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RETHINKING THE MEANING OF BEING A SCIENTIST – THE ROLE OF SCIENTIFIC INTEGRITY BOARDS AND SOME THOUGHTS ABOUT SCIENTIFIC CULTURE

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Abstract: Biomedicine is a fast moving and often challenging research field. To this extent, it seems that preserving one's integrity is becoming more and more complex and occasionally stressful for individual researchers. Highly competitive funding and publication, the commercialization of biomedicine in general, the media hype about some scientific fields, the politicization of research and higher education, and, last but not least, the increasing specialization necessary to deal with increasingly sophisticated experimental systems and technologies are aspects of this complexity. While guidelines and overseeing control boards are important regulatory instruments, which also serve to enhance awareness of scientific integrity and to increase transparency, are not sufficient to maintain and further develop a positive academic climate that motivates the community to adhere to high and consistent professional ethics. Here, scientific misconduct and misbehaviour will be illustrated by referring to well-documented cases and to the need for improving scientific culture, which will be discussed in depth.

Keywords: Scientific Integrity; Scientific Misconduct; Research Misconduct; Research Ethics; Scientific Integrity Board; Good Scientific Practice; Scientific Culture.

INTRODUCTION

According to general agreement, being a scientist implies clear and obvious ethical standards. These refer to understanding science as a self-verifying

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system, a strictly logical and objective process discovering the truth. The ideal scientist should therefore be honest, fair, open-minded, flexible, attentive, self-critical, dedicated, self-disciplined, responsible, motivated, ingenious, modest, and mindful. In short, it should be the saintly version of you and me. Furthermore, she or he should be able to keep this character over many decades in the highly competitive atmosphere of the scientific realm that is characterized by a Reward System linked to an Authority Structure[1], both relying on the efficiency principle and asking for a high degree of acculturation.

Departure from the virtuous ideals ascribed to science and scientists is now generally termed *scientific* or *research misconduct*; its spectrum ranges from outright fraud with the clear intention of deception to "minor deceptions [which] arise in virtually all scientific papers, as they do in other aspects of human life"[2]. Biomedicine appears to be particularly misconduct-prone; but eminent misconduct cases have been reported from other fields of research, too. One example is the case of Jan Hendrik Schön, a German physicist who worked at the US-based Bell Laboratories and published 80 papers in two years, several of them in *Nature* and *Science*, containing fabricated data[3].

For some experts, fraud seems to be nothing but an unpleasant epiphenomenon, a gaffe in an otherwise flawless system, efficiently controlled by science itself. "Science is self-correcting, in the sense that a falsehood injected into the body of scientific knowledge will eventually be discovered and rejected". This metaphor of a scientific immune system by David Goodstein[4] is still broadly embraced. Furthermore, Gerald Weissmann, editor-in-chief of *The FASEB Journal*, a highly prestigious biomedical journal, concluded that there is no

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1. Goodstein D, Woodward J. Inside Science. *American Scholar*, Autumn 1999; available on the homepage of the California Institute of Technology at: http://www.its.caltech.edu/~dg/science_art.html (accessed on July 9, 2009)

2. Goodstein D. Scientific Misconduct. *Academe* Online, January-February 2002, online at: http://www.aaup.org/AAUP/pubsres/academe/2002/JF/Feat/good.htm (accessed on July 9, 2009),

3. Dhand R. Does research misconduct extend beyond biomedicine? *The COPE report* 2002, p. 6-7, online at: http://publicationethics.org/static/2002/2002pdf4.pdf (accessed on July 14, 2009).

4. Goodstein D. Scientific Misconduct. *Academe* Online, January-February 2002, online at: http://www.aaup.org/AAUP/pubsres/academe/2002/JF/Feat/good.htm (accessed on July 9, 2009).

way to stop scientific fraud yet since "science is self-cleansing: flawed work is soon forgotten and remains uncited".[5] Other authors, however, are less optimistic. "With depressing regularity, the media continue to uncover cases of scientific fraud" stated Frank Gannon in an editorial with the conclusion that "honesty is the only weapon against fraud and against public mistrust".[6]

Nearly 30 years ago, William Broad and Nicholas Wade already observed that scientific fraud was quite a "regular minor feature of the scientific landscape" in their classic book *Betrayers of the Truth*. It is "a phenomenon which the conventional ideology of science could not properly account for" and the authors concluded "that science bears little resemblance to its conventional portrait". Rather, since the scientific process is sometimes quite irrational; science "should not be considered the guardian of rationality in society, but merely one major form of its cultural expression"[7].

However, the idea that science is a cultural expression of human rationality. Therefore, being part of a culture produced by human beings and influenced by socio-cultural trends is rarely acknowledged. Rather, it is still common to turn science into the search for the Holy Grail performed by untouched, super-rational priests of truth. Scientists themselves are "guilty of promoting, or at least tolerating, a false popular image" of themselves, thereby creating the "Myth of the Noble Scientist"[8]. Each story of serious scientific misconduct, *i.e.* scientific fraud, that is disclosed challenges this myth. It "reinforces a negative view held by the public and destroys their trust in the scientific system"[9].

5. Weissmann G. Science fraud: from patchwork mouse to patchwork data. *FASEB J* 20, 587-590, 2006.

6. Gannon F. Fraud in our laboratories? *EMBO reports* 8, 1, 2007.

7. Broad W, Wade N. Betrayers of the Truth. Oxford University Press, Oxford, 1982. Citations from the preface.

8. Goodstein D. Scientific Misconduct. *Academe* Online, January-February 2002, online at: http://www.aaup.org/AAUP/pubsres/academe/2002/JF/Feat/good.htm (accessed on July 9, 2009).

9. Gannon F. Fraud in our laboratories? *EMBO reports* 8, 1, 2007.

SCIENTIFIC MISCONDUCT – A NEVER-ENDING STORY

Scientific misconduct, in terms of fabrication or falsification of data and plagiarism, is a phenomenon that may be as old as science itself. Famous historical examples are Ptolemy, who seems to have used data from Hipparchos without referencing him; Galileo Galilei, who is referred to as the founder of the scientific method but appears to have relied more on thought experiments than on the empirical experiments he claimed to have performed; or Isaac Newton, who "improved" the accuracy of certain measurements (using a "fudge factor"[10]) in order to make his work more convincing, took advantage of his position as president of the Royal Society, in his fight over who first invented calculus, in order to wrongfully accuse Leibniz of plagiary over this matter.[11] Further eminent scientists, such as Gregor Mendel, Charles Darwin, Albert Einstein, Robert A. Millikan, James Watson and Francis Crick appear to have violated the rules of good scientific conduct.

In 1830, Charles Babbage, then Lucasian Professor of Mathematics at the University of Cambridge, already reflected on questionable practices in his book *Decline of Science in England and Some of Its Causes*.[12] He identified *hoaxing, forging, trimming* and *cooking* as the major forms of scientific misconduct. Whereas hoaxing and forging use inventions and fictions, trimming and cooking "optimize" observations either by "clipping off little bits here and there" or by making "multitudes of observations, and out of these to select those only which agree, or very nearly agree".[13] By current standards, this behaviour is classified as *scientific misconduct.* Nevertheless it has been argued that genius justifies the means, because "in the hands of one of the geniuses of science such practices, guided by wise judgement and remarkable discerning sensitivities, "separate the wheat from the chaff"", "resolve contradictions,"

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10. Westfall RS. Newton and the Fudge Factor. *Science* 179, 751-758, 1973.

11. A detailed and still valid analysis of these cases is found in: Broad W, Wade N. Betrayers of the Truth. Oxford University Press, Oxford, 1982, chapter 2.

12. Babbage C. Reflections on the Decline of Science in England and on Some of Its Causes. 1830. Online: http://www.gutenberg.org/files/1216/1216-h/1216-h.htm (accessed July 10, 2009),

13. Babbage C. Reflections on the Decline of Science in England and on Some of Its Causes. 1830. Section 3. On the Frauds of Observers. Online: http://www.gutenberg.org/files/1216/1216-h/1216-h.htm (accessed July 10, 2009).

and lead to “giant leaps forward”.[14] This Machiavellian attitude hardly helps to improve trust in scientific method today, although scientific culture has clearly changed over the centuries and the findings and theories referred to are evidently correct. The era of lonesome scientific heroes ended just a few decades ago when the “economic competitiveness encouraged a multidisciplinary, multi-institutional, multinational research model with multiple collaborators and therefore multiple authors”.[15]

Despite this obvious change in culture, the mythic scientific hero sometimes emerges again and is warmly welcomed by the scientific community as well as by the public. A recent example is the Korean stem cell researcher Woo-Suk Hwang. Before his fall, he had the image of a humble and hard-working man dedicating his life to science with monkish discipline. He was supported by his team which he likened to “a troop fighting the “war for humanity and curing the disease”” and he became an icon of science in South Korea and in the international stem cell community.[16] The first shadow was cast over his glory in 2004 when it was suspected that a lab member of Hwang had donated eggs for his research.[17] The full extent of the case was not revealed until the end of 2005 and severely challenged the reputation of stem cell research in particular, of science in general and of all the sophisticated means of guaranteeing scientific integrity, such as the peer-review system.[18] Moreover, the idea of “therapeutic cloning” which Hwang and his co-workers promoted with their fraudulent work is still a major pulling force in embryonic stem cell research even though the technique has not yet been established for humans. The concept is also a persistent “therapeutic misconception” that promotes the misleading view that

14. Klotz, I. Cooking and trimming by scientific giants. *FASEB J* 6, 2271-2273, 1992; cited from page 2273.

15. LaFollette MC. The evolution of the “scientific misconduct” issue: an historical overview. *Proc Soc Exp Biol Med* 224, 211-215, 2000; citation from p. 211.

16. Mandavilli A. Woo-Suk Hwang. *Nature Medicine* 11, 464, 2005.

17. Cyranoski D. Korea’s stem-cell stars dogged by suspicion of ethical breach. *Nature* 429,3, 2004.

18. For comprehensive summaries see the following references: Cyranoski D. Verdict: Hwang’s human stem cells were all fakes. *Nature* 439, 122-123, 2006; Couzin J. And how the problems eluded peer reviewers and editors. *Science* 311, 23-24, 2006; van der Heyden MAG, Derks van de Ven T, Opthof T. Fraud and misconduct in science: the stem cell seduction. *Neth Heart J* 17, 25-29, 2009.

cloning human embryonic stem cells is a therapy[19]. This clearly contradicts Weissmann's view that "flawed work is soon forgotten" and has no impact on science[20].

CLEANSING AND REGULATING AS MEANS TO REBUILD TRUST

Serious challenges to public trust in science, the scientific process, and scientists arose during the 1970s and 1980s, when cases of severe scientific misconduct in four of the major US research centres became known to the public[21]. Whereas previous investigations into such cases remained within the institutions, the publicity of these cases "drew Congressional and federal agency attention"[22] to scientific misconduct which thus became a controversial policy issue leading finally to government regulation. The scientific community reacted by setting up codes of conduct, *e.g.* Good Scientific Practice guidelines, but was reluctant to develop investigative procedures. Switching from self-control to governmental control, from inside to outside surveillance was a far-reaching paradigm shift challenging scientists' self-concept, their autonomy and the highly esteemed principle of scientific freedom. Moreover, the first political reaction to the increased awareness of scientific misconduct was blame, and not until later did the focus shift to "improving the investigatory process and developing strategies for prevention or deterrence"[23].

In the US, the Office of Research Integrity (ORI) was established in 1992 from a merger of the Office of Scientific Integrity (OSI, found in 1989 by the

19. Cho MK, Magnus D. Therapeutic misconception and stem cell research. *Nature Reports Stem Cells*, Published online: 27 September 2007 | doi:10.1038/stemcells.2007.88. Online at: http://www.nature.com/stemcells/2007/0709/070927/full/stemcells.2007.88.html (accessed on July 12, 2009).

20. Weissmann G. Science fraud: from patchwork mouse to patchwork data. *FASEB J* 20, 587-590, 2006.

21. A review on the Darsee case and the development of ORI is given in Wright DE, Titus SL, Cornelison JB. Mentoring and research misconduct: an analysis of research mentoring in closed ORI cases. *Sci Eng Ethics* 14, 323-336, 2008.

22. LaFollette MC. The evolution of the "scientific misconduct" issue: an historical overview. *Proc Soc Exp Biol Med* 224, 211-215, 2000; citation from p. 211.

23. Reviewed by LaFollette MC. The evolution of the "scientific misconduct" issue: an historical overview. *Proc Soc Exp Biol Med* 224, 211-215, 2000; citation from p. 213.

National Institutes of Health (NIH)) with the Office of Scientific Integrity Review (OSIR, found in 1989 by the Secretary of Health). This institution "promotes integrity in biomedical and behavioural research supported by the U.S. Public Health Service (PHS) at about 4,000 institutions worldwide. ORI monitors institutional investigations of research misconduct and facilitates the responsible conduct of research (RCR) through educational, preventive, and regulatory activities"[24]. ORI appears to be by far the most advanced institution dealing with scientific integrity worldwide, offering numerous programs and a wealth of information via its homepage (http://ori.dhhs.gov/). Investigations or oversight reviews of some 800 formal cases of alleged misconduct in research were conducted by ORI since its inception in 1992.[25]

As with every human endeavour, even the procedures used by ORI and its predecessors had serious shortcomings which became painfully clear in the so-called Baltimore case[26] and led to deep reorganization of the institution. However, as it was put in a *Nature* editorial, this "system, imperfect as it may be, is still more advanced than that of many other nations", an issue which was reaffirmed in the Hwang case.[27] The systematic work of ORI and of expert committees like the Ryan Commission revealed the shortcomings of several definitions and the necessity to install surveillance as well as to investigate the deeper reasons for misconduct and to provide positive instruments like educational programs for improving standards of research ethics.[28]

In most European countries, scientific communities traditionally prefer to rely on intramural investigations and on the codes of conduct set up in the late 1990s in most institutions and universities[29]. A recent survey by the European

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24. Cited from ORI's homepage, online under: http://ori.dhhs.gov/ (accessed on July 14, 2009).

25. Wright DE, Titus SL, Cornelison JB. Mentoring and research misconduct: an analysis of research mentoring in closed ORI cases. *Sci Eng Ethics* 14, 323-336, 2008.

26. The complexity of the case is analyzed in Kevles D.J. The Baltimore Case. W.W. Norton & Company, New York, London. 1998.

27. Editorial. Ethics and Fraud. *Nature* 439, 117-118, 2006; citation from p.117.

28. More information on several programs and definitions at http://ori.dhhs.gov/

29. Representative bases are the guidelines of the European Science Foundation. Good scientific practice in research and scholarship, European Science Foundation Policy Briefing 10, December 2000; PDF available online at: http://www.esf.org/publications/policy-briefings.html (accessed on July 14, 2009).

Science Foundation (ESF)[30] summarized the provision of guidance and promotion of scientific integrity in 32 European countries by scientific organizations, excluding universities. The study focused on (1) codes and guidelines to promote good research practice; (2) activities and policies of institutions and bodies with responsibility for research integrity; and (3) explicit procedures to handle allegations of research misconduct at an institutional and national level. The survey underlined that measures to ensure good research practice in Europe are quite inconsistent. However, the European Commission has called for the development of a coherent approach to promote and safeguard good research practice in Europe. A number of countries, *e.g.* several Scandinavian countries, the Netherlands, England and, most recently Austria, have established independent scientific integrity boards, agencies, committees or expert groups to deal with alleged misconduct.

Responsible conduct of research (RCR) as well as the investigation and prevention of scientific misconduct have by now become a science in itself. For those scientists who are involved in setting up institutional guidelines and procedures, this field became a "virtual academic subspecialty"[31]. Globalization implies a harmonization of international efforts to promote scientific integrity and a series of international conferences on RCR were recently held and will be held in the near future.[32] Scientific integrity boards and institutions have become major players in governing science and huge administrative bodies and organizations have been set up. However, is this top-down effort based on announcement, control and deterrence, this often "pious hand wringing and angry finger pointing"[33] really an efficient remedy for preventing misconduct and improving integrity in science?

30. European Science Foundation. Stewards of Integrity. Institutional Approaches to Promote and Safeguard Good Research Practice in Europe. Strasbourg, 2008; online at: http://www.codex.vr.se/texts/StewardsOfIntegrity.pdf (accessed on July 13, 2009).

31. Goodstein D. Scientific Misconduct. *Academe* Online, January-February 2002, online at: http://www.aaup.org/AAUP/pubsres/academe/2002/JF/Feat/good.htm (accessed on July 9, 2009).

32. Office of Research Integrity Newsletter, 17 (2), 3, March 2009; online at: http://ori.dhhs.gov/documents/newsletters/vol17_no2.pdf (accessed on July 13, 2009).

33. Weissmann G. Science fraud: from patchwork mouse to patchwork data. *FASEB J* 20, 587-590, 2006; citation from p. 587.

SCIENCE AS CULTURE

According to a recent meta-analysis[34] of 18 surveys on severe scientific misconduct (here defined as fabrication and falsification of data but excluding plagiarism), 1.97 % of scientists "admitted to have fabricated, falsified or modified data or results at least once" (serious scientific misconduct) and "up to 33.7 % admitted other questionable research practices", such as having "modified research results". If reporting on the behaviour of colleagues, the respective numbers were 14.12 % for falsification and up to 72 % for other questionable research practices. Misconduct was reported more frequently by medical/pharmacological researchers than others. The author concludes that this is "a conservative estimate of the true prevalence of scientific misconduct".

Looking beyond falsification, fabrication and plagiarism, another study[35] analyzed 3,247 responses from early- and mid-career, US-based, NIH-funded scientists about their participation in a wider range of questionable research practices. Among the top ten behaviours identified, "overlooking others' use of flawed data or questionable interpretation of data" and "changing the design, methodology or results of a study in response to pressure from a funding source" were admitted by 12.5 and 15.5 % of scientists, respectively. Other common behaviours were "publishing the same data or results in two or more publications, inappropriately assigning authorship credit, withholding details of methodology or results in papers or proposals, using inadequate or inappropriate research designs, dropping observations or data points from analyses based on a gut feeling that they were inaccurate, and inadequate record keeping related to research projects". In summary, 33 % of survey respondents admitted to one or more of the top-ten behaviours that extend the classical concept of misconduct defined as falsification, fabrication and plagiarism. The authors concluded that important factors, such as inequities in resource distribution, and structures in the scientific environment obviously promote scientific misconduct.

Biomedical research has numerous characteristics which may explain why it

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34. Fanelli D. How many scientists fabricate and falsify research? A systematic review and meta-analysis of survey data. *PLoS ONE* 4(5): e5738. doe:10.1371/journal.pone.0005738, 2009.

35. Martinson BC, Anderson MS, de Vries R. Scientists behaving badly. *Nature* 435, 737-738, 2005.

is particularly afflicted by misconduct[36]: (1) scrutiny is complicated by the complexity of experimental systems, the use of biological materials and sophisticated methodologies; (2) research in compartmentalized laboratories, e.g. sequencing centers, increases efficiency but dilutes responsibility; (3) the increasingly inter- and trans-disciplinary nature of the work makes it more difficult to assess the quality of colleagues' work; (4) biomedicine is highly competitive urging rapid and sometimes premature publication and intense competition for scarce resources; (5) publicly and privately funded endeavours are intertwined, financial interests and intellectual property play an important role, and clinical research is controlled by the industry; (6) the pressure to produce positive findings, the difficulty in publishing negative results and the request to "sell" basic research as directly applicable raises false hopes and leads to exaggerated expectations; (7) the "publish or perish" mentality, impact factors and number of publications and citations have become crucial career factors even at an early stage in one's career which leads to conflicts over authorship; (8) publishing in top journals like *Nature* or *Science* has become an end in itself; (9) scientists may be tempted to exaggerate results in order to catch the attention of editors; (10) publishing in high-impact journals is important for attaining visibility within both the scientific community and the general public; (12) media visibility justifies research expenditures and is therefore actively propagated by universities and funding bodies. Franzen et al. conclude what scientists know from experience: "institutional conditions might encourage scientists to cut corners", and "open discussions of fraudulent cases, the creation of oversight agencies and the codification of the scientific ethos might be useful in regaining public trust in science" but are "unfit to restore trust within the scientific community" and may lead to a "spiral of mistrust" as is indicated by increasing numbers of allegations while the number of proven cases has remained quite stable over the past years. Moreover, the "institutionally induced deviant behaviour of many scientists" resulting in a culture of "everybody does it" could lead to "imprinting of normal misbehaviour" in "future generations of scientists". In other words, as a result of the current scientific culture the number of senior scientists acting as negative role models for the younger generation seems to be increasing.

36. Franzen M, Rödder S, Weingart P. Fraud: causes and culprits as perceived by science and the media. *EMBO reports* 8, 3-7, 2007.

Against this background, it is not surprising that researchers from major US-universities did not identify falsification, fabrication and plagiarism as the most troubling issues but felt that everyday problems were major challenges, *i.e.* (1) the interpretation of data; (2) the rules of science; (3) life with colleagues and (4) pressures of production.[37] Moreover, the negative effects of competition such as "strategic game-playing [..], a decline in free and open sharing of information and methods, sabotage of others' ability to use one's work, interference with the peer-review processes, deformation of relationships, and careless or questionable research conduct" jeopardize scientific integrity.[38]

In conclusion, regulatory boards such as scientific integrity boards and the advanced training of students and staff are important means to elevate the standard of research conduct. In place of the current climate of mistrust and competition which focuses on deficiencies in individual scientists, a positive environment that allows developing their personal skills and attitudes should be fostered. A more supportive scientific culture could be created by reducing competition, developing instruments of evaluation that rely on quality rather than on quantity, reducing the student/mentor ratio, reducing administrative and teaching duties, and offering long-term perspectives for funding and a career structure for young scientists. This might be even more efficient in terms of costs and scientific insight. Focussing on the scientific process instead of the prestige that might accompany its results is usually much more rewarding for most scientists. One may assume that positively motivated scientists are less prone to scientific misbehaviour than stressed ones.

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37. de Vries R, Anderson MS, Martinson BC. Normal Misbehaviour: scientists talk about the ethics of research. *J Emp Res Hum Res Ethics* 1, 43-50, 2006.

38. Anderson MS, Ronning EA, de Vries R, Martinson BC. The perverse effects of competition on scientist's work and relationships. *Sci Eng Ethics* 13, 437-461, 2007.