels in order to give a fuller picture of the roles science communication can play, and to encourage readers to reflect on which potential benefits might motivate their own communication. As discussed further in Section 5.1, being clear about your reasons for communicating is key to doing it both responsibly and well.[9]

3.1 Benefits to society

- *Democratic imperative*: Publicly funded research institutions rely on taxes, and should communicate with taxpayers about how their money is spent. Even privately funded institutions rely indirectly on the infrastructure of a tax-funded democratic society. Setting aside economic arguments, research institutions produce knowledge that aims to affect society for the better. As such, they should arguably involve those who will be affected – though to what degree is a matter of ongoing debate (see e.g. Irwin, 2009; Bultitude, 2011).
- *Scientific citizenship*: If citizens are expected to engage with research and join in debates, they arguably need to know something about science and how it works. *What* exactly they should know is a matter of controversy – is it more useful for citizens to know scientific facts, understand methodologies, appreciate the social and economic contexts of research, or ponder the philosophical implications? (Gregory & Miller, 1998; Bell, 2010). Scientists can span these domains of knowledge, offering not just clear explanations of research findings, but also

9 Note that this section focuses on the motives of scientists and their institutions. Media producers – ranging from professional journalists to bloggers, artists, and museum curators – might have other motives for communicating, not least fascination, aesthetics, and entertainment.

offering an inside view on the processes, uncertainties, and implications of research.

- *National prestige and economics*: The televised moon landing of 1969 was in part a celebration of the scientific and technological advances that allowed it to happen. As TV viewers around the world watched Neil Armstrong's 'giant leap for mankind' they were also taking in a message about US power and prestige (Gregory & Miller, 1998; p.13). International EXPOs and science and technology fairs are also examples of how communicating research on the international stage enhances a country's reputation, which can then attract future talent and investment in research (Gregory & Miller, 1998, ch.8).
- *Improved research translation*: Research institutions are increasingly asked to translate their research into practical (and profitable) applications. User research is an important part of this process and involves communicating about science with non-experts. In a wider sense, the more that research is part of public culture, and the more that scientists listen to public responses, the stronger basis there will be for designing applications in a way that will be both effective and socially acceptable (Stilgoe, Irwin, & Jones, 2006; Wilsdon & Willis, 2004).
- *Shared culture*: It has also been argued that science is part of a shared heritage and as such should be a widely accessible part of our culture, independently of educational goals (Bultitude, 2011). Similar arguments are sometimes made for other cultural domains such as classical music.
- *Public attitudes*: For scientists working in controversial areas, public attitudes can affect their ability to do their work and to obtain future funding. For governments, applications of research in areas such as agriculture, food safety, and social policy can also be hindered by public protest. Contributing to accurate media portrayals of controversial research, providing expert commentary, and participating in public debate can help combat hype (Cossins, 2014), nurture trust (Bultitude, 2011), and possibly prevent protest (Taylor, 2007). But increasing public discussion of controversial research is not guaranteed to have positive results – it can also draw more attention to controversial areas and increase public anxiety. It is also unclear how exactly public responses should be used. For example, how should we handle religious perspectives, what happens if different public groups disagree, and to what degree is it appropriate to allow non-experts shape future research directions? To take a more cynical perspective, communication can also be used to control public reactions – e.g. by emphasizing the safety or potential benefits of new techniques and downplaying the risks (see Irwin, 2009).

3.2 Benefits to universities

As mentioned in Section 2, universities are increasingly under pressure to engage with the society around them. Quotation c) in Box 3 is taken from the manifesto of the UK National Co-ordinating Centre for Public Engagement, which supports British universities in improving their public engagement efforts. The last line highlights that the benefits should be mutual – both bringing practical benefits to the university and expanding the university's positive social role. Some of these benefits are listed below (see also Bultitude, 2011).

- *Branding*: Communicating about research in popular media can increase awareness of a university, its staff, and funders. In other words, it is an important part of 'branding' the institution and thus increasing its competitiveness in attracting funding and investment.
- *Reputation and Trust*: Scientists participating in open communication, comment and debate can increase public trust and improve the university's reputation in the wider community. Whilst openness can of course backfire if scandals and controversies come to light, being found to have hidden something is arguably more dangerous.[10]
- *Social Accountability and Responsibility*: Demonstrating social accountability is particularly important in a climate where universities are increasingly under scrutiny for their benefit to society. Social responsibility can be improved

10 There is a similar debate around whether more disclosure of conflicts of interest will improve public trust or instead increase public attention to the potential impacts of conflicts of interest on researcher integrity, see Chapter 7.

both by involving publics in research and its translation and by making researchers more aware of social issues and public perspectives – both are activities that involve communicating about science in public contexts.
- *Recruitment and Training*: Communication with the wider society can help to inspire and recruit future students and staff. Supporting researchers in taking part in public communication can enrich their work experience and provide valuable transferable skills

3.3 Benefits to individual scientists

The benefits to society (3.1) and research institutions (3.2) discussed above might seem irrelevant to individual scientists – or at least less pressing than their research. And scientists might also argue that the collective responsibility of the university to communicate does not apply to them individually (Section 4). But there are also a range of individual benefits to taking part in public science communication (Research Councils UK, n.d.):

- *Enhance your scientific CV*: As universities are under pressure to engage more with society, experience in this area can be a bonus point on top of a good research and teaching record.
- *Build a career outside science*: For those young researchers who decide that a career in research is not for them, communication experience signifies valuable transferable skills. It can also lead to specific research dissemination or public engagement roles in, for example, universities, funding bodies and charities, and government research or education departments.
- *Improve your grant applications*: Whilst it is a minor part of an application in highly competitive funding rounds when every point counts, a stand-out section on dissemination or public outreach can give you an edge. Previous experience is helpful, but so is being able to come up with original and thoughtful ways of communicating with public groups.
- *Improve your communication skills*: Intra-scientific communication such as writing journal papers or preparing conference presentations has more in common with public communication than you might think – both involve translation for an audience that is less informed than you (see Section 1). So practicing how to explain research in public will benefit your scientific writing too.
- *Make connections with other scientists*: Scientists are also part of the 'public', and as the use of social and online media increases, the boundaries between science communication for the general public and for interested experts are blurring (e.g. Wolinksy, 2011; Andersen & Söderqvist, 2012). Communicating 'in public' can thus enhance your reputation and recognizability amongst other scientists too. It can also be a way of making direct connections with potential colleagues, collaborators and future employers (Research Councils UK, n.d.), especially through social media (Andersen & Söderqvist, 2012, p.10), and it can, for example, lead to invitations to present your work in person.
- *Keep up with your field and its impact*: Many scientists read the front section of journals such as *Nature* and *Science* to keep up with developments in their field and with wider issues in science funding, governance, and careers. Keeping an eye on how your field is covered in popular media can be an extension of this process; part of a wider passion for research and how it shapes and responds to society. Noting what you do and do not like about other media coverage of your field can also help you plan your own public communication work.
- *Have fun!* Lots of scientists who do public communication work do it because it is enjoyable. It can give you a break from research and make you feel more connected to the world outside the lab.

4. Whose responsibility is it to communicate?

The Danish Code of Conduct for Research Integrity (Ministry of Higher Education and Science, 2014) states that university researchers have "a right and an obligation" to communicate. This does not imply that all individual scientists have an obligation to communicate all of their research – the duty is a collective one, and therefore lies primarily with the institution. If researchers do want to get involved, particularly at an early stage of their career, their institutions should support them through a culture that values

science communication and advises researchers on how to communicate responsibly (see Ministry of Higher Education and Science, 2014; Section 3.2 v. & vi.).

In Section 3.3 we listed positive benefits of doing public science communication for individual researchers. There are equally many reasons scientists give *not* to communicate. One of the main reasons scientists give for avoiding public communication is that they do not have enough time (Royal Society, 2006, p.10). Researchers must of course balance a shared duty to communicate against other duties in relation to research, teaching, administration etc., and be aware of potential conflicts of commitment. Scientists also often refer to it being the wrong time to communicate – e.g. to avoid being scooped or due to restrictive publication agreements with funders or industrial sponsors. And if scientists are asked to participate in public conversation about controversial topics, they may be worried about being drawn into a polemic or being misinterpreted. For example, in 2011 Professor of Political Science Marlene Wind made comments about a political agreement on increased Danish border control and was accused of using her position as expert to air her personal opinions, resulting in her taking a break from media work.[11]

Another response which researchers might give to questions about why they do not do public communication is that it is the journalists' responsibility, not theirs. But when researchers are an expert in a field that is currently in the news, they may feel a duty to share their expertise and improve media coverage by, for example, giving interviews to journalists. Even as an early stage researcher, you are likely to be able to offer a reporter or public audience valuable insight into your research area. It is also worth thinking about the benefits of communicating more directly with public audiences. This can offer the researcher more control over the conversation, and without the strict length constraints of news articles, it can also allow researchers to give greater insight into the 'behind the scenes' of how science works. In the past, only the most high-profile or dedicated scientists would have spoken in their own voices – e.g. through televised lectures or writing popular science books. Today, public events and online and social media have massively expanded scientists' opportunities to communicate directly, even at an early stage in their career.

Even if you decide not to communicate about your own research, talking about research in general achieves many of the same goals. For example, you can inspire future scientists by talking about biology in a school or inviting students to visit your lab without mentioning sensitive details of your own studies. This also applies to researchers in highly abstract or technical areas, although it is worth remembering too that the Internet has opened up access to audiences even for geeky or esoteric subjects.

In sum, it is a duty of the scientific community and institutions to communicate with the wider society, but individual researchers are not obligated to communicate; they must decide when to contribute to this communal duty. In this chapter we cannot give a simple formula for deciding whether, when, and how to communicate. Instead we introduce some relevant factors to consider.

5. How to communicate responsibly

If you have decided to communicate, how can it be done responsibly? The Danish Code of Conduct for Research Integrity states that "Research results should be published in an honest, transparent, and accurate manner" (Ministry of Higher Education and Science, 2014), and the European Code of Conduct for Research Integrity ALLEA, 2017) states that "Authors (...) are honest in their communication to the general public and in traditional and social media" (p. 7).

These statements imply that a set of core values apply to all forms of communication, whether in scientific or popular media. However, it is important to acknowledge that what exactly honesty, transparency and accuracy mean in practical terms depends on the context. Whilst researchers should always aim for honesty in public (and should certainly avoid *dis*-honesty), it is often impossible to be accurate in the same

11 A summary of the case with links to media coverage can be found on Wikipedia (2016).

way for a popular audience as you are for expert colleagues. This, as Gregory and Miller (1998) argued in the quotation in Section 1, does not make popular communication untrue – and it does not mean we should give up and indulge in hype. Rather, it should encourage researchers to recognize the constraints of public communication and work as well as possible within them.

In the remainder of this section, we go through some key questions to consider when planning public communication, to help researchers make the most of the benefits it offers whilst also satisfying the demands of research integrity (5.1-5.5; summarized as a checklist in Box 4). These questions are not highly technical – they just require some reflection and common sense – and writing out answers to each one is good preparation for media work. If you are preparing for public communication activities your department or faculty communication office or media section can also help and advise you. There are also many practical guidelines, courses and workshops to help scientists learn more and improve their communication skills (see Section 7).

BOX 4: CHECKLIST OF QUESTIONS FOR RESPONSIBLE RESEARCH COMMUNICATION

1) Reflect on your goals – why do you want to communicate, and what kind of relationship do you want to have with your audience? (see Section 5.1)
2) If you have a choice, which media will best match your goals? If you cannot choose which media to use, do you need to adjust your goals? (Section 5.2)
3) Which aspect(s) of research do you want to communicate about? (Section 5.3)
4) Within the constraints of your medium, what is your key message? How can you honestly and accurately describe the novelty, importance, certainty, statistics, practical applications and ethical or societal implications of your research? (Section 5.4)
5) Are there any requirements or restrictions (a) on what you communicate and (b) how you present your affiliation and expertise? (Section 5.5)

5.1 Reflecting on your goals

Being clear about your goals is essential for planning communication effectively and can help to avoid frustration and disappointment. Reflecting on the possible outcomes from a societal, institutional, personal and audience perspective (see Section 3) can also draw your attention to potential unanticipated effects. For example, your primary goal may be to raise the profile of your department, but emphasizing your cutting edge techniques may also draw attention to uncertainty surrounding their safety or ethical status. Being clear about the goal of communication can also help you to explain and defend your activities to others, and is crucial to a meaningful evaluation of whether the communication was successful (Research Councils UK, 2011).

One key dimension to consider when thinking about goals is what role you want the audience to play – do you want them to learn or to contribute? In other words, will you focus on one-way dissemination of information from a scientific expert to a public audience, or do you want to engage in two-way dialogue or public engagement? Box 5 gives a brief history of this key distinction, which also relates to the democratic arguments for involving publics in discussions about research outlined in Section 3.1. Of course, many communication activities will contain elements of both one-way dissemination and two-way engagement, and both are appropriate in different settings. What matters is being clear about your expectations and communicating them clearly to your audience or participants. This helps to avoid the frustration that can arise when, for example, scientific institutions say they will take public opinion into account and then fail to do so. When thinking about your goals, it is important to recognize that communication professionals such as journalists or university media officers have different goals, duties and constraints. For example, journalists may consider it their duty to report how basic biomedical research is relevant to patients, whilst the scientists they interview consider it their

duty to downplay how close we are to practical applications. Understanding and respecting each other's professional goals can help the diverse players in the science communication landscape to make the most out of working together. To continue the example above, if you respect a journalist's need to report on the future clinical application of research you can prepare an answer that clearly emphasizes the uncertainties and timescale of translation. There is of course always a risk that a journalist will misquote, misrepresent or misunderstand you, but this is often a risk worth taking. You can also reduce the likelihood of being misrepresented by preparing well for interviews and by asking to read a quote or full article before publication if the journalist's timescale allows.

5.2 Matching the media to your goals

Once you are clear about your goals, consider which media would best help you fulfil them. For example, if you want to encourage young people to take part in democratic debates about the use of cloning technology, a discussion activity may be more effective than a lecture. If you want to get as much

BOX 5: WHAT ROLE SHOULD THE AUDIENCE PLAY IN PUBLIC SCIENCE COMMUNICATION?

For many scientists, the main goal of public communication is to increase public understanding of science (Royal society, 2006, p.9). From this perspective, the task of the communicator is to translate technical details as accurately as possible into simple language; to disseminate information. But thinking of communication as dissemination can also imply that it only goes in one direction: that the listener has nothing to say in return. This has been referred to as the 'deficit model'; assuming that the public is deficient in knowledge, and that good science communication will solve the problem. The deficit model also tends to assume that the public's *attitudes* are deficient, and that knowing more science will make them feel more positive towards research and researchers – assuming that 'to know it is to love it'.

In the late twentieth century there was a widespread perception that public trust in science had been damaged (e.g. by the atom bombs of World War Two), and governments and scientific organizations instigated explicit science communication programmes in response. These programmes tended to be grounded in the deficit model and focused on improving public knowledge. Towards the end of the century ongoing public protest around issues such as GM crops, BSE and vaccines suggested that this was not having the desired effect, and sociological studies of scientific controversies emphasized the shortcomings of the deficit model as well as its failure to acknowledge the democratic arguments outlined in Section 3.1. The conclusion taken up by government and scientific institutions around the turn of the century was that scientists should 'engage' with publics rather than lecture them, thinking of them as scientific citizens who might inform and shape as well as consume and appreciate science (see e.g., Taylor, 2007; Ministry of Higher Education and Science, 2014; for more detailed accounts see Irwin, 2009; Broks, 2004; or Wilsdon & Willis, 2004).

Public engagement formats range from informal discussions, creative activities and crowd-sourced research (Davies et al., 2009) to formal consultation exercises set up to gather public perspectives on controversial issues. There is a strong tradition in Denmark of this kind of work (e.g. see Horst, 2008). Social media are a key medium of two-way engagement, as they are fundamentally structured to invite reciprocal communication and break down barriers of expertise – although this also presents new problems with deciding who to trust (Wolinksy, 2011; Mandavilli, 2011; Andersen & Söderqvist, 2012). In practice, it can be hard to draw a clear line between one-way and two-way communication. Many forms of communication lie somewhere in-between, and it is surprisingly difficult to produce genuinely reciprocal dialogue (Irwin, 2009; Broks, 2004).

attention as possible for a high-profile result from your lab, working with the university press office to get the national newspapers interested may be better than writing a detailed blog post about methodology (although the impact of a blog post going viral should not be underestimated).

Of course, sometimes the medium is decided for us – if a newspaper calls for a quote about your recently published *Nature* paper, you are unlikely to turn it down in favour of using Facebook. If the media is decided for you, you may need to adjust your goals. For example, you are likely to be frustrated if you aim to communicate a nuanced picture of the uncertainty surrounding the future trajectory of research by giving a quote over the telephone.

5.3 Communicating different aspects of science

At several points in this chapter it has been suggested that if we want public audiences to engage in meaningful discussions about research, we need to communicate how science *works*, not just the results that come out at the end. There are several reasons for this. First, science is always 'in the making' (Shapin, 1992) – a scientist should never express 100% certainty that a particular finding will hold forever. More likely, they will admit to some uncertainty over how future experiments will refine or revise current knowledge. Communicating about this uncertainty is a difficult task, but it is worth the effort. For example, someone who has read about changing advice on drinking during pregnancy might think either that scientists are lying or that the research is unreliable. But if they understood that certainty about the effects of alcohol evolves over time, and were given information about the levels of certainty attached to current recommendations, they would then have a firmer basis for deciding how to utilize those recommendations in their own lives.

Another reason for communicating about the processes and methodologies of science is that this kind of knowledge is generalizable. If people understand how clinical trials work, for example, they can apply this knowledge to future media reports about other trials. And finally, if we are serious about doing two-way public engagement that invites audiences to participate in the discussion of research, some knowledge of methodology is essential. 'How science works' most obviously refers to methodology or theory of science. But it can also refer to social and ethical aspects of science – for example, to the way funding and safety legislation works or to ethical debates surrounding particular techniques. Communicating about these wider aspects of research also contributes to a culture where people are equipped to take part in debate, and to act as scientific citizens.

It is important to note that this section has focused on which aspects of science *scientists* would like to communicate about. If we take arguments for two-way engagement seriously, we should also be asking what aspects of science are important and interesting from the perspective of the public groups we are trying to engage (Turney, 2003; Broks, 2004; Bell, 2010). Turney (2003) argues that rather than deciding in advance which bits of knowledge, methodology and social context people need to know about, we should focus on situations where science is relevant to their lives or where they are genuinely being invited to participate, and then communicate the information that they want in those contexts. The news media often claim to reflect 'public interest', covering stories that are of interest to their audience, but they also shape those interests.

5.4 Novelty, importance, certainty, statistics, and practical applications

In attempting to communicate *"in an honest, transparent, and accurate manner*" (Ministry of Higher Education and Science, 2014) there are several common pitfalls, and these relate to the temptation to exaggerate the importance of research findings. This temptation can be strong when your goals include increasing the public profile of your work or institution, and it is exacerbated by the drive of many media outlets to produce 'big splash' stories. Making a list of phrases that accurately describe the novelty, importance, certainty, and practical and societal relevance of your research is good preparation for any communication activity (see *Guidelines for Scientists on Communicating with the Media* (Social Issues Research Centre, 2006) for more details and other practical tips):

- How *novel* are your findings? How do they relate to other work in the field? Do they contradict an accepted view or introduce a new hypothesis?
- How *important* are your findings? For example, do they close a gap in our knowledge, provide a missing technique, or promise to lead to an important practical application?
- How *certain* are you about the results? What are the sources of uncertainty, and are there experiments in progress that will help to confirm, refute or revise your findings? How widely accepted are your findings by other scientists in your field?
- Do your results include a *probability*, or do you need to communicate a level of *risk*, particularly in relation to health? If so, be very careful how you present these statistics and consider how to make them meaningful to a public audience.
- What are the potential *practical applications*, how close are they, and what factors stand in the way of progress? Relatedly, are there any *ethical* or *societal issues* associated with your research which you may be asked about or want to communicate?

5.5 Restrictions, requirements and affiliations

University of Copenhagen legislation supports scientists in their freedom to communicate about research (see Box 3). However, there may be specific restrictions on when you communicate, as well as on what exactly you say. These might come from your supervisor or from colleagues, in which case they can often be negotiated. Restrictions may also come from funders, sponsors or professional bodies, or from a journal embargo that prevents you discussing a paper before it is published. As a researcher you may also wish to adjust the timing of communication to avoid being scooped. If you have any concerns, check with your supervisor, or funder, or with other parties whose interests may conflict with your own (see Chapter 7 for a discussion of how to define and handle conflicts of interest).

There may be requirements as well as restrictions when you do public communication. For example, a funder may require that you mention them, or your university may require you to include a link to a media enquiries page whenever you write online about your research. There may also be rules about when you present yourself as a representative of your institution. Again, check with your supervisor or media department if you are unsure.

Finally, it can be unclear how to present your expertise. Scientists sometimes worry about not being experts outside their own specific research niche, but even when you are talking more broadly about research, your expertise is probably greater than the interviewer's. On the flip side, scientists sometimes offer opinions on the implications of their research – e.g. on societal or ethical issues – that step well outside of their field of expertise. To tread this fine line responsibly you are not necessarily required to avoid discussing topics outside your specific research niche. It is important, however, to be clear about the limits of your expertise and to be certain whether what you are saying is backed up by evidence.

6. Practical advice

Section 5 summarized some key points to consider and prepare before doing public communication work. The guidelines below give more details. They are split into general advice and practical tips for science communication and public engagement (6.1) and for using social media (6.2), plus some suggestions for courses and workshops if you are interested in learning more (6.3).

6.1 General advice on communication and public engagement

- National Institutes of Health, US. (2016). *A Checklist for Communicating Science and Health Research to the Public*. Retrieved from https://www.nih.gov/institutes-nih/nih-office-director/office-communications-public-liaison/clear-communication/science-health-public-trust/checklist-communicating-science-health-research-public
- Social Issues Research Centre (SIRC) (2006). *Guidelines for Scientists on Communicating with the Media*. Retrieved from http://www.sirc.org/messenger/messenger_guidelines.pdf
- Science Media Centre UK. Publications. See http://www.sciencemediacentre.org/publications/ These short leaflets

offer practical tips for a range of scenarios, including some targeted directly at scientists.
- National Co-ordinating Centre for Public Engagement, UK (2010). *The Engaged University: A Manifesto for Public Engagement.* Retrieved from http://www.publicengagement.ac.uk/why-does-it-matter/manifesto. See also case studies and practical guidance on the same website.
- Research Councils UK. Resources for public engagement. See http://www.rcuk.ac.uk/pe/guides/

6.2 Advice for social media communication
- Bik HM & Goldstein MC (2013). An introduction to social media for scientists. *PLoS Biology* 11(4): e1001535.
- AAAS Communicating Science Online. See http://www.aaas.org/page/communicating-science-online
- Webicina Social Media Course, focusing on medicine. See http://thecourse.webicina.com/
- Superfund's list of social media resources and courses (focused on the US): http://superfund.oregonstate.edu/apha-roundtable-communication-strategies#.VLwiUmTF_fb

6.3 Courses and workshops

In Denmark:
- Videnskab.dk does one-day courses: http://videnskab.dk/om/kurser-i-kommunikation-og-formidling.
- The newspaper *Information* runs a longer medieskole course for PhD students which happens in the spring as part of their 'PhD cup' programme: http://www.phdcup.dk/kurser/

In the UK:
- One-week science communication Masterclass at the University of the West of England: http://www1.uwe.ac.uk/research/sciencecommunicationunit/trainingandshortcourses/masterclass.aspx
- The Royal Society has one-day courses and a two-day residential course: http://royalsociety.org/training/communication-media/

Distance learning:
- Edinburgh University has an online masters programme in 'Science communication and public engagement': http://www.sciencecommunication.mvm.ed.ac.uk/online/
- Online science journalism course from the World Federation of Science Journalists, in close cooperation with the Science and Development Network SciDev.Net: http://www.wfsj.org/course/en/index.html

7. Test yourself questions
- Give three reasons for doing public communication from a societal perspective, three from a university perspective, and three from the perspective of an individual scientist. Which do you find the most convincing and why?
- Describe two or three motivations for communicating science to the public from an individual researcher's perspective, and for each one discuss whether there are any conflicts of interest involved.
- Why is public communication included in a textbook and course on RCR? Do you agree that it should be?
- Describe the difference between top-down dissemination of scientific knowledge, and two-way public engagement. Discuss some of the reasons for engaging the public in dialogue.
- What roles can social media play in science communication?
- Discuss whose responsibility it is to communicate about scientific research in public, and how you think the responsibilities of the individual scientist and the university differ.
- What does it mean to do public communication responsibly?
- How does scientific communication relate to public communication?
- As a researcher, what challenges might you face in talking to journalists? Give four examples of questions you should prepare to answer before giving an interview.
- Discuss the role of public communication in establishing public trust in science.

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9
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10
Index

Since 2011 it has been mandatory for all new PhD students at the University of Copenhagen to take a course in RCR (Responsible Conduct of Research). This book will serve as a textbook for the courses held at the Faculty of Science and at the Faculty of Health and Medical Sciences.

The book aims to give an accessible presentation of what PhD-students are supposed to learn about RCR; to present a clear and consistent terminology; and to focus on the way RCR is dealt with in Denmark and at the University of Copenhagen. The intended readers are from two faculties where the large majority of research falls under the umbrella of the natural sciences, broadly construed.

The book can also be of use to other scientific staff at the University.

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