

Scientific revolutions and moral revaluations

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The title of our Symposium is further proof of the emergence of an ethical movement in the sciences. My contribution attempts to provide some original perspectives on this major phenomenon, and its scope will cover both general and practical questions.

A comparison will be sketched between science and ethics, taken as social and historical enterprises, via the notion of *moral revaluations*, viewed in a relationship of similarity/contrast with the older notion of *scientific revolutions*. The practical benefits of such an enlarged perspective are to make it easier, for scientists and other citizens, to grasp and fully understand what is at stake, and to become stakeholders in this collective process.

1. Science and ethics

At the start of Western modernity, in Italy, the very concept of *Rinascimento* implied considerations on processes of decadence and progress. The pioneers of modern physics (Galileo, Newton), while acknowledging their ‘standing on the shoulders of giants’, were well aware that their achievements amounted to a scientific revolution. Later on, during the Age of Enlightenment, ardent debates opposed meliorist philosophers, contemplating continuous joint intellectual and moral progress, against skeptics *à la Rousseau*, claiming that science was corrupting morality and arguing for the merits of *blissful ignorance*.

A third doctrine, which became quite widespread, and remains endemic nowadays, asserts that the relation between science and ethics is neither positive nor negative, but actually null by essence. Science is about facts, and thus is indicative. Ethics is about values and norms, and thus is imperative. Therefore (so the argument goes) science and ethics belong to different tenses, and are unfit for conjugation.

However, during the last eight decades, growing waves of concern about the connections between science and war, about the health of our planet, and about the manipulation of life processes have convinced most people that serious reflection and action was due. Around the turn of the millenium, it became accepted practice that any novel important research program should include an ELSA component (Ethical, Legal and Social Aspects of science).

For many years, a set of practical questions have persistently haunted me : At which conditions, can a student embrace a career in scientific research, without becoming or turning into a public hazard ? What share of his/her time and efforts should be devoted to ethics-related reflection, and what background formation should he/she be offered ? Which initiatives, within teaching and research institutions, could help and nurture a proper environment ? « Science as salvation » was part of my youth dream ; to what extent, and how, can such a dream be sustained, honestly, nowadays ?

2. A reminder on scientific revolutions

Expressions such as Copernican revolution (astronomy), Newtonian revolution (mechanics), Darwinian revolution (biology), etc, have long been in common use. The concept of scientific revolution has been further

elaborated and refined after the pioneer book of Thomas S. Kuhn (1). In a subsequent essay (2), Freeman Dyson introduced a useful distinction between concept-driven revolutions (associated with names like Copernicus, Newton, Darwin, Maxwell, Einstein) and tool-driven revolutions, such as the telescope (Galileo), microscope (Leeuwenhoek), chronometer (Harrison), ..., X-ray analysis of the DNA structure (Crick-Watson), computers, transistors, lasers, genetic engineering, and so forth.

The Newtonian revolution is widely known, and provides a good illustration. It brought together terrestrial and celestial mechanics, thereby merging two earlier distinct disciplines. Because of its remarkable successes, it established a strong model for theoretical science : quantitative, mathematical, deterministic, predictive. This paradigm became so dominant during the 19th century that many physicists were led to disparage other forms of theory, and notably (most mistakenly) Darwin's fundamental inputs to biology. Still later, Ernst Rutherford (1871-1937) was quoted as saying that *science is physics, and the rest is stamp collecting*.

But within physics itself, during the first half of the 20th century, several developments (special relativity, general relativity, quantum mechanics) showed limitations of validity for the Newtonian laws of motion, which lost their status of absolute truth to become approximations of more elaborate theories. Thus, by that time, through a cascade of scientific revolutions, the Newtonian paradigm had been reduced in scope and, even within the domain of physical sciences, restricted in its accuracy, acceptable only within limited spans of values for several physical parameters.

This story contains the gist of the notion of scientific revolutions. Science is not monolithic and uniform. There exists a diversity of sciences, partly autonomous, partly inter-connected, each one with its own historical evolution. Phases of normal paradigmatic science are separated by periods of transition from one paradigm to another. Sometimes two disciplines merge into one (convergence) ; other times, one discipline branches off into two (divergence). The scientific landscape evolves, with observable instances of both unification and diversification. There is thus an element of fluidity in this evolution, and also an element of geographic diversity : at any time, some sciences may flourish better here or there. Before the present dominance of English (almost everywhere in natural sciences), the linguistic diversity in the various disciplines used to be an indicator of cultural and geographic diversity. It is still the case in many social sciences, and of course in the humanities.

Thus the picture of science is one of a complex chart, and open flow. During my lifetime, many scientific revolutions occurred, and many disciplines emerged or matured : molecular biology, microelectronics, green revolution of agronomy, information and communication technologies, sciences of the planet and of outer space, reproductive biomedicine, cloning and stem cells, synthetic biology, to name a few.

Thus what remains of the universality of science ? there remains a notion of truth, approached honestly, *in good faith*, via methodical procedures of trial and correction. The claim to universality has to be compounded with adequate recognition of the manifold (spatio-temporal, thematic) diversity of the sciences.

3. *Moral revaluations : a descriptive survey*

About ethics, it is convenient to introduce a preliminary distinction between descriptive ethics and normative ethics. Descriptive ethics is the objective description of moral attitudes and behaviours, as they can be observed via historical and sociological studies (in this sense, moral sciences are akin to political sciences ; indeed both are associated within the French *Académie des sciences morales et politiques*). This section is bent on descriptive ethics, and the next (section 4) on normative ethics.

The topic of moral revaluations, because it is still far from being an established concept, is best introduced by giving some illustrative examples : abolition of slavery, liberation of women, decolonisation, European construction (replacement of war by law), etc.

At first sight, a survey on collective and individual mores brings back much evidence of incoherence : cultural

and regional arbitrary traditions, subjective personal convictions. Temporal discontinuities are also observed. Abortion, previously prohibited by law, has become legal practice in a large number of countries. Many physicians taking an Hippocratic pledge in their youth have been led to abide, later on in their career, by different rules. Drastic is the change in content of the Russian medical oath, which occurred after the collapse of the Soviet Union.

However one may detect coherent spatio-temporal patterns of change, in ethics like in science. These observed processes may be interpreted, at a piecewise scale, as progressive evolutions and thus allow for at least « local » meanings, if not for a global one.

Abolition of slavery and liberation of women are two examples of moral revaluations which are (hopefully) lasting reformations, i.e. transitions from one state to another so widely deemed as preferable that the transition appears quasi-irreversible (at human view). But it is not difficult to quote also many cases of transient changes, which may have seemed improvements in a first phase but were later abandoned or rejected, in a second phase.

One neat example of transient moral change is prohibition of alcohol. Around 1919, all alcoholic drinks became legally prohibited in Finland, Norway and the USA. The move was undertaken *to reduce crime and corruption, solve social problems, reduce the tax burden created by prisons and poorhouses, and improve health and hygiene*. Indeed these measures were promoted by many economists and social scientists. But a few years later (by 1926 in Norway, 1932 in Finland, 1933 in the USA), the prohibition laws were retracted. The *noble experiment* had come to be considered as an aberration.

Other transient changes (of variable duration) are below listed in disorder : factory work for children in England and France during one phase of the industrial revolution, consumption of « radioactive drinks » after the Radium discovery, occasional spells of religious iconoclasm, eugenics promoted by most biologists during several decades in the wake of social Darwinism, apartheid regime in South Africa (1948-1990) long supported by the calvinist Dutch Reform Church. To some extent, the communist regime of the Soviet Union (1917-1991) may also be inserted in this category.

In contrast, a list of potentially enduring changes might include : the demographic transition (female fertility rate eventually dropping from around 8~6 to about 2) which is one element in the liberation of women, legalisation of abortion, request for informed consent in human experimentation, care for animal welfare, restrictions on smoking in public places, strict controls on the extraction and use of asbestos, and a large number of other practices inspired by the precautionary principle and/or the goal of sustainable development. In addition, may be mentioned the whole corpus of international law, associated with the Universal Declaration of Human Rights, and the principles of the United Nations system.

Concerning sexual mores, one may note opposite, sometimes complementary, trends of wider tolerance and stricter regulation – and absence of consensus in many debates surrounding the issues of homosexuality, polygamy (3) and infant circumcision. One noticeable evolution is the ongoing revision of attitude of the Catholic Church toward priests' paedophilia, which came about as a result of financial ruin of several US bishoprics, due to heavy judicial penalties. Till then, the Church had felt more indulgence for the weaknesses of its clergy, than concern for children's rights. In striking contrast with the innovative practice of repentances, which the Roman Church expressed concerning several aspects of its past history, after engaging in courageous and thorough processes of moral revaluation. But around the issue of clergy paedophilia, an internal aggiornamento proved impossible, because of a deeply ingrained self-complacent 'law of silence' : thus the change had to be imposed from outside.

Revealed religions encounter difficulties to accommodate both scientific revolutions and moral revaluations with their holy scriptures. After several epoch-making crises (Galileo, Darwin), many established churches have come to accept, more or less grudgingly, an intellectual magisterium of natural sciences within their fields of competence, where the holy writs are now interpreted as metaphors. But this act of intellectual renunciation is often traded, in compensation, against enhanced claims at ethical supremacy. Such an attitude does not prompt smooth, positive adjustments in domains related to internal ethical matters within the churches (status of women, fair-play between

generations, etc).

These examples, picked among many others, invite to formulate a set of broad issues : to which extent are such morality changes advening through genuine internal conversions, and to which extent are they imposed by external pressures ? Is force ruling over justice and truth ? Might over right ? Such questions stand at the border between descriptive and normative ethics.

4. Normative ethics and the legitimacy of retrospective judgments

Addressing now a crucial issue, let us consider whether is it legitimate to proffer retrospective judgments. For instance : was slavery wrong, even before its legal abolition ?

It has been common lore to dismiss such a question with the argument that « one cannot judge past actions according to present-day criteria ». However, at this point, an analogy between scientific revolutions and moral revaluations appears relevant.

The Newtonian theory of mechanics was an immense intellectual achievement and it has been considered as absolute truth for more than two centuries (as mentioned in section 2). Nowadays it has the status of an excellent approximation in large domains of values of the physical parameters. It would be foolish to criticize Newton for not conceiving quantum mechanics in his time, when all pertaining evidence was lacking. Yet it would be equally foolish to consider that a preference for classical mechanics or quantum mechanics, in a particular physical problem, remains today a matter of subjective opinion. In brief, retrospective judgments are legitimate in science. It makes sense to claim that a scientific revolution has brought progress, from a paradigm A to a paradigm B, with B superior to A (in terms of accuracy, completeness, coherence, etc).

There are also historical cases in science when a piece of theory A was later radically rejected. For instance the notions of phlogistics (in chemistry) or ether (in electromagnetism) have been eliminated. They no longer survive as linguistic vestiges (e.g. sunset, sunrise), or approximations of a better theory B. Past motivations for the formulation of such hypotheses may be studied and understood by science historians ; yet nowadays, with the benefit of hindsight, they may be judged as aberrations. Of course, internal consistency has it that these retrospective judgments will be themselves, later on, submitted to retrospective scrutiny.

In conclusion, it is possible to argue meaningfully and intelligently (even if, perhaps, not absolutely and for ever) about retrospective truth judgments in science.

Coming back from science to ethics, let us return to the earlier question : was slave trade and slavery always a crime against humanity ?

On 10 May 2001, a law was passed by the French Parliament « tendant à la reconnaissance de la traite et de l'esclavage en tant que crime contre l'humanité ». Its Article 1 states : *La République française reconnaît que la traite négrière transatlantique ainsi que la traite dans l'océan Indien d'une part, et l'esclavage d'autre part, perpétrés à partir du XVe siècle, aux Amériques et aux Caraïbes, dans l'océan Indien et en Europe contre les populations africaines, amérindiennes, malgaches et indiennes constituent un crime contre l'humanité.*

Four months later, the UN World Conference against Racism, Racial Discrimination, Xenophobia and Related Intolerance, held in Durban (31 Aug – 8 Sep 2001), issued a Declaration, whose Article 13 deserves full quotation : *We acknowledge that slavery and the slave trade, including the transatlantic slave trade, were appalling tragedies in the history of humanity not only because of their abhorrent barbarism but also in terms of their magnitude, organized nature and especially their negation of the essence of the victims, and further acknowledge that slavery and the slave trade are a crime against humanity and should always have been so, especially the transatlantic slave trade and are among the major sources and manifestations of racism, racial discrimination, xenophobia and related intolerance, and that Africans and people of African descent, Asians and people of Asian descent and indigenous*

peoples were victims of these acts and continue to be victims of their consequences.

These two statements (French law, international Declaration) are signs that a phase of fairly worldwide consensus has now been reached on the issue of slave trade and slavery (4). For a proper perspective on the achieved progression, « le chemin accompli », let us go back two centuries ago and consider three sentences proffered by Antoine Barnave (1761-1793), a brilliant protestant lawyer from the Grenoble parliament (sent by the Dauphiné as its representative to the Etats-généraux in 1789), enlightened advocate of constitutional monarchy :

Ce régime est absurde, mais il est établi.

Ce régime est oppressif, mais il fait exister, en France, plusieurs millions d'hommes.

Ce régime est barbare, mais il y aurait une plus grande barbarie à vouloir y porter la main.

On 29 november 1793, Barnave was guillotined. In February 1794, slavery was abolished in French possessions, but re-established in 1802 under Bonaparte.

And now here is another example of sensitive question : was Hiroshima (i.e. the launching of nuclear bombs over Japanese cities, in August 1945) a crime against humanity ?

So far this question has seemed to remain pending, socially undecided, perhaps undecidable. The post-war trials (Nuremberg, Tokyo) pronounced sentencings against losers only : the winners had safely granted total impunity status to themselves. However a steady revaluation process may be beginning.

Justice of the victors seems to be discredited. The International Criminal Tribunal for the former Yugoslavia is aware that its moral authority depends on its capacity to dispense a fair justice, equitable with respect to all sides (winners or losers), be they Serbians, Croats, Albanians, Orthodox, Catholic, Muslim. Moreover the advent of Commissions « Truth and reconciliation », successfully set up in several post-conflict situations, notably in Latin America and Africa, have spread the notion that no lasting reconciliation can happen without a honest effort toward admission of the full truth by all parties involved.

The decision to use the nuclear bomb on Hiroshima, taken by Truman, was probably unavoidable, in the context of the traditional US doctrine of overwhelming force. With the benefit coming from longer perspective, it is now better appreciated how high, in conflicts waged by this country, tends to be the ratio between enemy casualties (soldiers and civilians) and US losses : often around thirty (5). There seems to be little limitation to the amount of power that the US people is willing to wield, in order to crush an opponent, and force it to full surrender. For a US president, right or wrong is decided by subsequent election polls. In such framework, the rational choice for Truman could hardly be else than to use the bomb. Non-use might have been internally divisive, and thus implied political risks. Use was proven right by Truman's election for a second mandate in 1948, according to home-made criteria. This law of the game was stressed again by George W. Bush, after his re-election in 2004, as justification for the invasion of Iraq, the year before.

This long-standing policy has been reinforced by two factors. Since 1989, the end of the Cold War and the demise of the Soviet Union, the USA possess the highest military, economic, scientific supremacy, ever enjoyed by any empire on earth. Secondly, they know that their ever-increasing privileges are so manifestly unjust that they would not stand a chance in any honest and fair international court. Thus the growing US contempt for international law is logical : it is both a forgone conclusion and a confession. The American way of life, including its way of waging war, is not sustainable without impunity status. Maximal deterrence against the others, total impunity for themselves : the breach of the principle of reciprocity (i.e. the golden rule of ethics) could hardly be more radical. In contrast, the rival Soviet Union regime, totalitarian and oppressive as it was, never used its nuclear weaponry and in the event, collapsed peacefully.

Coming back to the initial question, it appears then, at this stage, that the only way to save the Hiroshima bombing from retrospective condemnation is to grant permanent everlasting impunity status to the USA, under a principle that might makes right (6). Not a minor stake.

5. *Individual and collective aspects*

So far, the emphasis has been put on social, collective aspects. However there is also a personal, intimate experience of moral reevaluation process. From childhood to youth, and to maturity, any person acquires experience of revisions, sometimes conversions. The pious pictures of infancy (on family, cast or class, nation), the ideal visions which govern the choice of a profession or youth engagement, are submitted, later in life, to many shocks and tests. These personal moral reevaluations are processes of apprenticeship, which come about through a mixture of acting and learning.

In 2000, the physician/lawyer/ethician Margaret Somerville published a commendable book on biomedical ethics, *The Ethical Canary* (7). The title is a metaphor alluding to past use of these birds, which were placed in coalmine galleries as detectors of air quality. Fainting of a canary was a signal, alerting in advance about a proximate danger for miners' health, before human perception could detect the threat. In the Spring of 2003, Margaret Somerville was selected as the first laureate of the Avicenna prize for ethics in science (granted by Unesco, at the initiative of the Islamic Republic of Iran).

On 17 July 2003, the renowned British microbiologist David Kelly, a worldwide authority as inspector for chemical and biological weapons (with many missions accomplished in Russia, then in Iraq), committed suicide. The tragic death of this internationally respected colleague created shock and dismay in his country, and abroad.

Only two years later, did I come to realize that the metaphor used by Margaret Somerville was a fair insight on the mystery of our colleague's passing. If David Kelly had not performed the supreme sacrifice of his life, our attention would not have been so efficiently awakened about the gravity of a threat, which he had been able to detect (through his unique experience at the crossroads of science, politics, secret intelligence, news media), but had found no way to communicate otherwise. Thus we are now left with the duty to do our best and interpret this silent oracle, before it gets too late for us also.

My suspicion is that there is perhaps no unique solution to this enigma. Still, I can offer an educated guess, which may convey part of the message (8). The guess is that David Kelly wished to attract our attention toward the looming danger of hyper-hypocrisy. The Latin proverb *Summum jus, summa injuria* carries millenary wisdom : the higher the law, the higher the (risk of) injustice. In the context of British nobility, one might add this variant : *Highest nobility, summa ignobilitas*. Bush alone would not have gone far in building a 'coalition of the willing' to invade Iraq. It took Tony Blair, his claims at good faith and straight honesty, his ability to fill the Honours lists and House of Lords with « safe pairs of hands », to reach new heights of deception and mislead public national and international opinion. David Kelly was himself caught in, and discovered only too late how irretrievably corrupting this system was (9).

6. *The ethical movement in the sciences. Why now ? Why so late ?*

About the three main streams of the ethical movement in the sciences (bioethics, science and war, future of the planet), many studies have dealt with the question : why now ? why is this ethical movement emerging now ? For bioethics, see for instance (7). For science and war, some memorable dates are Hiroshima (1945), the Russell-Einstein manifesto (1955) and the Nobel peace prize (1995) given to the Pugwash Conferences on science and world affairs (10). For the future of the planet, the ecological movement has received abundant media coverage and even entered the political arenas (green parties).

In order to acquire a wider view on the historical process, it is also instructive to ask the complementary question : why so late ? Indeed, it is via this last question that I came to perceive the ethical movement in the sciences as one

specific instance within a larger category : the category of moral revaluations. Obviously, for abolition of slavery or liberation of women, it is quite a relevant question to ask : why so late ? isn't it surprising that it took so long to grant equal civil and political rights to women ? Such a new perspective has also a major practical benefit : because any scientist can thus easily relate the moral revaluation process presently affecting his/her profession, to the scientific revolutions he/she has long been familiar with.

- Knowledge brings responsibility, because knowledge is (a form of) power, and power brings responsibility.
- Scientists have a duty of alert, because they are best placed to alert society to the possibly harmful consequences of their activities, discoveries and inventions ; they have competence, and capacity for early warning.
- Scientists have a continuing responsibility, because the outcome of scientific research (its direct and indirect consequences) is at least partly unpredictable ; this continuing responsibility implies a duty of discernment and vigilance, sustained on the long term.

In his Nobel lecture, Jo Rotblat said : *Whistleblowing should become part of the scientific ethos*. The life of Albert Einstein provides an illustration of scientific whistleblowing : duty of alert (his four letters to Roosevelt, from 1939 to 1945), continuing responsibility (his last signature was for the Russell-Einstein manifesto, which thus acquired the symbolic value of a testament). Encouraged by the example of Einstein (and his readings of Albert Schweitzer, Leo Szilard, Linus Pauling, Niels Bohr), Andrei Sakharov has given a model of personal moral revaluation, unique in its amplitude and subsequent worldwide impact ; in his words : *Every true scientist should undoubtedly muster sufficient courage and integrity to resist the temptation and the habit of conformity*.

Albert Einstein (1879-1955), Joseph Rotblat (1908-2005), Andrei Sakharov (1921-1989), David Kelly (1944-2003) : different countries, different disciplines, different generations, but four courageous scientists inserted in a continuous stream, and transmitting a meaningful legacy.

Collective responsibilities are best discharged via institutions. Scientific institutions (universities, research agencies, academies, associations for the promotion of science) should provide adequate protection for the courageous individuals who proffer disturbing truths. From Galileo to Sakharov and beyond, history has amply demonstrated the importance of this collective duty.

In a recent, eloquent and timely essay (11), the Swiss chemist Richard Ernst, Nobel laureate 1991, addressed two major questions : *Why should we researchers and university teachers carry particular societal responsibility ? And why is there a relevant European context ?* In his answer, constructive and far-reaching propositions on the tasks of universities, and other academic institutions, are presented.

Ernst's perspectives are utopian in the best sense, i.e. opening new fields (in a pastoral/cultural sense) for collective deliberations and reflections, about all issues that are really important for the future of humanity : societal concerns, economic rationality, international security, global equality, long-term relevance of research projects, inter-disciplinary dialogues. Because of his own personal profile and achievements (creative interplays between basic and applied sciences, university and industry), the following sentences carry special authority and weight :

I am convinced that science departments with a broad scope, integrating also societal concerns and questions of global relevance in their courses and daily discussions will succeed in overcoming the present difficulties of recruiting students. (...) I have to admit that I myself would prefer, if I had to start again, a study that combines top science with societal concerns and global vision, rather than detached, stand-alone science, even if the latter would be taught by the most knowledgeable international specialists. (...) Who else, if not the scientists, is responsible for setting guidelines for defining progress and for protecting the interests of future generations ? (...) A unipolar world will surely lead to a disaster in politics, economics, and science.

Freud (1856-1939) considered morality as *etwas Selbstverständlicher*, a matter of course, 'une chose qui va de

soi'. But nowadays in the domains of science and technology, 'ce qui va de soi est un besoin', the matter of course is a deeply-felt need for collective ethical reflection, all the way : early on and continuing.

7. Two sets of concluding remarks

Primo. Similarity and contrast between science and ethics.

Both science and ethics are difficult, serious, social (collective) activities, which request continuing efforts and call for continuing responsibilities. That is a strong similarity.

Contrast. The cartesian method is analytic : divide large problems into smaller, and smaller ones, till they become solvable. Whereas ethical reflection is necessarily synthetic, because its purpose is an arbitration between conflicting values, interests, logics, and setting priorities between those.

Secundo. Scientific barbarity versus science-as-salvation.

Scientific (educated, sophisticated) barbarity, namely excellent professional work serving abominable ends (one notorious example is Fritz Haber's chemical talents) performed by perfectionist, voluntary servants : that is the nightmare, which stands at the opposite of the dream of 'science as salvation'.

References

1. Thomas S. Kuhn, *The Structure of Scientific Revolutions* (The University of Chicago Press, 1962).
2. Freeman Dyson, *Imagined Worlds* (Harvard University Press, 1997).
3. Somewhat unexpectedly, the paternity tests via DNA analysis are triggering science-driven moral revaluations in traditionally monogamy-only countries, about the status of children born out of wedlock, who used to be dubbed « illegitimate » and deprived of equal rights to inheritance.
4. To be more complete, mention should be made here of another law, passed by the French Parliament on 23 February 2005, *portant reconnaissance de la nation et contribution nationale en faveur des Français rapatriés*, a seemingly harmless title. However its Article 4 brought havoc with this sentence : *Les programmes scolaires reconnaissent en particulier le rôle positif de la présence française outre-mer, notamment en Afrique du Nord, et accordent à l'histoire et aux sacrifices des combattants de l'armée française issus de ces territoires la place éminente à laquelle ils ont droit.* This *rôle positif* was more than many were prepared to withstand. It rekindled a bitter dispute between Algeria and France, and raised protests within multiple strata of the French citizenry. As a result of these intense debates, the Article was abolished one year later, under decision of the French president.
5. See for instance Walter Russell Mead, *Special Providence : American Foreign Policy and How It Changed the World* (Knopf, New York, 2000). A similar ratio is observable in many dissymmetric conflicts, such as those waged by past (and present) colonial powers.
6. *Let us have faith that right makes might ; and in that faith let us do our duty as we understand it*, Abraham Lincoln (1809-1865).
7. Margaret Somerville, *The Ethical Canary. Science, Society and the Human Spirit* (Viking, Montreal, 2000) ; French translation, *Le canari éthique* (Liber, Montréal, 2003).
8. Some further elaboration on the whereabouts of this tragedy may be found in G.T., *Science, Truth and Trust. Permanent and novel challenges, individual and collective responsibilities*, to be published in the Proceedings

of the Workshop on 'Scientists, investigation and mitigation of tensions in society' (Saint Petersburg, April 2004), and in G.T., *La responsabilité continuée des scientifiques, et quelques priorités actuelles*, to be published in the Proceedings of the International Symposium on 'La science au service de la guerre et la responsabilité des scientifiques' (Paris, September 2005).

9. The confrontation David Kelly vs Tony Blair is reminiscent of Antigone vs Creon. The motto of latter-day political leaders is : *Failure is not an option* (i.e. failure at next polls). But David Kelly did behave according to a different, older rule : *Potius mori quam foedari* (rather dead than sullied), the motto of ancient Brittany's white ermine.
10. The web site of this pioneer scientific NGO is resourceful and well maintained : www.pugwash.org
11. Richard Ernst, *The Responsibility of Scientists, a European View*, *Angew. Chem. Int. Ed.* 42 (2003) 4434-4439