The rules of good science

Preventing scientific misconduct is the responsibility of all scientists

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When scientists hear about scientific fraud, they quickly denounce the culprits as not being 'true' scientists. The true scientist, they argue, is only interested in unveiling step by step the countless enigmas of nature. He or she labours long hours and weekends at a desk or in the laboratory to find the truth, not to invent it. When describing her attitude to science, Nobel Prize-winning cytogeneticist Barbara McClintock once said, "I was so interested in what I was doing I could hardly wait to get up early in the morning and get at it. One of my friends said I was a child, because only children can't wait to get up in the morning to get at what they want to do" (National Academy of Sciences, 1995). It is probably the scientist's greatest motivation and satisfaction to understand or observe what has never been understood or described before. But is the ensuing 'eureka' experience really the greatest award for all that hard work? Is this the only reason for doing science? Or is this too idealistic and naïve a view of scientists, one that ignores the fact that our profession may be driven by other ambitions, such as glory, recognition or even money?

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We scientists think that we enjoy the highest degree of freedom in our work. Many societies have also accepted the notion that research is done best when unhindered, and have included in their constitutions the freedom of science as a basic human right. Science and scientists have been entrusted to set up their own rules, based on trust, respect and the welfare of society. The general public shares this idealistic view of how research is done and does little to interfere with its freedom and its self-imposed rules. Despite some recent scandals, the public trust in science and scientists is still very high. A few years ago, the Allensbach Institute (Germany) carried out a poll of public trust in persons, politics, industry, administration and academia. The question asked was: "What is the institution earning the highest respect and credibility in Germany?" The Max Planck Institutes, representing top research in Germany, came third after the Federal Reserve Bank and the Federal Supreme Court and even ahead of the President of the Federal Republic.

This may be the reason why misconduct in research still gains enormous media attention, whereas fraud or deception in other professions are hardly mentioned at all. But are scientists really as honest as the public tends to believe? Let us first take a look at a few famous cases of puzzling behaviour in the history of science (Broad & Wade, 1982). In the second century AD, Claudius Ptolemy of Alexandria, one of the greatest geographers and astronomers of antiquity, stole astronomical data from Hipparch of Rhodes, who in turn published data from Babylonian sources as his own observations. Ptolemy recalculated and adapted Hipparch's figures without reference to the source, a clear case of plagiarism. Many centuries later, Galileo Galilei developed the law of gravity, but his famous experiments involving weights dropped from the tower of Pisa were most probably never carried out. The great Isaac Newton used what biographer Richard Westfall called a "fudge factor"—he arranged his equations in such a way that the result came out as he required. The data reported by Gregor Mendel on his famous pea experiments seem to be too good to be true. However, commentators differ on whether Mendel in fact manipulated his data or whether there is an innocent explanation for why his results perfectly adhered to a mathematical formula. The most spectacular fraud or hoax of the twentieth century occurred in 1912 in Burlington House, London, the home of the Geological Society of Great Britain. Known as the Piltdown case, the fraud involved a faked early hominid discovered and presented to the society by amateur geologist

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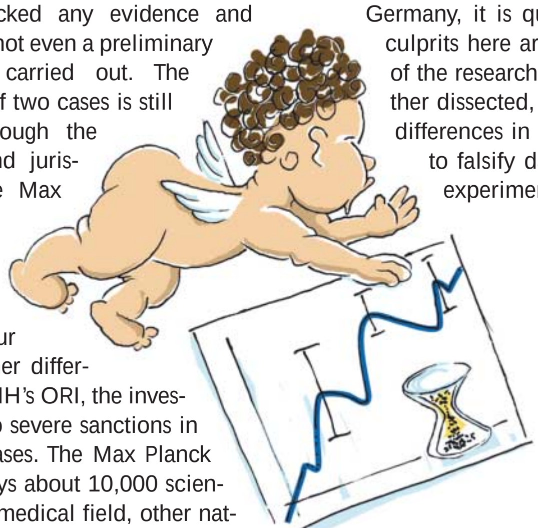
Charles Dawson. It took almost 40 years to prove the fraud, and today it is still not clear who committed it—assistants on the dig, senior scientists who validated the discovery, Charles Dawson himself, or whether it was a hoax fabricated by Sir Conan Doyle to place blame on his colleagues (Tobias, 1994).

Even if we accept that misconduct in science is not a new phenomenon, this neither takes away the embarrassment when new cases become known nor relieves us of the task of preventing them. Every new case should rather increase our sensitivity to good practice in science. Furthermore, it should make us aware of the need to draft new rules or improve existing ones and that we have to engage actively to weed out cheats (Check, 2002). Most countries or national scientific organizations, academies, universities and other institutions have accordingly worked out rules of good scientific practice for their research staff. Under the influence of US Congress, the US National Institutes of Health (NIH) has set up an Office of Research Integrity (ORI). It publishes an annual report on scientific wrongdoing among the world's largest national biomedical community (Office of Research Integrity, 2002). In the first five years of its existence, 400 cases of scientific misconduct were indicted and processed by the ORI. Among those, falsification was the most common allegation over fabrication, plagiarism and others, but many cases involved more than one allegation. There is also a tendency towards increased reporting and, as a result, positive findings of misconduct rose from 33% to 56% in 2001 (Office of Research Integrity, 2002). The ORI's data could probably be extrapolated to other nations as well; however, there may be national differences with regard to the nature of misconduct and its culprits.

In 1997 the Max Planck Society adopted regulations for good scientific practice and set up an internal audit system to investigate allegations (Max-Planck-Gesellschaft, 2000a). During the past five years, the individual Max Planck Institutes reported 22 cases of misconduct to the central office: 16 in the biomedical field, 4 in physics and chemistry, and 2 in the social sciences. In two cases, misconduct was confirmed and the behaviour of the individuals was condemned. Two more contracts were cancelled during the preliminary inquiry because the evidence was found to be sufficient. In 13 instances, the investigators chose not to open a formal case after the preliminary inquiry because of insufficient proof of misconduct. In three cases the allegations lacked any evidence and consequently not even a preliminary inquiry was carried out. The investigation of two cases is still pending. Although the procedures and jurisdiction of the Max Planck Society—which have arisen from German labour laws—are rather different from the NIH's ORI, the investigations led to severe sanctions in 4 of the 22 cases. The Max Planck Society employs about 10,000 scientists in the biomedical field, other natural sciences and the social sciences. The equivalent number of researchers working at the NIH is not known, but is probably higher by a factor of 20. Taking these numbers into account, it seems that both the NIH and the Max Planck Society have had a similar low number of allegations of wrongdoing during the same five-year period.

According to the ORI annual report, the number of American PhD students accused of misconduct is relatively high in comparison with Germany. In a typical case described by the ORI, "an MD/PhD graduate student was suspected of fabricating experimental data over several years. When asked to return to the laboratory to repeat the work on blinded samples, the student repeated the results in the presence of a co-worker. However, when the laboratory director evaluated the materials used in the repeat experiment, the director found changes indicating that the student had surreptitiously determined the contents of the blinded tubes before doing the new experiments. The student admitted to doing so when challenged, and ORI obtained a debarment of the respondent from receiving federal funds" (Office of Research Integrity, 2002). Many PhD students in the USA are under enormous time pressure to finish their studies and obtain a degree, but a large number of them later find a job in industry or other businesses. Thus, they are not pursuing an academic or research career. Although such individuals can do much damage to the laboratory in which they work and can cloud the reputation of the department if they commit fraud or forgery, they do not harm the spirit of future science because they are leaving research anyway. If we look at the recent scandals concerning scientific fraud in Germany, it is quite obvious that the culprits here are in the higher ranks of the research hierarchy. When further dissected, this reflects national differences in scientists' motives to falsify data or manipulate experiments.



Cosi fan tutti?

The degree of trust and respect awarded to colleagues in academia is very high and an important basis of the intellectual world in which we live. Science needs openness, free exchange of ideas, sincerity and fairness. All these essential virtues are at stake if we treat our colleagues as possible forgers and consider our students as prospective swindlers. Consequently, distrust would be answered with distrust, a scenario that would destroy any scientific or intellectual climate and would do away with the joy of science.

There is yet another aspect of fraudulent behaviour in science that has rarely been considered. I became aware of it when a former student of mine became rightfully accused of falsification and forgery of data for his PhD thesis submitted to a university in a neighbouring European country. When I challenged him, he admitted even more than I had expected. He was a brilliant student and I could not understand why he had done these things. He said quite emotionally: "You know, if you have done it once successfully you go on and it is like an addiction: the more often you do it, the more you want to have it." His explanation reminded me of the justifications offered to excuse doping.

Indeed, the similarities to professional sport and the disgusting problems of doping are obvious. I do not care that these people ruin their health and their bodies, but what is unfair is the advantage that the doper gains over his competitors: his comrades, who assume that they are performing their beloved sport under the same conditions as everyone else. Replace a few words, and you are facing a similar situation in research under the conditions of dishonesty. In science, the forger is the doper. He or she gains an advantage over his or her competitors by unfair means, such as smoothing the statistics, leaving out controls, reducing the number of experiments but reporting satisfying figures, or citing imaginary literature. Surprisingly, many of our colleagues do not take such allegations too seriously, although they are the ones who suffer most from such unfair practices. The worst effect, however, occurs in the human environment of the professional forger's laboratory: the 'cosi fan tutti' effect. The students and postdoctoral researchers learn from their master how to deal with 'dissonant statistics' or with a scattered distribution of data caused by lousy experimental conditions—simply drop some disturbing values and get the curves straight. 'Cosi fan tutti'—everybody does it. That is unfortunately the message they may learn from this pattern of behaviour.

Consequently, the responsibility of the senior scientist to maintain the integrity of science cannot be overestimated. 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. He or she also sits on various committees, decides on appointments, and reviews grants and manuscripts submitted for publication. In short, senior scientists have a responsible and sensitive role in the scientific enterprise, pivotal to the success of modern science. In conjunction with the principles of confirmation and eventual correction of published data, their work forms the basis of the validity of scientific knowledge on which modern technological civilization is founded and still depends. As R. Stephen Berry concluded in a *Science* editorial on scientific validity and ethics, "scientific self-correction is alive and well", while "fraud and validity are separable matters" (Berry, 2003).

Scientific honesty and adhering to the principles of good scientific practice are not only essential for our work but are indispensable in gaining the respect and trust of the public. Violations of these principles are irreconcilable with the essence of science itself, but they also destroy public confidence in the scientific results on which our modern world relies. Although dishonesty in science cannot be fully prevented by rules alone, appropriate precautions can nevertheless guarantee that all those involved in scientific activity are regularly made aware of the standards of good scientific practice. This is an important contribution to limiting scientific misconduct and hopefully recognizing or dealing with fraudulent practice if necessary.

The regulations adopted by the Max Planck Society govern four main principles in scientific research: day-to-day scientific practice, relations and cooperation with colleagues, the publication of results and the appointment of ombudspersons at every institute (Max-Planck-Gesellschaft, 2000a). In their day-to-day work, Max Planck researchers are expected to follow discipline-specific rules, mostly regarding the acquisition and selection of experimental data. All primary and other important data should be clearly and comprehensibly documented and must be securely stored for at least ten years. The regulations further encourage systematic scepticism and doubt, especially about one's own results and the results from one's own group. The Max Planck Society also encourages alertness to any wishful thinking motivated by self-interest and systematic watchfulness for any possible misinterpretations or over-generalization of data.

The regulations also impose clear rules regarding relationships and cooperation with students and colleagues. Researchers must not hinder or delay the work of competitors, by, for instance, delaying reviews or breaking the confidentiality of manuscripts in the reviewing process. They should also be open to extramural criticism and doubt, careful and unprejudiced in their assessment of colleagues, aware of possible bias and should actively encourage students and junior scientists to care for their scientific qualifications.

The most frequent source of conflict is the publication of results. Publications are also the most important medium for the dissemination of research to the scientific community and the general public. The Max Planck Society's guidelines therefore require that, in principle, all results obtained with the support of public funding must be published. They also recommend and encourage scientists to publish disproved hypotheses and admit possible errors or mistakes. Furthermore, the guidelines also state very clearly that Max Planck researchers must be strictly honest in their recognition and appropriate consideration of the contributions of predecessors, competitors and colleagues.

Appointment of an ombudsperson in every Max Planck Institute has now been established. The ombudsperson should act in cases of conflict on matters of good scientific practice. He or she is the confidential advisor in cases of violations of the principles of good scientific practice and should be particularly aware of the consequences that whistleblowers may face.

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The Max Planck Society has compiled a 22-page booklet containing the rules of good scientific practice and the rules of procedures in cases of suspected scientific misconduct (Max-Planck-Gesellschaft, 2000b). When a researcher receives a contract of appointment, he or she also receives a copy of this booklet. These regulations have also been adopted by a number of universities in Germany and have been translated into Bulgarian and Japanese. Last year a delegation from the most prominent academic institution in China, the Academia Sinica, visited the Society to discuss the possibility of adopting parts of the regulations for their own rules. In this context it is interesting to see how a different cultural background modifies some of our principles and results in a different implementation of rules.

Above all, however, we must do more to reach out to the scientific community—senior scientists, postdoctoral researchers and students alike—and make them more aware of the pitfalls and consequences of fraud. Handing out a booklet with rules for good scientific practice and expecting scientists to adhere to them is certainly important, but we need to raise awareness further. I have given several lectures on this topic at national and international meetings, to junior scientists at summer or winter schools and in graduate colleges. It is indeed the younger generation of scientists, today's graduate students and postdoctoral researchers, that we have to make aware of how seriously fraud and misbehaviour can damage science and science's public image, and how it can destroy honesty and openness, the very foundations on which modern science rests.

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