Scientific misconduct

When the Search for Truth Bears Lies

So you have this nice data series but there's just one data point that doesn't fit. Can you simply leave it out? Where does fraud start? Rosemarie Marchan analysed the situation in our current "Publish or Perish" scientific society.

Something is rotten in the lab

We scientists have our own special brand of rock stars. Granted, their fashion sense is usually questionable and a detailed mechanical explanation of what lies under the hood of a sports car may be more forthcoming. Nevertheless, as their Birkenstock-clad feet hit the accelerator of their trusty 15-year old Honda, they are our unassuming heroes who literally save the world every day. From penicillin to the atomic bomb, the last century has brought with it an explosion of scientific discoveries that have changed the way we currently live. "Let there be light" is a controlled act today thanks to a group of men whose names read as a list of "who's who" in any discipline including Franklin, Volta, Ørsted, Ampère, Faraday, Tesla, Edison, Bell, Westinghouse and Werner von Siemens. In laboratories across the globe, thousands of women and men continue to fervently search for a cure for the world's diseases, create the fastest, most compact computer, find the best alternative fuel to save the planet without compromising lifestyle, or solve the mystery of "outer space". Yet amidst all this "discovery" and desire to "do good", lingers the darker side of human nature – the side that would create a graph out of thin air, fudge data, hold back reviews, lie, cheat, steal - in layman's terms, commit fraud to get ahead.

Misconduct: an unclear definition

Fraud or scientific misconduct, its politically correct euphemism, is alive and kicking within the esteemed walls of the world's laboratories. But what is scientific misconduct and how is it different from an honest mistake or just downright carelessness? Unfortunately, no clear-cut definition exists as misconduct can have different meanings depending on country and/or institution. A 2009 report by the Council of Science Editors (CSE) provides several variations of what misconduct means in various countries and research institutions around the world. A general definition provided by the CSE is "any action that involves mistreatment of research subjects or purposeful manipulation of the scientific record such that it no longer reflects the observed truth". Considering the accuracy that science demands, this definition, as most that are available, is fairly ambiguous and leaves room for self-interpretation. As described in the CSE's report, perhaps the broadest description hails from Norway, which includes "(1) fabrication and/or falsification of data, (2) plagiarism of data or articles, (3) intentional selection or withholding of results for publication when those results are relevant to the conclusion, (4) erroneous use of statistical or other methods, (5) intentional or gross negligence in withholding details in methods, (6) erroneous listing of authors, (7) erroneous presentation of research by other investigators, (8) presentation of research to the general public without scientific publication, and (9) unacceptable duplicate publication".

Despite the various definitions used for scientific misconduct, some words common to all include fabrication, falsification and plagiarism. Fabrication, an obvious misdeed, describes the act of making up data. Plagiarism indicates using words, ideas, or results from others without giving due credit to the original author. Falsification, which leaves room for most ambiguity, is described by the US Public Health Service as "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". Falsification runs the gamut of actions from playing with various statistical methods until one is found that would support an initial hypothesis, deleting data points to create a clearer curve, omitting data that does not support the original hypothesis, "mining" data to find a significant relationship or "photo shopping" images.

How much is make-believe?

Woo Suk Hwang was one such rock star. In 2004 and 2005, his laboratory at Seoul National University reported that they had successfully cloned embryonic stem cells, creating waves in the field of stem cell biology. A year later, the world looked on as Hwang was indicted for fraud and embezzlement. His is not an isolated event and sadly, will not be the last. This case of misconduct was discovered and made public with such hype because of the cutting-edge nature of Hwang's research and its potential benefits to curing diseases. In reality, not all cases are as high profile and most go unfounded or, if uncovered, are only known to the few who are affected. Incidentally, these are published studies that made it past at least one review process and are now free to be considered true by the unassuming public. Therefore, how much of the scientific literature is a lie?

Several studies have attempted to quantify misconduct using different approaches. One method is to report on the number of cases that have been discovered. The major flaw to this approach is that it is not a true representation of reality because it depends on people who have already been caught. Others have looked at the number of retractions in the literature, which again depends on fraudulent behaviour being uncovered. Many studies have relied on anonymous questionnaires asking after the behaviour of those being surveyed or their peers. Thus far, the numbers from most surveys suggest that about one percent of researchers admitted to serious actions of misconduct.

"Liar! Liar!" (*The Economist*) and "One in 7 scientists say colleagues fake data" (*Times Online*) are headlines generated from a recent study (*PLoS One, 4(5) May 2009*) by Italian-born behavioural ecologist cum social scientist, Daniele Fanelli. His current interest lies in trying to quantify the subjectivity of science. According to him, "There is an intrinsic bias in a lot of what scientists do and there may be facts that allow one to understand and predict where bias is more likely. Once this is known then decisions made are all based on scientific knowledge." His goal in this study was to systematically review previously published survey data on scientific misconduct using a meta-analysis, which allows similar data from different studies to be pooled and statistically compared.

Honest scientists

Trawling the literature from his office at the University of Edinburgh using keywords such as "research integrity", "falsification", "fabrication", "scientific fraud", he identified over 3,000 potential studies. Most of these were deemed inappropriate for reasons such as studies that were not relevant to misconduct, not research related, unoriginal data or poor quality data. His stringent criteria led to a final number of 18 studies, which he used to conduct the meta-analysis.

After crunching the numbers, it would seem that about one in 50 (~2 %) researchers have admitted to serious forms of misconduct, such as making up data or modifying their data to improve their results. Whilst one may be left shaking one's head in disapproval of the "one in 50 persons"; when asked about "less serious" acts, such as dropping data points to achieve a better-looking graph or using improper study design if pressured by a funding agency, one in three researchers were guilty. If we consider the number of people we interact with on a daily basis, one in three is practically every other person we meet.

Before stones are cast, what exactly are these "less serious" actions? Fanelli refers to them as questionable research practices (QRP). "There are a lot of valid behaviours, which are a lot harder to define," he explains, "And they are sometimes done for good reasons but they can also be a source of bias." He continues to explain that these QRP occur a lot more frequently than fabrication or falsification, an opinion, which is supported by his and other studies, and may be the main source of bias in literature.

In addition to self-confession, the number of people who have actually witnessed their colleagues commit questionable actions in the laboratory was also addressed. Not surprisingly, the percentage was much higher. Approximately 14% admitted to observing their colleagues committing serious acts of misconduct whereas up to 72% admitted observing QRP.

These high numbers may be difficult to accept and also difficult to interpret. For self-reports Fanelli explains, "The accuracy of self-reports on scientific misconduct might be biased by social expectation." And the social expectation for scientists is that they are "purely devoted to seeking the truth and are unlikely to admit something that will have very serious consequences on their fields or for themselves, personally." Also, the lower frequency of misconduct for self-report is explained away by Fanelli as "researchers might be overindulgent with their behaviour and overzealous in judging their colleagues". Additionally, for non-self reports there may be several reports for one incident. Therefore, the values attained for self-reports may be an underestimation of the true value, whereas those for non-self-reports may be an overestimation. Regardless, the truth may always prove elusive because, as Fanelli bluntly states, "If people are going to be dishonest, they will do it when no one is able to look at them."

A costly game

Admittedly, addressing the question of honesty is beyond the scope of this article. For scientific research, in particular, some excuses seem to be more readily given: the high pressure environment in many laboratories, resulting from a need to secure funding or to beat out the competitors, pushes scientists to toe the line when it comes to their research. "Publish or perish" is the motto of many 21st century scientists as publication number and quality is a typical measure of success, and is proportional to funding. These stressors are blamed for offences ranging from general sloppiness to data fabrication as the desire to get results in as little time as possible may result in quality being sacrificed. Georg Kreutzberg, a former director of the Max Planck Institute (MPI) of Neurobiology in Germany, compared the forger to a doper in a 2004 Viewpoint article in *EMBO Reports*. His own experience with one of his students who was caught falsifying data led him to this analogy when the student compared cheating to an addiction saying, "The more often you do it, the more you want to have it."

A 2005 newsletter from the International Society for Behavioral Ecology (*ISBE Newsletter, 17:1*) presented a cost-benefit model to explain scientific misconduct. The model suggests that for minor misconducts costs are lower but the benefits may also be low. Examples of cost include loss of grants, students' reputation and the difficulty in regaining these once lost, whereas benefits include prestige, salary, grants and employment. Interestingly, this model is dependent on the perception of the offender, as someone who is highly ethical may have a different concept of misconduct compared to one without scruples.

Many proposals have been made on how to deal with, decrease or eradicate scientific misconduct. Psychiatrists, educators, lawyers, journal editors, politicians, journalists and scientists have all voiced their opinions on how to get a handle on scientific fraud, using elaborate questionnaires, television documentaries, newspaper and journal articles, international meetings and even threats. Currently, policies are in place, mainly from governmental and private organisations that fund research, but the success of these policies is debatable.

A wolf in sheep's clothing?

By popular vote, the first step to fighting fraud is education, which should ideally occur early on in any scientist's career. In his report, Kreutzberg places the responsibility on senior scientists, "He or she should have the competence, the commission and the power to guide students and make sure that they adhere to the highest standards, both scientifically and morally." Sandra Titus from the US Office of Research Integrity (ORI) (*Nature, 453 (19) 2008*) stresses the importance of modelling ethical behaviour and proper training of student mentors as measures to combat misconduct. Regulations by the Deutsche Forschungsgemeinschaft (DFG), Germany's largest funding source for basic research, recommend that "all universities and institutes develop standards for mentorship and make them binding for the heads of the individual scientific working units". Though proper mentoring is indeed important for young scientists, some argue that mentors and senior scientists, unless directly involved in the fraudulent act, should not be blamed for the wrongdoings of their students – past or present.

Despite regulations being in place, mandatory training on scientific integrity or mentoring appears to be the exception rather than the norm. Any formal training is usually dependant on policies at the research institution, which, in turn, are dictated by how stringently regulations are enforced by the government or funding organisations.

Breaking the law

Laws governing scientific misconduct exist only in a handful of countries. The United States was the first to set up regulations in the late 1980's. Currently, the Office of Research Integrity (ORI), a branch of the Department of Health and Human Resources (DHHS) and the National Science Foundation provide both guidelines for research practices and support for investigations involving allegations of misconduct. The Nordic countries, Australia, Canada and Germany are examples of countries with legal guidelines in place to address misconduct. The United Kingdom relies primarily on guidelines and assistance from private organisations such as the Wellcome Trust and the UK Research Integrity Office. In most countries, the governing bodies require that institutions have a plan of action to address scientific integrity, but much of the education and implementation of policies is at the discretion of the institution itself. Whether these policies are communicated to the people for whom they were designed appears to be institution-dependent.

What would you do if you suspected someone of misconduct: confront the wrongdoer, report it to the supervisor, contact the journal if the work has been published, or do nothing leaving it up to someone else to act? This is where communication of clear, defined policies on misconduct is beneficial.

In her study, Titus lists strategies to 'champion integrity". In addition to training and modelling ethical behaviour, she recommends a zero-tolerance culture where all suspicions of misconduct must be reported. This seemingly rigid policy will only work if there are well-defined instructions on who to report to and the assurance that an investigation will be conducted in a thorough and timely fashion. For instance, every Max Planck Institute (MPI) in Germany has an ombudsman on its staff, whose responsibility it is to advise and act on cases of scientific misconduct.

In spite of a call for zero-tolerance, there are many reasons to not report fraud: fear of wrongful accusation, tarnishing the area of research, time away from research and fear of retribution. For many, having to report a colleague requires some measure of moral gumption. Unfortunately, our society does not always commend bravery and many whistleblowers face reprisals and are even encouraged by administration to drop their allegations, mostly in an attempt to prevent bad publicity and protect the reputation of the institution. In light of these factors, it is important that regulations protect both whistleblower and accused. For the latter, confidentiality is important until misconduct is confirmed so as to prevent the possibility of false accusations.

In many countries, investigations are managed by the university or research institution with assistance from the government-appointed body. A timely resolution is always highly recommended for the benefit of all involved. In the event of a guilty verdict, the final decision and punishment are determined by the university. Serious misconduct usually results in grave repercussions such as dismissal, retraction of publications and monies, and irreparable damage to one's reputation.

The right instinct

We learn to differentiate right from wrong early on in life; therefore, the validity of certain acts should be instinctive. For all others, we can question. To this end, training in integrity may not be sufficient to combat integrity. Hence, there should always be "some mechanisms in place to review and evaluate the research and training environment of the institution", suggests Titus. This calls for accurate record keeping, regular review and auditing of work, and a willingness to share and have one's work evaluated by others. Some view these audits as too rigid, suggesting that they create an atmosphere of distrust, preventing the free flow of ideas. On the other hand, there should be nothing to hide. Too many cases of misconduct have been uncovered where co-authors pleaded innocence or ignorance. Understandably, there are instances where "top-secret" projects should remain top-secret but openness among co-authors is necessary, as everyone should be able to defend the work with which their names are associated. A recommendation by the DFG is that all findings be controlled and replicated, preferably independently, before being submitted for publication.

With all these preventative measures in place, some scientists are wily enough to sneak their work past the review process and be published. This act is not only detrimental to themselves, if uncovered, but to science itself. This arises as others try to build on published results, wasting time and resources attempting to confirm or replicate fraudulent data. More important is the impact of misconduct on the public's view of science. Melissa Anderson, a professor of Higher Education at the University of Minnesota, stresses, "The public must be able to trust scientific findings that affect their health, environment, economy, industry and society in general; their trust is critical to the ongoing support for scientific research."

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