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Will/May Quality Suffer from Moral Demands?

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I. Foreword

Gérard Toulouse

This title in form of a double question was proposed by the Yearbook Editors and it has been well received by our recently rejuvenated 'Science & Ethics' committee. As the reader will readily observe, the task assigned has been seized as an opportunity to stimulate intellectual cooperation and to bring several major concerns to the fore.

In accordance with our science-and-ethics viewpoint, quality will be understood henceforth (unless otherwise stated) as professional scientific quality. Moral demands addressed to science may arise from various sources, 'external' (from society, in short) or 'internal' (from within the scientific community).

As a necessary background, it should be recalled that scientific quality suffers first and foremost from immoral attacks: invasive external pressures and internal cases of misconduct. Steadfast resistance, against these corrupting factors, whether from without or within, is a constituant part of the scientific ethos. In recent years, increased attention has been given to the promotion of 'good scientific practice in research and scholarship' (ESF, 2000), also called 'scientific integrity'

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(KNAW, 2001), to quote two recent European documents. That domain belongs to science deontology.

In contrast, ethics may be defined as the arbitration between conflicting logics, interests, values, allegiances. In this light, our title appears central within the science-and-ethics field, insofar as it points to potential conflict between scientific excellence (supreme professional value for scientists) and other moral demands.

Although the distinction between deontology and ethics does carry relevance, I must hasten to say that it does not affect the general unity of ethical thinking. Consider, for instance, the following version of our question: May disciplinary quality suffer from moral demands? Many scientists and scholars have experienced recurrent debates around this theme, which pertains both to deontology (fair-play within academic institutions) and to ethics (balance between different disciplinary 'qualities').

In summary, with the above definitions, the question - Will/May overall quality suffer from ethical demands? - would be answered by the negative (assuming ideal collective ethical process). If only because one prime purpose of ethics is precisely to reach fair adjudication over conflicts of values.

Let us now turn to consideration of some concrete issues. Firstly, one cannot avoid mention of the historical aberrations of eugenics, the 'science' devoted to the improvement of the quality of living beings, through the control of genetic factors. For many decades, various projects of human quality betterment via eugenics were advocated as rational responses to social and moral demands. This fateful story should serve as a reminder about a major danger: the mismeasure of quality. Racist eugenics is no longer fashionable, but genetic engineering of plants, animals, or human individuals, is becoming evermore present on our horizon. And the problems posed by proper quality assessment are still with us.

Ironically, the scientific emphasis on objective, quantitative measurements, has now backfired on scientists, with the spread of quantitative evaluation tools (through citation indexes and impact factors) of research quality, not only for institutions but also for individual scientists.

To a large extent, the tension between scientific quality and moral demands is linked to the tension between freedom and responsibility. Responsibility begins with a capacity to respond to questions, and first

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to moral demands. The aspiration to freedom and independence leads to a claim for autonomy, but this legitimate claim is abused when it allows for closure into an impunity culture, i.e., a culture of irresponsibility.

Many seminal views about *European science and scientists between freedom and responsibility* were collected in the proceedings of the Amsterdam Conference organised by ALLEA, in December 1997 (Drenth et al., 1999). Our Committee has made a plea in favour of an *Amsterdam+X Conference* (around 2004, with X = 7), which would build on the landmark of the previous event to start the tradition of a regular series of European gatherings, devoted to collective reflection on deep and important issues, in symbiosis with the establishment of a European Research Area.

Certainly, the responses of scientists to moral demands should not be construed as restricted to the category of suffering! Scientific quality may and does often benefit from moral demands. Ethical questioning is a creative activity.

John Selborne's contribution (next section) is based on a talk presented during a Colloquium on *European scientific community: Toward fair play practices,* organised by our ALLEA committee in association with Euroscience, and European National Commissions for Unesco (Maison de l'Unesco, Paris, October 27, 2001). His paper on *Stakeholder participation in a global agenda for science and technology* provides a neat instance of positive response to moral demands, i.e., an illustration of enlightened convergence between morality and creativity.

Finally, a few remarks about method. Science and ethics are human endeavours, with one deep similarity. Rightness, like truth, is an asymptotic goal, to be approached patiently, modestly, honestly. In ethics, as in science, quality depends much on proper methodology.

The reader may be curious to know how our European committee attempts to make headway, in its complex missions. One focus is on best practices: exchange of experiences and comparative analyses (e.g., on codes of conduct, formation in ethics, etc.). Our membership diversity is a great asset.

Stakes of power are left out of our deliberations. Every member is assumed to participate with good faith and good will, and to bring a sincere care for fair-play (between disciplines, regions, cultures, genders, generations). On this shared common basis, without any imposed constraint, every member is invited to present his/her personal perception of the priorities. Such disposition favours an open, genuine and congenial spirit; and this empiric method seems to prove apt.

The elaboration of our main contribution to this Yearbook started with a cooperation between two astrophysicist colleagues from East and West: Ene Ergma is Vice-President of the Estonian Academy of Sciences and Lydie Koch-Miramond (Saclay, France) chairs the (newly set-up) Euroscience working group on ‘Ethics in science’. At mid-course, the philosopher Beat Sitter-Liver accepted to offer his complementary skills, together with his multicultural experience as Secretary General of the Swiss Academy of Humanities and Social Sciences, and of the Council of the Swiss Scientific Academies.

As a result of this joint elaboration process, *Science, morality, and qualit; Some outline queries* assembles views coming from an usual diversity of origins; and it has become more than the sum of its parts.

II. Stakeholder Participation in a Global Agenda for Science and Technology

John Selborne

This contribution seeks to address the issue of equity between stakeholders in science and technology. National governments have most successfully generated wealth creation from the output of science and technology. This has manifested itself in the shape of expanded economies, greater employment and national defence. The sciences have also been harnessed to the improvement in quality of life particularly in the case of the medical sciences. Producers (including agriculture and industrialists) have been able to implement science and technology to transform their businesses. Consumers in advanced economies and in many developing countries have greatly benefited from the range of products and services now on offer.

A further stakeholder which has to be represented in deliberations on science policy is the environment. We need to maintain ecosystems on which ultimately life depends. Our concern about the hole in the ozone layer and the threats of climate change demonstrate that science has a fundamental role in monitoring and informing appropriate policies to protect our planet's life systems. Loss of biodiversity would have far reaching consequences for future generations.

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However there is one further group of stakeholders who have not benefited from science and technology. There remain one billion people who are either malnourished or starving. Half a billion in the world have no access to energy and therefore inadequate access to fresh water or to the fundamental requirements for food production and processing. Why is it that the benefits of science and technology have not been appropriated for the benefit of this very significant minority of the global population? It is easy to blame the failure on poor governance and indeed much of the failure can be attributed to a failure to create the appropriate infrastructure or to provide adequate political stability. However this is not a sufficient response.

Science and technology itself have a responsibility to ensure that all stakeholders are able to inform the debate on what is the appropriate agenda for science policy, on a local, regional and national basis. Most of the world's science and technology is funded by large multinational companies, by first world governments and by major charities. With the exception of larger medical charities, these fund-providers of research have only a limited concern in meeting the needs of those sectors of the global community who, at the moment, lack the fundamental requirements for a sustainable life.

I chaired the UK Agricultural Research Council in the 1980s at a time when the British Prime Minister Margaret Thatcher was keen to ensure that our research contractors, whether they were research institutes or universities, successfully exploited their intellectual property rights. This, in turn, meant that these research contractors were required to auction their intellectual property to the highest bidder, which tended to be a multinational company. Yet if we take, for example, new biotechnology, the application in food production - which is perhaps most relevant to global security - is for developing agricultural systems for marginal agriculture and for crops which are not traded on a global scale.

These research applications can only be developed on a regional basis where the long-term trials and field work can be put alongside strategic research. I saw to my concern that, at least in the United Kingdom, the opportunities for the biotechnology to benefit those in the greatest need were reduced by this requirement to maximise research income.

It is by no means inevitable that the benefits of science and technology should be so heavily balanced in favour of the prosperous

North. The improvements in transport, including motor vehicles, rail, shipping and space have been of little relevance to the sector to which I refer. Our own life styles and daily activities have been transformed by the many opportunities for wealth creation and for leisure activities. Medical sciences have produced benefit for most of us and there have indeed been opportunities to help the disadvantaged. Some of the impacts on the environment to which I have referred, loss of biodiversity, holes in the ozone layer, climate change, arise from an inappropriate use of new technologies. The depletion of natural resources has implications for future generations which are very often inadequately addressed.

There needs therefore to be a global concept of a stakeholders' forum for science and technology which takes into account not only the existing beneficiaries of developed countries but also those sectors of the communities excluded at this point in time from this dialogue. This includes not just those one billion people who lack adequate food but also the interests of future generations and of our natural environment.

The concept of a dialogue between stakeholder and consumers is a fashionable concept at present. I chair the UK Chemical Stakeholder Forum which allows all sections of the community to give its views on those existing substances which might be deemed bioaccumulative, toxic, persistent or otherwise of high risk. We seek to ensure that there is public participation in the determination of how these risks should be managed, and how chemicals should be tested and how the data should then be used.

Scientists have not always welcomed what they sometimes consider as an uninformed contribution from the lay public. Yet the debates that we have had in the United Kingdom arising from BSE (Bovine Spongiform Encephalopathy) and Chernobyl, to name just two examples, have demonstrated the urgency for scientists to engage in dialogue with the wider public. We need therefore to widen the concept of public participation not just to regions such as Europe where it is relatively simple to put in place an appropriate mechanism. We need to think how this can be done in areas where science has not in the past engaged in adequate dialogue. I would start with universities and research institutes and build an outreach programme of dialogue, consultation and involvement. For example UNESCO's COMEST (World Commission for the Ethics of Scientific Knowlege and Technology) is developing a fresh water initiative called RENEW which identifies best

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practice, be it in research and development, in education, in regulation or in local participation of policy issues and which encourages this best practice to be applied elsewhere in the region. There is already one such group based in Australia and the Pacific Islands, and another group is starting soon in Scandinavia and the Baltic States. A third group will be set up soon in Egypt. I have no doubt that such groups will help determine a different set of priorities for research and development than that which might have recommended themselves to Mrs Thatcher.

Take for example the simple requirement to make energy accessible to a much wider section of the world community. A number of existing technologies offer a potential to assist progress. They span electricity generation, transmission, storage and metering. They include lower capacity limited current systems, single wire earth return systems, gasifier and certain hybrid systems. In the longer term research on small gas turbines and fuel cells appears to have great potential. Equally the potential for solar and wind power is high though the research must be appropriate to regional requirements, hence the need to have local involvement.

I return to the subject of new biotechnology and its application for food production and processing. I would like to see those countries which are spending public funds on biotechnology research consider whether the intellectual property rights should be transferred as part of gift aid to appropriate academies of science in the developing world. This would ensure that the decision as to what application, if any, might be made of this science would be made by those with the greatest interest and the greatest stake in the future of the region.

I chaired a conference in Bangkok in July 2001 on new biotechnology and its application for agriculture and food. Inevitable the debate was polarised between practitioners in the United States, China, Argentina, Australia and those who were more cautious from parts of the world who had not yet embraced this technology. There were also a large number of participants from third world countries and their attitude was that they would like to have a greater input in determining how this technology could be more adequately applied to their needs and to make their own risks assessments on human health and on the environmental impact.

I make a plea therefore for dialogue and involvement of all stakeholders in setting a global agenda for science and technology. This should challenge both governments and the existing science infrastructure to question whether or not the interests of the environment and of future generations, as well as the interests of the most deprived of the world are indeed adequately included in the dialogue determining science policy.

III. Science, Morality, and Quality: Some Outline Queries

Ene Ergma, Lydie Koch-Miramond and Beat Sitter-Liver

In search of a new balance

Immanuel Kant once said that there are two things that fill our hearts, over and over again, with wonder and respect: the starry sky above and the moral law within us (Kant, 1788). In contradistinction, Robert Musil has rendered famous the dichotomy between the world of science and that of life, in his celebrated novel *Der Mann ohne Eigenschaften*. Insofar as the scientist's first priority is professional excellence, any consideration of social responsibility, not to mention moral demands, is often scornfully rejected as irrelevant. This self-protective attitude was unknown to the founding fathers of modern science, Descartes and Bacon especially, but also to many excellent scientists and engineers up to our time. It emerged when the Janus face of science and technology appeared, notably during World War I, when the use of asphyxiating gases initiated the suspicion of unethical conduct among scientists.[1] The idea of science not being devoted exclusively to the welfare of humanity came to the public and it has remained an explosive topic, attracting particularly widespread attention, for example with gene technology, embryonic stem cell research and possible cloning of humans. We must admit that reconciling scientific and technical contemporary discoveries with respect for human dignity implies some decision as to the question of freedom of research. The first claim - both rational and emotional - is that the thirst for knowledge is part of hu-

[1] Fritz Haber, Chemistry Nobel Prize winner in 1918, admitted having been one of the principal supporters of the use of gases for military purposes.

man nature. Satisfying this desire belongs to what we call the basic rights and is therefore among our highest values. However, as J.-J. Salomon recalls, the right to be informed and to give information, and to freely express one's findings and opinions does not imply the right to act according to those opinions, if others are affected by their consequences. Freedom of opinion is not freedom of action. The latter demands a 'correlative responsibility' because of the dangers it involves.[2]

Moral demands made on scientists by themselves, by scientific institutions and by society at large appear inescapable. What we learned from the effects of 20th Century development of nuclear physics; what we are confronted with - through the breath-taking advances of molecular biology and biotechnology - has made this a truism. The first entails a second truism - although frequently contradicted and declined by members of the scientific community laying a blind-eye stress on the principle of freedom of research. Only in complying with moral demands will we be in a position to ascertain a proper balance between freedom of research and the social responsibility of scientists.

Quality of research, moral obligations and 'big' money

In science (more than in scholarly endeavours) the quality of research work depends largely on the amount of the resources allocated to it. Looking at the recent past (and confining our view to public funding), we identify two large investments made by governments that led to enhancement and acceleration of research.

More than fifty years ago two atomic bombs were dropped on Japan. That event changed the relationship of science and society to remarkable degree. As a result of the bombing, scientists came to be viewed as actors in an 'evil plot', leading to an enormous moral dilemma for the scientist in relation to military applications of his/her

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[2] Colloque *Science et droits de l'Homme* sous l'égide d'Euroscience et de l'Unesco, avec le patronage de l'Académie des Technologies, de la Commission nationale française pour l'Unesco et de la Fondation La Ferthé (Maison de l'Unesco, Paris, 8-9 mai 2001). Proceedings to be published by the Editions de la Maison des Sciences de l'Homme.

research. The dilemma grew acute and of general concern so as to reach even the stage.[3]

> The atomic bomb was unique in many respects, particularly in the speed with which a discovery in fundamental physics was put to use (a real dream nowadays). A few short years transformed an abstruse piece of theoretical physics into the most devastating weapon the world had ever seen. No longer would scientists, conducting pure research for its own sake, be ignored on the grounds that their work was not relevant to the real world (Atiyah, 1995).

In line with this acknowledgment the urgent request to assume moral responsibility and to accept legal liability, addressed to scientists in general, has been heightening. Even though the development of nuclear power stations and hence the emergence of a new source of energy seemed to restore scientists' reputation, the problems and dangers associated, e.g., disposal for thousands of years of long-life threatening wastes, throw their shadows on it. Then the Chernobyl disaster dealt a devastating blow to that positive effect. The more it became transparent that application of scientific findings not only served humane objectives, but was often motivated and promoted by heavy and mostly private economic interests, trust in the good intentions of all members of the scientific community started fading away. Given that nowadays 'big' money and big science go openly hand in hand, the moral trustworthiness of science is even more subject to questioning. But science does occupy an important position in modern life. Public trust must therefore be restored, not so much by propaganda and early promises, but much more by modesty, openness, transparency and a sincere pledge to the traditional ideal of seeking common good.

There is another area in which science is very close to military and industrial collaboration: the space industry. A thriving space industry will inevitably lead to extensive cosmic research and, as a result, deeper human understanding of the universe. However, it is quite clear that this progress has been largely (and still is) determined by military needs. Alongside nuclear research, the space industry also produces very powerful weapons of mass destruction (e.g., intercontinental rockets). At the same time, it is interesting to note that public opinion is generally much less critical about space programmes than it is about nuclear research. Indeed, space research yields many benefits, for in-

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[3] Cf., e.g., Friedrich Dürrenmatt's *The Physicists*, 1962.

stance, starting from pure scientific interest in astronomy and ending with telecommunications. Thanks to the excellent work conducted by the PR sector of the astronomical community, space research has succeeded in acquiring favourable publicity [the Hubble telescope pictures, information from NASA, ESO (European Southern Observatory), etc.]. Against this background, the unfortunate accidents with cosmonauts have been viewed by the general public as catastrophic, however inevitable - in the light of much hoped for progress. And we should not forget the fascination - a substitute of religion (Mutschler, 1998/99) - by extremely intricate and sophisticated technology. This might sound cynical, but there certainly is an acquiescing effect of the fact that many more people get killed in car accidents each year than in the rare though sensational misfortune of the space adventure. Fortunately enough, humankind has not yet had to suffer, for example, because some space device fell inadvertently and unpredictably on a large city, causing devastation and loss of life. It is not unusual that moral advertency is aroused by acute danger and bad luck. We can but hope that in the context we are discussing, it will develop spontaneously and in due time. Actually, this worry is only one among others caused by the accumulation of space debris.

To sum up, it seems that public opinion is influenced by and learns from only those events that have already occurred but is unaware of the risks that may lie ahead. This may also be true for scientists. But if not, then the question arises as to whether it is the scientists' moral duty to warn the people of such dangers.

The mismeasure of competence and quality

Throughout history, examples abound where science has been repressed because its research results did not find favour with ruling ideologists, or did not serve the interests of the economic or political authorities (Drenth, 1996).

When Galileo Galilei published his *Dialogue concerning the two chief world systems* in 1632, he was of course referring to the heliocentric and the geocentric models of the universe. But as he rapidly found to his cost, the debate went much deeper than trivial matters of astronomy. The old geocentric view of the universe underpinned (for no particularly good reason other than tradition and power) the tenets of the

Christian Church. It stood for former certainties, as the emotional crutches that religions have provided for us since the dawn of human history. The continuing interest for this debate today might originate in our failure to come to terms with the Enlightment's discovery that the human species is not, after all, the centrepiece of the universe, the reason for its existence (Dunbar, 1995).

The origin of our modern theory of chemistry provides another example. We owe this to Antoine Lavoisier, a businessman, tax receiver and occasional geologist who, in 1775, was appointed by the French government to oversee the production of gunpowder at the National Arsenal. He completely reorganised the manufacturing process at the Arsenal to produce the best quality powder in Europe - not to mention the Americas, where French gunpowder materially contributed to the defeat of the British colonial masters in the war of independence. The theory of chemistry emerged as a by-product of Lavoisier's practical work, aided and abetted by a bit of curiosity about what happens when substances burn. It was Lavoisier's bad luck to be a tax receiver for the monarchy in the days immediately before the French Revolution. He was tried in 1794 before a revolutionary tribunal and guillotined, with his father-in-law the same afternoon. He was fifty-one years old. In the words of the mathematician Joseph-Louis Lagrange, the following day: *It required but a moment to sever that head, and perhaps a century will not suffice to produce another like it* (Dunbar, 1995).

These two stories are among the classical references supporting the claim of modern science to independence from external powers: religion, law, politics, etc. This well-founded and respectable aspiration to autonomy is overplayed, however, when it fosters an impunity culture.

Was Galileo in a position to anticipate the effects of his scientific discoveries, liberating as well as endangering ones? They were of such fundamental and deep-reaching nature that we may answer by the negative, freeing him of an important part of his moral responsibility. This does not seem to be the case with Lavoisier: his scientific achievements with gunpowder were much more limited and focussed. He could have imagined at least some of their devastating consequences. Yet we would not hold him responsible for them, but for the lack of issuing appropriate warnings. However, these very consequences might have brought him proud and public acclaim: the historic situation in which scientists act, with its expectancies, values, concepts, and longings, has always fashioned the general moral alertness. It may lead the public opinion to forcing scientists to answer for things that simply lie beyond their competence (Lavoisier's case, at least to some extent). And yet we know that scientific excellence has never been a guarantee of moral, let alone ethical expertise. The corollary in our scientific and technological culture is evident: scientists ought to be educated in such a manner to become true moral experts.[4]

Should scientists opt for and support moratoria?

Uncertainty and risks are inherent elements of scientific and technological adventures. It is a truism that new and promising borders cannot be reached without accepting the unknown with its impending unwanted outcomes. Yet at a time where scientific skill and technological power have reached present levels, the truism no longer is a good argument for neglecting reasonable circumspection and reserve. In 1997, Anne McLaren asserted that it was mandatory to implement 'slow-go areas' and 'no-go areas' and she gave convincing examples. The abovementioned controversies about human cloning, stem cell research but also the use of genetically modified organisms in agriculture and food production may be at the forefront for the general public. Settling such controversies is an urgent task the burden of which lies on all those capable of participating in an open and in the end political debate. The issue must involve a multidisciplinary approach. Confrontation of interests and competencies is inevitable. Scientists nonetheless have to comply with particular demands resulting from their expertise: having accepted the onus to engage in disinterested search for truth and to distinguish clearly between what is right or wrong, they ought to neutralise, as far as they can, the different interests tying them to their own needs as well as to various external loyalties. Where uncertainty with regard to outcomes and risks becomes high, they ought to opt, as Anne

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[4] It is a yet open question whether an oath for scientists could be a profitable element of such an education. In 1999, Arnold Wolfendale, president of the European Physical Society, wrote: "*I am not so naive as to think adoption of an oath of this sort would solve all our problems, but at least it would be a start. Something will have to be done, that's for sure.*" (cf. The Scientist's Oath, President's column, *Europhysics News*, Nov./Dec. 1999). He proposed the following oath: "*I will not, knowingly, carry out research which is to the detriment of humanity. If, in the event, research to which I have contributed is used, in my view, to the detriment of the human race, then I shall work actively to combat its development.*" Such a moral demand would not be detrimental to the scientific quality of research.

McLaren suggested, for a 'no-go area', which implies, if not a definite stop, then at least a moratorium. More than twenty years ago, the German philosopher Robert Spaemann (1979) provided them with a useful criterion: in a controversy, dissenting scientists have to stand up publicly against arguments that they do not consider convincing. Although being a minority, they thus permit the non-specialists to distrust the persuasive force of majority arguments. In doing so, scientists do not enforce a moratorium on themselves, but they free the way that might lead to a rational decision in a field where not only rational attitudes and actions prevail. This is what they may be rightly expected to perform, insofar as it is in line with their professional qualification and distinction.

Quality assessment

It is not just in their relation to society at large that scientists are bound by moral demands. The scientific community forms, of course, a social entity with its particular ethos and moral rules and this under various aspects. One of the latter has gained extraordinary weight over the past two decades. We therefore wish to dedicate it as our concluding discussion.

It is well known that evaluation procedures occur at all levels, from national research and development systems to institutions, individual research groups or researchers. Results of an evaluation touching individual researchers are particularly important for young scientists (e.g., applying for a postdoctoral position), but as well for senior scientists (e.g., in quest of a tenure). Large research groups and institutions requiring funds for their research and development projects depend on quality assessment alone by national research councils or by international funding agencies. Considering the routine, the significance and the impact of evaluation procedures the most pressing question arises quite naturally: how should the individual rating of researchers be fashioned and realised in order not just to assess output quality but also to meet moral standards resulting from respect due to those evaluated? And how do we avoid or neutralise the influence of external, though quite human factors, in the assessment process? Today evaluation procedures are commonly based on the examination of a number of output criteria, including the number of the applicant's publications in well-known, peer-reviewed international journals with a high impact factor; the presence in citation indexes; the success rate of grant applications both in the domestic and in the international market; the success rate of patent applications, and the number of doctoral and postdoctoral students involved. The significance and the weight of each of these indicators may vary, depending on whether the research project centres around more basic or more applied inquiries.

Recently, Alessandro Figà-Talamanca (2001) discussed the role of the so-called 'impact factor' in the evaluation of research projects. He argued that the cost of an uncritical application of this criterion far exceeded its supposed merits; it could cause significant damage to the scientific system as a whole. More than fifty years ago, Robert K. Merton, a renowned sociologist of science, compared citations to a science currency. Today, this metaphor seems totally outdated, the main reason being the introduction of citation indexes as an instrument of evaluation. The use of citations in the social context of the science system has completely changed: with a view to common evaluation practices, it is often enough driven by well-informed strategic and vested interests. As a matter of fact, many of today's citations can be passed or else substituted by quotes from other sources. When assessing the value of the impact factor by analysing citation indexes it would be imperative to recall what Virginia Trimble pointed out that citation of texts on important discoveries very soon disappear from scientific articles for the simple reason that they have become classical. Every specialist knows and uses the results. In physics, for example, everybody is well acquainted with the *Landau level*, and in astronomy the *Chandrasekhar limit mass* is commonly known and few authors would refer to the original paper.

Quite obviously, assessing the impact factor of scientific journals and science citation indexes is biased by the sheer number of researchers involved in different research areas. Scientific communities for chemistry, molecular biology, or plasma physics are quantitatively much more important than the respective community in pure mathematics, to give just one example. The *Annals of Mathematics,* the periodical that published Andrew Wiles' proof of the last theorem of Fermat has a low impact factor. In contrast, it may occur that a paper is frequently quoted because it outlines a new and broadly helpful method. For example the Chemical Abstracts Service database record showed that up to 1999 the most frequently cited article was by Laemmeli, published in *Nature* in 1970. It proposed an improved method for polyacrylamide gel electrophoresis based on a process to break down proteins into their individual polypeptide chains. This method has been used in many projects and in consequence has been referred to in many papers, leading Laemmeli to his top position in the citation index. In contrast, this database does not highlight any article written by one of the recent Nobel prize winners among the list of most frequently quoted papers.

Circumspection and high competence will be demanded of those deciding about careers and grants allocation would they equitably use these quantitative evaluation tools. A very careful treatment ought to be the maxim. And certainly using citation indexes and the impact factor of journals should not provide the main argument in an evaluation procedure. They are not to be used for comparisons outside of a very homogeneous group. This request is not more than an outflow of the idea of 'good quality assessment practice'.

But what exactly is the ethical consequence of all these statements? Since referring to the impact factor and to citation indexes does not seem to be an all too relevant tool, but certainly an instrument possibly causing harm to many researchers, that whole rating system ought to be suspended, at least for a certain time, so as to allow revision and thorough reform, and this out of ethical reasons shaped by the principles of fairness, of equity, of doing no harm - all of them leading and commonly accepted principles of everyday morals and ethics.

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