MEMO

To: The COST Nanoscience and –Technology Advisory Group (NanoSTAG)

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One-Paragraph Summary

In this memo, I review the reasons why it is important to study the ethical and societal aspects of nanoscience and nanotechnology. First, public acceptance is a prerequisite for the successful implementation of technology, and this is no longer a trivial thing. Secondly, the interplay between technological development and that of society is important in its own right. As the development involves large uncertainties and essential unpredictability, conventional risk assessments, cost-benefit-analyses and conventional ethical analyses tend to miss the important questions. Thus, I recommend the use of alternative analytical methods and mention a few (notably that of "post-normal science" and critical strands of the philosophy and sociology of science and technology).

1. Aims and Scope

The aim of this memo is to provide some **general background** for discussing the prospects and utilities of studies of ethical and societal aspects of nanoscience and nanotechnology. Legal aspects of nanotechnology will not be discussed as they are outside the author's field of competence. To achieve this aim, the memo will not review the existing ELSA studies of nanotechnology (to be found here and there in the literature and the academic world) but rather focus upon and **discuss** what I find to be the **important methodological issues**. Finally, it should be added that the viewpoints in the memo are mine and not to be automatically attributed to other researchers in the field. The reason for this disclaimer is that I have chosen to be quite frank and **informal** in this memo to spark off some discussion, rather than being "academic" with lots of conditionals and references. If references should be desired by some reader, I would be happy to help provide them.

2. The Demand for ELSA Studies of Nanoscience and Nanotechnology

ELSA studies, or studies of the **ethical, legal and social/societal aspects** of science and technology, have been in vogue for some years. Although such studies might be said to have existed ever since ancient Greece, a milestone was in some sense reached by the decision to include ELSA studies in the Human Genome Project.

I will stress three interrelated causes of the recent development.

First, **public attitudes** in industrialized countries towards technological development **have changed**. Higher studies in natural science and technology are losing in popularity throughout the OECD area. Even though most technological innovation apparently is endorsed by the public (notably in the case of information and communications technology), there are important cases in which the views of the public and of the expert/technocrat establishment are in serious conflict, leaving the political system caught in-between. The major example is the public perception of **biotechnology** in the countries of Western Europe, in particular concerning the use of transgenic strains (GMOs) in agriculture. This situation has led to a general acknowledgment of the need to understand public perception and attitude towards technology. Some would stress the desire for a platform of strategic knowledge of public perceptions from which one could try to act upon and change them. Others would keep the case open as to whether the public have good or bad reasons for their opposition towards biotechnology, and stress the general need for understanding and learning from the various perspectives present in the debate. Most would agree, however, that the present situation of **distrust** between the public and the technological establishment is highly unwanted and costly.

Secondly, during the latter decades there has been substantial **progress** in the academic fields concerned with the relationships between science, technology and society. Although philosophical and historical studies of science have been present for centuries, and the sociology of science was academically well developed already in the 1930s, the focus of attention during the period 1920-1970 was often the internal structure of science, above all scientific logic. This was particularly true of the Anglophone academic communities. The seminal work of Thomas Kuhn in 1962 ("The Structure of Scientific Revolutions") can be seen as a turning point in this respect, introducing not only the buzzword "paradigm" but also the general interest in seeing science in relation to the society and the culture in which it is produced. Since the 1970s and 80s one has seen a **redirection of philosophy of science**, a growth in the philosophy of technology and the emergence of an entire academic discipline often called "STS" or **Science, Technology and Society Studies**, with its own journals, university departments etc. Furthermore, after a period of decline in the central half of the 20th century, normative **ethics** or moral philosophy has blossomed and is now a vital academic discipline with an increasing number of research institutions. Also in this case, the underlying cause is a re-orientation towards external and concrete cases, above all exemplified by the establishment of the fields of *medical ethics, bioethics, research ethics* etc. Thus, the tools for the study of the ethical and social aspects of science and technology are better than ever.

Thirdly, there are some signs of a **growing concern** for ethical, legal and social aspects also among the producers of science and technology, in particular **among scientists**. One might identify this as a growing trend ever since the Manhattan project and the initiatives of Leo Szilard and other prominent physicists in the 1950s and 60s concerning the nuclear race. However, in the 1990s the development has accelerated. Courses in bioethics and research ethics are being implemented in various university curricula. Scientists take initiatives to ELSA studies of their own speciality (as in the Human Genome Project). Scientific journals contain more letters (although still few) in which scientists reflect upon ethical, philosophical or social aspects of their own practice, see e.g. *BioEssays* and *Science*. This development should be welcomed, I think, as a sign of the "human face" of science that perhaps the general public and the lost science recruits have failed to discover.

These three causes may be interpreted as different expressions of the same reality: Science and technological development, taken as enterprises, have basically changed their nature during the 20th century and deserve a lot more general attention than before. **Science** used to be a rather marginal, curiosity-driven enterprise. Now, it is a massively organized and in part commercialised venture spending large resources, often with the explicit **purpose** of producing **technological applications** and even **economic profit** for investors. Likewise, technological development in its rather recent science-driven form is regarded to be one of the **chief engines of the global economy**.

However, scientific and technological innovation has the fundamental characteristic of being **unpredictable** in the sense that the results are in principle unknown until they are found. If science and technology is the locomotive of society, it is apparently one without steering devices. Often, the train has run into **great benefits** for humanity (improved wealth, improved health). Simultaneously, there have been aspects of the development that has created the fundamental **ambivalence** towards technology that characterizes our time: Our **dependency** upon advanced technology and the resulting alienation when its workings transcend what the ordinary citizen can grasp literally or mentally; the **destructive** potentials of technology (the icon of which would be Hiroshima and Nagasaki); the unanticipated **environmental problems**; and the religious, aesthetic or ethical **disgust** resonating with the myth of Frankenstein or, in Jewish culture, the Golem (as in the disputes over the cloning of Dolly and the production of the sheepgoat).

Thus, as technology almost invariably has the potential both for human and environmental benefit as well as harm, and the magnitude of this potential has increased vastly in our time, the desire to reflect upon, study and understand the relationship between science, technology and society seems to be well justified.

This line of reasoning would also apply to the development of nanoscience and nanotechnology, even more so because quite a few practitioners in these fields have expressed the belief that **nanotechnology can become very powerful** in the future. Indeed, it appears to be a characteristic feature of the existing discussions of nanotechnology that one foresees technological potentials far beyond that which exists today, even in the absence of workable ideas of how to accomplish such technologies. It is tempting to contrast this with the unfortunate claim of the Nobel laureate Jacques Monod who wrote in 1969 that molecular biology had shown that and why cloning was in principle impossible. The claim was put into ridicule in less than five years. In this respect, the nanoscience / nanotechnology community can be credited for its will to apply foresight, and the **logical consequence** would be to **encourage ELSA studies** for a professional academic treatment of the matters.

To sum up, I have noted several arguments that might lead us to encourage the demand for ELSA studies of nanoscience and nanotechnology:

(i) The need to understand public perceptions and attitudes before the launch of new technology,
(ii) The recent advancements in the academic fields concerned with such studies,
(iii) The weak but distinct trend of a growing social and ethical concern inside the sciences,
(iv) And above all, the presence of good reasons for being ambivalent and ethically and socially concerned about new and possibly powerful sciences and technologies.

It remains to specify somewhat more concretely what exact issues to follow and which methodologies apply. This is in part a matter of that research process itself and thus it cannot be answered fully yet. However, I will point at some directions (leaving legal aspects out as they are outside my field of competence).

3. Studying Ethical and Societal Aspects

The underlying concerns that motivate studies of ethical and societal (or social, but this author prefers "societal") aspects could be formulated in questions such as: **What will society look like** when this or that nanotechnological method or product, or nanotechnology in general, are introduced? Will the products be **profitable?** Will the development be to our **benefit or harm?** Whose benefit or harm? Are there **ethical problems?**

It is important to realize the strengths and limitations of academic approaches to such questions. In a nutshell, the limitations arise because the questions above are inexact and the future, including the nano-future, in general is **unpredictable**. So what can one do?

First, one can investigate the **intrinsic ethical character of** real or hypothetical **practices and products**, relative to various systems of ethical principles (religious doctrines, Human Rights) or relative to real persons' ethical intuitions and beliefs. This has been part of the controversies about biotechnology, in particular the **cloning** and/or genetic modification of humans and higher vertebrates. The obvious nanotechnology candidate for such intrinsic ethical considerations would be the coupling of information technology with biological brains and bodies (say, **coupling of microelectronics with nerve cells**). Already, this has been a public concern for some time, as manifested in popular culture (**"cyborgs"** science fiction novels; note also the popularity of movies such as "The Matrix" and tv series such as "VR 5"). Such studies are important in order to understand the issues; their limitation lie in the obvious multitude of and disagreement about ethical principles.

Secondly, an important type of ethical thinking relates the moral character to an action with the benefits and harms that result from it. For instance, in the classical formulations of **utilitarianism**, the morally good action would essentially be that which produces the greatest happiness in the world (averaged over all people, leaving out the difficult question of the moral status of other living species). Thus, in this type of ethical thinking, the **future consequences** become a major target of concern, rendering them in that way similar to economical **risk-cost-benefit analyses**. The main difference would be that economical analyses tend to assume that all value can be reduced to monetary value (perhaps even leading to a definite estimate of a cost-benefit ratio!), while the typical ethical/sociological consideration would be sensitive to the **distribution of risk, cost and benefit** (who are the affected?) as well as justice and power. In other words, an economical risk-cost-benefit analysis actually is equivalent to a utilitarianist analysis in which all ethical choices have been made by the design. For instance, the choice of discount rate determines the importance of the concerns of present and future generations (relative to one's over-all theory of future economical development).

Likewise, one can have studies of societal aspects focusing on the present or the future. The present would be things such as current public perception and knowledge, current legislation and current institutions to support and govern nanotechnology – useful information as a basis for strategic action. However, one might speculate to what extent this kind of report writing in itself is worthy of the grace of research funding agencies. Rather, to stand up to academic standards, such studies should be enforced by theoretical perspectives to produce new understanding of the situation. An excellent example from the **risk sociology** literature would be the studies by the British sociologist Brian Wynne and co-workers on e.g. the societal dimensions of the Sellafield nuclear reprocessing plant.

At this point I would like to make a highly subjective remark. There is a danger, I think, in the planning of ELSA studies, that the process of formulating research objectives gets too heavily dominated by natural scientists. Of course, natural scientists and "technologists" have invaluable insight into practices to be studied. But as for the research methods of social science, they are normally best considered lay-people. The result is sometimes that what could have been interesting research projects get reduced (by the project constraints) into a production of uninteresting reports of trivialities. This is a problem almost exclusive to ELSA studies of science and technology, and is related to existing power relationships between the sciences. Other types of practitioners (industry workers, craftsmen, etc) do rarely think themselves competent to control a social science design problem. Thus, my conclusion in this paragraph (and let me mention that my Ph.D was done in the natural sciences!) is that the **planning of ELSA studies** is an **interdisciplinary** task, in which the competence of the **humanities** as well as the **natural and social sciences** need to be well represented.

Social science studies of the future involve exactly the same methodological problems as those of ethics or economics: The **future** of systems that include humans **cannot be** safely **predicted**. Indeed, the publication of a prediction is in itself an action that might change the future (through the well-known mechanisms of **self-fulfilling or self-destructive prophecies**). The essentially innovative character of science and technology adds to this unpredictability. Ordinary **risk assessments** or risk-cost-benefit-analyses are accordingly only meaningful for short-term and narrow-scope analysis of already well characterised pieces of technology. To calculate the risks of harm or accidents of presently non-existing technology is **nonsense**.

Indeed, it is a general feature of **technology** that it will be **transformed** in the hands of society in **creative** ways, leading to uses that were not thought of in advance. The development of personal computers and in particular the **world wide web** are striking examples. Risk assessments and their like assume that the complete set of possible outcomes is known, as well as their probabilities. Many adversary (and beneficial!) effects of science and technology were, however, unknown at the implementation. For example, the implementation of **thalidomide** was done in the **ignorance** of the possibility of birth-defects specific to humans (no birth defects were seen in rats or mice). In hindsight, it is easy to see that this ignorance rendered any prior risk assessment highly misleading.

Thus, risk assessments and risk-cost-benefit-analyses (and for that reason, to some extent ethical analyses) work well only with well-characterised systems and in situations of limited responsibility. It has been argued that **risk assessments do not answer** the questions "What will happen?" or **"Is it dangerous?" but rather "Can**

they sue us?" As such, they are natural activities for industrial and short-term governmental enterprises (and will to some extent be performed with or without the presence of ELSA studies). The main benefit of aligning ELSA activities with ordinary risk assessments is to contribute to a partial broadening of their scope.

4. Practical *vs* Technical Problems

At this point, a distinction made by Jerome **Ravetz** (philosopher of science and technology) can be useful. Ravetz distinguishes between **scientific, technical and practical problems**.

Type of Problem	**Specific Goal**	**Purpose**
Scientific	(may drift)	**Accumulation of Knowledge**
Technical	**Pre-set Specification**	(may drift)
Practical	(may drift)	**Ultimate Values**

Basic ("pure", "core") **research** can be characterized as the **curiosity-driven** pursuit of scientific problems. At the onset of a project, one will have a **specific goal**, but if during research this goal is replaced by another, this was traditionally no problem at all as long as good research was being done, good publications were being produced and thus knowledge was accumulated. Following Ravetz, to **allow some drift** of the specific goal is a prerequisite to good basic science.

Technological problems, on the other hand, are defined by the **technical specifications** to be met. If one needs a transmitter of a given size, the problem is normally not solved by inventing an excellent transmitter which is too large. Also, a technical problem is not defined in terms of the underlying purpose (for instance, if society really benefits from having even more cellular phones).

In contrast, **practical problems** are defined by the **ultimate purposes**, such as **health, wealth, sustainable development, equity**, the preservation of wild animal and plant species, the well-being of the individual citizen, etc. Solutions to practical problems are to be held responsible for the ultimate good. Thus, in such terms DDT cannot be defended on the grounds that it met its technical specifications if its over-all effect was detrimental to the environment. Somewhat more controversial, the **Green Revolution** introduced agricultural strains that certainly met the specifications of **higher efficiency**, but it is unclear to what extent this helped the practical problem of starvation and malnutrition. It has been argued that in some countries (such as Mexico) the Green Revolution with its need for more advanced agricultural technology **changed the social**

structures of agriculture so that although the production increased, the distribution of the goods were changed to the worse for the poor people.

It seems fair to require that **ELSA studies should be concerned with the practical problems**. Indeed, science and technology take excellent care of the scientific and technological problems, respectively. It is in the realm of the practical problems we tend to be helpless. For centuries, the ideology of the modern **Western culture** has been to think that **practical problems** can be efficiently solved by their division and **reduction into** smaller **technical problems** (the great philosopher of this ideology being René **Descartes**). In particular during the 20^{th} century we have learnt, however, that this ideology only works if the involved systems are simple enough. If feedback patterns etc are sufficiently complex (such as in human societies), technical solutions will achieve the practical purpose according to plan only with a combination of skilful adjustments and pure luck. Rather, what often happens is that the practical problems get **redefined** from the original purpose ("general welfare") to a new purpose which is **technically feasible** and thus operational ("economic growth"). ELSA studies could also be an effort to monitor such processes. For instance, it is sometimes striking how certain fields of medical technology development appear to direct themselves exclusively to the needs of rich middle-aged men with the typical life-style diseases of westerners, to the point at which even the WHO appears to have decided that overweight is a health problem comparable to that of starvation and malnutrition. What is needed, is thus something far beyond narrow-scoped discussions of the possible ethical concerns of the intrinsic qualities or short-time adversary effects of a given technical device. One needs to address questions such as: **"What are the really important problems in the world, and how can technology in general and nanotechnology in particular contribute?"** "Could the development of nanotechnology constitute possible great dangers to important values or practical purposes in the world?"

Within the current research policy regimes of most countries, a special effort is required to keep the scope from collapsing into the narrower questions of "Can this science or technology be profitable for our industry?" "Can they contribute to national competitiveness?" Indeed, one could argue that **supranational bodies** of research funding such as that of the European Union would have to take special **responsibility** as it is harder for individual countries and indeed commercial enterprises to **overcome the myopia of short-term profitability**.

5. Broad-scoped Studies

The arguments above actually constitute a severe criticism of **most existing ELSA studies** of science and technology both in the general case and with respect to nanoscience and nanotechnology. Although they can be useful to the elucidation of certain short-term decisions (of the more technical type), it is my general opinion, for the reasons explained over the preceding pages, that they more than often **fail to address the practical problems**.

On the other hand, some natural scientists have been able to address the practical problems, above all in the writings and activities of **the Foresight Institute** and notably the American scientist K. Eric Drexler. The **science fiction** literature has also been more than willing to address the need for creative and imaginative thinking about the unknowns of nanoscience, above all scenarios involving self-replicating nano-entities that wreck amok ("the Star Trek scenario", "the grey goo problem" etc). Indeed, a somewhat cruel evaluation is that the writings of Drexler and those of science fiction novelists constitute a continuum.

These efforts to use creative imagination are valuable in themselves and deserve recognition. However, as Michael Gross acutely observes in his book "Travels to the Nanoworld" (1999), visions such as those of Drexler are "illustrations of what might happen if everything went according to their plans (as it never does!)" (quoting Gross, p. 210).

What is **needed**, is to **combine** scientific **imagination** with a critical **search for sources of uncertainties and ignorance** within and on the border of nanoscience. Indeed, it is often claimed that nanoscience is one of the unexplored frontiers of science. If this is so, we should expect our body of scientific knowledge to be improved, meaning that it is currently incomplete and/or partially incorrect. This furthermore implies that some of the scientific assumptions we will use in practical or technical decisions will be incomplete or wrong. Scientists may often have hunches or experiential skills that indicate in which directions there might be uncertainties, flaws and ignorance. However, such qualitative, partly implicit or even tacit insights can rarely be quantified as risk and frequently evaporates on their way to the decision-makers. In the 1990s, Silvio **Funtowicz** (EC JRC, Ispra) and Jerome **Ravetz** developed an **analytical framework** to characterize and communicate such uncertainties (see the book "Uncertainty and Quality in Science for Policy", 1991) and later sparked off an entirely new development within environmental science / ecological and technological governance designated to manage uncertainties in contexts of practical problems (to be found in a large body of literature on so-called **"post-normal science"**, see e.g. the journal *Futures*).

Furthermore, in the eyes of any reader well informed of the traditions of the humanities and the social sciences, deliberations upon ethical and social aspects of nanotechnology written by **natural scientists** (as those available from the Foresight institute) are often preciously **naïve** with respect to the cultural and **political assumptions** and underpinnings they make along the way. They tend to treat not only current scientific knowledge as if it is 100% certain, but also the commonplaces of our (their) political and social life-world. If the recent of history of technological development has taught us one thing, however, it is that it will be accompanied with cultural and political changes. Thus, **proper ELSA research requires research personnel properly trained in the humanities and social sciences *as well as* nanoscience expertise** to make the studies well-informed. It follows that ELSA studies essentially ought to be interdisciplinary efforts, and my personal recommendation would be to support long-term collaboration between ELSA researchers and ingoing nanoscience research groups.

6. Summary and Recommendations

If my lines of reasoning are correct, we may conclude with the following:

(a) There is a well justified demand for ELSA studies of nanoscience and nanotechnology.

(b) Conventional studies of ethical and societal aspects can be useful to support short-term ("realistic") decisions relating to implementation and governance of technology.

(c) However, risk assessments, risk-cost-benefit-analyses, and their ethical counterparts, although being valuable for choice of action and clarification of responsibilities, cannot handle the inexactness and unpredictability of real world technology development.

(d) Thus, there is a need to address and monitor the questions of and solutions to the big practical problems: Will nanotechnology really be beneficial to us? How?

(e) To achieve this, a research funding agency could for instance explain not only the need for ELSA studies, but also give it a justification that transcends the current focus on commercial profitability and economical competitiveness.

(f) Thus, one needs broad-scoped ELSA studies, and they might be conceived of as a supranational responsibility.

(g) Broad-scoped ambitions will require interdisciplinary efforts, combining the best of scientific imagination with proper analysis and management of uncertainty and ignorance (such as in "post-normal science") and the critical powers of social science and the humanities (such as in the strands of sociology that apply critiques of modernity).

(h) Luckily, there are recent trends in the philosophy of science and technology and the so-called Science, Technology and Society Studies that accommodate these needs.