Introduction

Misconduct in scientific research has already since the 1980’s raised the concern of the public and prompted universities, research institutions and governments to act in order to prevent unethical behaviour among researchers [1]. Surveys aiming to estimate the prevalence of misconduct in scientific research have shown that unethical behaviour such as copying others work, granting unauthorised authorship on papers or avoiding of presenting conflicts of interest is widely occuring throughout the scientific community [2]. Misconduct in research is a significant topic of discussion, as it affects the outcome and quality of research in a way that may be harmful to the public. In order to gain trust from the population that is supposed to benefit from the research findings, we as researchers have to assure that our work is conducted in a responsible and ethical manner. This essay will focus on misconduct in scientific research. In order to discuss the impact of misconduct in this field, examples of unethical behaviour will be presented, followed by a definition of what misconduct is, possible reasons for actions included in the definition and how it can be managed and prevented.

Examples of misconduct in scientific research

Famous cases of misconduct in scientific research can be found already in the 1970’s. In 1974, William Summerlin was working in the transplantation immunology laboratory headed by Robert Goode at the Sloan Kettering Institute in New York. His research regarded the rejection of transplanted skin tissue in an experimental mouse model. Summerlin’s hypothesis was that if the skin tissue was cultured several weeks prior to the transplantation, the rejection of the transplant would be prevented in the recipient. According to his reports, he successfully transplanted skin patches from black-haired mice onto white-haired mice. However, his poorly conducted experiment was soon discovered by a laboratory assistant, who reported to Goode that the black colour of the supposedly transplanted skin patch could be washed off with alcohol. Upon investigation, Summerlin admitted that he had coloured patches on the white-haired mice with a black pen. Summerlin became suspended from further research, and he was required to correct the irregularities of his own work as well as publish retractions of his previously published papers. Although Goode was not involved in the actual misconduct, this incident ruined his reputation and career within immunological research [3].

Only 7 years later, a postdoctoral fellow at the Harvard University named Dr. John Darsee was accused of misconduct in his research regarding the assessment of drug therapy in protection against myocardial ischaemia. Darsee was found to have fabricated and falsified data in his experiments in five different papers, published while enrolled at Harvard, as well as in eight other papers published while he was doing his Ph.D. at the Emory University. Following the uncovering of his fraudulent behaviour in research, he continued working as a medical doctor [4-5].

A more recent case of misconduct in scientific research was brought up in 2004-2005, when professor Woo Suk Hwang at the Seoul University claimed to have derived human embryonic stem cell lines from somatic cells using therapeutical cloning [6-7]. Hwang claimed that the obtained human embryonic stem cells were genetically identical to the donor somatic cells. The published papers were considered milestones in stem cell research, and Hwang soon became known worldwide for his remarkable accomplishments. The studies conducted by Hwang involved many collaborators from other countries. In 2005, one of these collaborators accused Hwang of giving him misleading information regarding the source of the eggs used in...
the experiments. Later, Hwang confessed that the eggs were provided by his research subordinates, and each of them was paid up to $1400 for their donations [8]. Later, the editors of Science, where the papers were published, discovered that two of the images in the paper from 2005 were duplications. Additionally, one of the coauthors informed the media that 9 of the 11 described cell lines in the papers were in fact fabricated. Following this, an investigation at the Seoul University was initiated, and it was discovered that none of the derived stem cell lines were genetically identical to the donor somatic cell lines. It was also discovered that Hwang did not report the correct amount of donor eggs that were used in the experiments. Moreover, Hwang was found to have interfered unethically in the process of the egg donations and authorship on the published papers was granted even for minor contributions to the studies. Hwang resigned from his position at Seoul University in late 2005. In May 2006, he and five of his collaborators were convicted of charges of fraud, embezzlement and breach of laws in bioethics. However, their sentence was suspended [9].

Following the misconduct case involving Hwang and his collaborators, Science and other journals made changes to their peer-review policies in order to prevent similar incidents from occurring. Embarrassed by the fact that obvious errors such as image duplications had slipped through their peer-review process, the editors decided to pay more attention to papers considered high-impact. In response to the Hwang incident, the Committee on Publication Ethics (COPE) developed guidelines with the aim to assist journals in the process of dealing with misconduct [10]. Scientists and the public have also responded to the misconduct cases. Congressional committees have organised hearings on the integrity in research funded federally, funding agencies have formed policies on misconduct and conflict of interest, research institutions have developed and adopted instructions on responsible conduct of research, and scientists have conducted research regarding research integrity and mentored fellow students in responsible conduct of research. These actions have made researchers aware of the risks associated with misconduct and highlighted the importance of managing and preventing misconduct in research. However, fraud in scientific research is still occurring, and the scientific community is still far away from eradicating the problems linked to research misconduct.

Definition of misconduct in scientific research

The scientific community quickly realised that the determination of whether a certain action should be classified as misconduct or ethically questionable behaviour may be complicated. Therefore, there was a need for a definition of scientific misconduct, which would aid investigators in their determination of whether the researcher is guilty or not. In general, behaviours can be wrongful from an ethical perspective, a legal perspective, or both. Simply unethical behaviour includes actions that are considered wrong in the scientific community or in public, where laws regulating such behaviour are lacking. Hence, a person liable of unethical behaviour may not be prosecuted, even though the action in itself may be considered as rather shameful. Examples of such behaviour may be falsification and fabrication of data and results or plagiarism. An action may also be legally wrong, in the sense that the person liable of the action is breaking the law. Most often however, laws are created on the basis of what is considered as ethical behaviour. Therefore, a legally wrongful action is most often also considered as unethical.
The aim of the definition was to include actions that may be harmful and unfair for the public as well as towards fellow colleagues. In 2001, the U.S. federal agencies agreed upon the following definition of misconduct in scientific research: “fabrication, falsification, or plagiarism in proposing, performing, or reviewing research, or in reporting research results”. Fabrication includes the creation and use of data that does not exist in reality. Falsification is defined as manipulating research equipment, readouts or results in a way that makes the research outcome inaccurately presented. Plagiarism includes the adaptation of other’s ideas, written work or results without stating so when these are presented [11].

The definition of misconduct in research has set the basis for federal agencies as well as universities and other research institutions for detecting fraud. However, the individual universities and institutions may have established broader definitions than the ones set by the U.S. federal agencies. For example, The Wellcome Trust Fund additionally include “deliberate, dangerous, or negligent deviations from accepted practices in carrying out research” and “failure to follow established protocols if this failure results in unreasonable risk or harm to humans, other invertebrates, or the environment” [12].

Although a definition of misconduct in research has been established, it may still be complicated for universities, research institutions and agencies to determine whether an action should be classified as misconduct or simply honest errors. The definition focuses on the three phenomena; fabrication, falsification and plagiarism. However, there may be questionable research practices such as improper citation that may seem unethical, but are in fact unintentional mistakes. Therefore, even though the definition has been widely used as a basis for distinguishing misconduct from simple errors, there are still situations in which the definition is not sufficient [13].

Reasons for committing misconduct in scientific research

As is the case with the definition of misconduct in scientific research, it is not always easy to identify the reasons for why scientists behave unethically. Consequently, the reasons are numerous and very diverse. However, there are some driving forces in the community of scientific research that could influence the decision of a scientist to commit misconduct. An influential factor is the requirement for researchers to produce results, with the aim to publish papers or to receive or maintain funding. This issue could be described as a kind of survival of the fittest; the more powerful results you provide, the more funding you get, which enables managing of larger research groups. Another driving force, highly linked to the first one, is the stress, mental burden and other kinds of psychologic factors accompanying the management of research groups and the constant hunt for research funding. For many researchers, the situation simply becomes too complicated to handle. Other factors concerning the early education of researchers could be inadequate training provided by former supervisors, lack of supervision during the actual experiments, or other poor influences from the supervisor during the management or interpretation of data. Moreover, there could be a lack of communication between the lab members or between research groups that are collaborating [14]. If a company is involved in the research project, there may be certain conflicts of interest that highly affects the performed research. Should a study conducted by a research group provide negative results for the collaborating company, the risk is high that the results will be discarded and remain unpublished. This could push researchers to modify data or the end result so that they fit the company’s demands, resulting in publication of the results.
Although the problems accompanying misconduct in research are considered as rather important by scientists, politicians and the public, there is still a lack of information about the actual incidence of misconduct. It is tempting to regard misconduct in research as accidental happenings, as the cases of misconduct that have become public may seem to be rather few. However, it is important to remember that what we may see or hear in the media, the scientific journals or even from the universities or institutions may just be a tiny part of all the unethical behaviour that is occurring in the scientific community. The public cases of misconduct in scientific research may be compared to the tip of an iceberg; there may be many more underlying cases of unethical behaviour that will never be brought up to the public. Fanelli performed a systematic review and meta-analysis of the reported incidence of misconduct in scientific research in 2009 [15]. This investigation, which included 21 surveys in the review and 18 in the meta-analysis, revealed that 1.7 % of scientists have admitted to fabrication or falsification of data at least once. A remarkable 33.7 % admitted to have been involved in questionable research practices. Even more astonishing, 14.12 % admitted to have observed their colleagues falsifying data, while 72 % admitted to have observed colleagues engaging in questionable research practices. As worrying as these rates are already, it is important to note that the methods used in estimating the incidence of misconduct in scientific research pose a high risk of underestimating or overestimating the actual incidence. Even if asked anonymously, a researcher guilty of performing unethical actions that may be embarrassing if leaked out to the public will most likely not admit these actions in the survey. However, when asked if colleagues have been involved in unethical behaviour in their research, they may base their opinions on rumours that are in fact false. Either way, it is still of importance to try to estimate the incidence of research and discourage such behaviour, as it undermines the trustworthiness in the research findings and the researchers themselves [16].

Management of misconduct in scientific research

In order to receive funding for research, the grant providers often require research institutions to adopt policies regarding the management of misconduct. Such institutional policies typically include four stages; an initial assessment, a formal inquiry, an investigation, and an adjudication. In the initial assessment, an informal accusation is brought to an institutional official. The complainant may remain anonymous during this step, in order to protect this person from possible threats from the academic environment. However, should the institutional official conclude that a formal inquiry should be initiated, the anonymity of the complainant can no longer be granted, as this step is no longer informal. A testimony from the accusing person may be needed in order to determine whether the accusation is sincere, trustworthy and if it meets the criteria for research misconduct. Moreover, it is investigated whether any animal or human research subjects have been involved or if there are any other issues regarding intellectual properties, conflicts of interests etc. that need to be addressed. If there is enough evidence that research misconduct has been committed, an investigation is initiated. In this step, there may be a need for a testimony from the complainant, which will be reviewed. Additionally, research records are reviewed, and some of these records may be kept by the committee investigating the issue to prevent anyone from modifying them during the process of investigation. If there is enough evidence to determine that misconduct has been committed, the committee will agree upon a punishment of some kind, which is the step of adjudication. Should there be a company or other sponsor involved in the research, they have to be informed
about the misconduct as well. Common punishments include correction of research records in the form of submission of retractions or corrections to the journals where the papers have been published, and exclusion of the guilty researchers from receiving further funding for a period of time. Moreover, the institution could also decide to terminate the employment of the researchers that have been involved in the misconduct [17].

However, the process of reporting and managing the incidents of misconduct in research may be affected if the institutional official has a conflict of interest. It could simply be a matter of not wanting to initiate scandals associated with their own research institution, in the fear of possible adverse affections on their own research career. Another issue that may affect the process of reporting incidents of misconduct could be the possible negative effects on the research career and reputation of the complainant. Should this person have a poor relationship with the supervisor or other colleagues, the situation may become worsened. Also, the accuser may fear the possible termination of employment initiated by the supervisor [18]. Whatever could be the case, it could lead to that some issues which should have been dealt with in an appropriate way will never face a solution. That is a significant problem not only for the research community, which will continue relying and referring to questionable research findings, but also for the grant providers and the public, who will continue investing money in research which in fact lacks trustworthiness.

Prevention of misconduct in scientific research
At this point, it is perhaps not surprising that great effort is taken into establishing effective ways of preventing misconduct in scientific research. Fabricated or falsified data cost a lot of money that could have been spent on honest research instead, the occurrence of questionable data and results may affect the chances of receiving research funding in a negative way, and the reputation of the universities or research institutions may be ruined. Therefore, it is common for universities and research institutions to have guidelines and plans of education in research ethics. For students attending programmes, courses in responsible research conduct and ethics may be an effective way of preparing them for their future challenges in their research. In the lab, mentoring by a supervisor could provide young and developing researchers the necessary awareness and knowledge about managing issues that could develop into scientific misconduct if handled poorly. Additionally, careful supervision by the supervisor could also lead to the early discovery of ethically questionable actions, which may then be prevented before any damage has been done [19].

Apart from education and mentoring, it may be effective for research institutions and universities to establish policies regarding the handling of possible issues of misconduct. If the guidelines in the policies are designed well, they will prevent possible incidents of misconduct by enabling early discovery of these [20].

Not only universities and research institutions are responsible of preventing any form of misconduct in scientific research. Scientific journals have started to use plagiarism-detectors, which enable them to detect whether a submitted paper contains plagiarised sections. This strategy is also used by many universities in order to discover plagiarism in theses written by
students, which also contributes to the early teaching of responsible research conduct to students [21].

Finally, another effective strategy of discovering misconduct is data auditing. Data auditing is the process of analysing how well the acquired data fits its purpose, thereby enabling detection of poor quality data. This strategy is used in many pharmaceutical companies, which may have invested a great amount of money in drug development. However, even the wealthiest company would not have enough resources to audit all acquired data, consequently only a fraction of the data is controlled in this way. Universities could use a similar approach in the form of committees reviewing data that is crucial for further experiments, for example data that would be used as a basis for the development of an animal model. It is often argued that universities and research institutions do not have the resources for such data auditing, however this could be enabled if grants would provide a budget for such processes as well [22]. Therefore, it is evident that universities, research institutions, agencies and grant providers need to collaborate in order to establish effective methods in preventing scientific misconduct.

**Conclusion**

Misconduct in scientific research is more prevalent than we would like to admit, and there have been many cases in history confirming that the consequences of misconduct in scientific research are significant. In this essay, the term misconduct has been defined, followed by an outlining of possible reasons for why one would consider to behave unethically. The strategies employed for managing misconduct have been described, and possible approaches to prevent misconduct from occurring have been discussed. Despite having a lot of information about the situations influencing researchers to commit scientific misconduct, methods to handle such behaviour and preventable strategies, we still have a long way to go in order to eradicate scientific misconduct. There is an urgent need of collaboration between universities, research institutions, agencies and grant providers when it comes to establishing effective methods of preventing scientific misconduct from happening. Furthermore, education and mentoring of future researchers is an invaluable step of prevention. Sadly, without effective methods of detecting and punishing misconduct, it will most likely continue to occur as some people will still see the benefit in it. The great challenge for the research community is hence to prevent misconduct from occurring, managing the cases of misconduct appropriately, but most importantly discourage every researcher from behaving unethically. If all researchers could be discouraged from committing misconduct and instead encouraged to honest and fair rivalry, we would obtain high quality research findings that would be a true benefit to the world.
References


