16
Nano-Ethics

Roger Strand

16.1
Introduction: Historical Background

Some readers might wonder if the title of this chapter is a joke. What is "nano-ethics"? Does it exist? The answer is yes. "Nano-ethics", the study of the ethical impacts, issues, and aspects of nanoscience and nanotechnology, emerged with the new (twenty-first) century and is currently consolidating as a research field, a field of expertise, and a set of practices in the regulation and governance of nanoscience and nanotechnology. For instance, in 2007 the academic publisher Springer launched a new journal called *Nano-ethics*. Several research anthologies [1, 2] and governmental and non-governmental reports on the ethics of nanotechnology have been published [3–6]. Often, for the ethical aspects/impacts of nanoscience and nanotechnology, the broader terms ethical, legal, and societal/social aspects (ELSA) and ethical, legal, and societal/social impacts (ELSI) are used; others prefer the term social and ethical interactions with nano (SEIN) [7]. We will return to some of the underlying reasons for such differences. For the sake of simplicity, I will use the term "nano-ethics" throughout this chapter, because it makes little sense to distinguish sharply between an "ethical" and a "societal" issue.

One may easily identify debates on the ethics of science and technology in other technological fields and at earlier times. Notably, many physicists participated in what we would now call ethics debates in the decades following World War II, when the full implications of nuclear technology, including the hydrogen bomb, became evident. It was only with the advent of biotechnology, however, that the ethics of science and technology became a focus of attention in its own right, with dedicated research projects, university programs, academic journals, ethics committees, and even specific regulations and laws being implemented in many countries. Of particular importance was molecular biologist and Nobel laureate James Watson's initiative in the 1980s to set aside a certain percentage (3%) of the total budget of the Human Genome Project for ELSI research. This decision implied a vast increase in the funding for bioethics research and was copied in many European countries and what is now known as the European Union. This policy has largely been continued as public nanotechnology

Nanotechnology in the Agri-Food Sector: Implications for the Future, First Edition. Edited by Lynn J. Frewer, Willem Norde, Arnout Fischer, Frans Kampers.

funding programs have been set up. For instance, it has been claimed that more than 40 million US dollars are spent each year on nano-ethics/ELSA in the USA alone[1)].

What do nano-ethicists discuss, then? The question is simple, but the answer is complicated, and most of this chapter will be devoted to providing an introductory guide to nano-ethics. A first observation to be made is the contrast between the ethics of nuclear technology and that of biotechnology. With respect to nuclear technology, one might somewhat disrespectfully say that the bomb arrived first and the ethical qualms arrived a few years later. In the case of biotechnology, much of the ethical debate occurred simultaneously with the development of the technology itself, and often the ethical problems appeared to be quite self-evident and pressing. For instance, it was seen as obvious that the handling of, and experimentation with, human embryos demanded careful ethical evaluation, at least in the Judeo-Christian cultural sphere. "Simultaneous ethics" means, however, ethics that ameliorates the effects of undesirable technologies, products or possibilities, rather than preventing the problems from emerging.

With the advent of nanotechnology, it was therefore argued by many ethicists that society should "seize the day" and take the "historic opportunity" to install ethics *in advance of* the technological development itself. Nano-ethics should not only deal with existing technologies, but also prepare for future technology, and foresee and prevent ethical problems. Furthermore, even many strong proponents of nanotechnology have called for ethics to be included at an early stage. Often, reference has been made to the political controversies over genetically modified food in Europe as an example of an unwanted situation. Ethics has been conceived both by nano-optimists and nano-skeptics as a way to avoid massive expenditure on the development of products that, at the end of the day, are found to be unwanted by citizens and consumers.

The diversity of nanotechnology ranges from well-established production methods for nanostructured materials to, say, basic research on hypothesized functional couplings between computers and animal (or human) brains. From this, one may appreciate how diverse nano-ethics debates may be. The nano-ethics literature discusses a myriad of existing and non-existing technologies; with observed or suspected or postulated impacts; and the impacts may be controversial, trivial, and difficult to identify. As might be expected by academics under such uncertain conditions, there is also a lot of discussion about what are the appropriate topics and methods for nano-ethics, and how this field should develop [8, 9]. We may concur with Kjølberg & Wickson [7] that the nano-ethics field in a certain sense is *immature*.

Immaturity does not imply fault or uselessness, though. On the contrary, in what follows, I will draw upon the current diversity of opinions of what nano-ethics is and ought to be in order to explain how one may ask ethical questions about a

1) In the absence of an authoritative reference, the blog of the "Editors of The American Journal of Bioethics" has been consulted: http://blog.bioethics.net/2006/01/nanoethics-the-elsi-of-21st-century-bioethics/ (accessed 16 November 2010).

certain technology in different ways and at different levels; they will be called three different ethical "gazes", or ways of looking at the system of research, development, and production of technology. This "system" is difficult to define in the general case, as it may or may not include this or that form of directed or applied research, various activities associated with technology transfer, and so forth, in the concrete case. However, I believe a general and rather undifferentiated concept of the "system" to be useful. From now on, I shall use the words "gaze" and "system" in this sense. This may all sound abstract, but we shall see that the implications are highly practical and policy-relevant.

16.2
Identifying and Avoiding Unethical Nanotechnological Products

Which nanotechnological products and processes are, or could be, unethical, and in what respect? In my subjective experience, this is the intuitive nano-ethics question for many journalists, policy-makers, and scientists. Many ethicists, perhaps striving to be useful in the eyes of those who pay their salaries, apply this kind of ethical gaze at the system, looking for potential harm, injustice, inequity, threats to human self-determination and dignity, and so on.

The first question to be asked is, of course, if the nano-product is or may be harmful, a question that belongs as much to risk–hazard assessment and management as to ethics. For instance, it is an open question as to whether free nanoparticles may travel through the body or the ecosystem and give rise to novel human health risks or environmental effects. The desirable properties of nanoparticles are due to their small size, which gives them a higher surface-to-volume ratio and different chemical properties. It is by no means unthinkable that these same characteristics may cause unforeseen effects that could be harmful. Such questions must be studied by the appropriate scientific disciplines, such as toxicology and ecotoxicology, and can of course not be decided upon by ethicists. No conclusion about harm can be made in the general case; it will depend upon the stability, mobility, and reactivity of the type of particles, their use, the adequacy and reliability of safety measures, and so on. Ethics may still be useful by debating the right thing to do given the certainty or uncertainty about positive and negative effects. Typically, a designed and certain benefit has to be weighed against uncertain or even unidentified harm.

One important discussion that follows is whether ordinary risk assessment and management procedures should be used, whether some version of the precautionary principle should be invoked, or if even more cautious measures are required. The ETC Group [10] has called for a moratorium to be applied to the environmental release of free nanoparticles on these grounds. Another non-governmental organization, Friends of the Earth, has argued that definitions of nanoparticles should be reworked to be more precautionary (including particle size up to 300 nm) [11, 12]. As nanotechnology gradually enters human medicine and food industries, one should expect ever more focus on the aspect of potential harm.

It is also important to bear in mind that the question of harm is not only one of undesired secondary effects. One may easily imagine nano-terrorism and other malevolent uses of nanotechnology, for instance by designing highly reactive particles that may penetrate the body or foodstuffs. Furthermore, it has been pointed out that nanotechnologies, because of their small size, might more easily evade detection, especially if one does not know what to look for. Again, this would be relevant for industries that could be the victim of sabotage. As for military research on nanotechnology, this is not within the expertise of the present author; and, indeed, sources of reliable public information do not abound.

Along the same lines, questions of autonomy and dignity of humans have been discussed. In the case of nanotechnology, one could imagine a further miniaturization of tracer technologies, for instance to improve logistics or knowledge of origin of products, which might also be used in surveillance of unaware subjects (see also Chapter 4 in this volume). Even with subjects aware of their use, nanotechnology-based medical technologies might constitute a complexity of "inner surveillance" and precision control over physiological parameters through directed medication within the body, to the extent that the subject is hardly informed and in control any more. It has been argued that such benevolent and medically beneficial technologies may also be a threat to perceived personal autonomy and integrity. Taking it to the extreme, the envisaged coupling of biotechnology, information and communication technology (ICT), and cognitive science at the nano level – so-called nano-bio-info-cogno (NBIC) – has raised discussions over potential technologies for human enhancement, that is, technologies that improve human senses and capacities, either for the individual or even for (part of) the human species. On this issue, the North Atlantic Ocean appears to be a sharp line of division: while arguments in favor of human enhancement and *transhumanism* are utterly politically incorrect in Europe, transhumanist visions have actually been put forth by central nanotechnology proponents in the USA [13, 14]. If one consults the web page of the MIT Institute of Soldier Nanotechnologies,[2] one may furthermore be convinced that the issue is not purely one of science fiction. I shall return below to the European response to US transhumanism.

Finally, the ethics debate has discussed the so-called *nano-divide*, or how the organization of research and development of nanotechnology might increase global injustice. It is true that nanoscience and nanotechnology are dominated by wealthy and developed countries: North America, Western Europe, Japan, and then South Korea and China. The nano-divide is not just focused on the question of who develops and owns nanotechnologies, but also whether these technologies get built into more production systems so that the lagging behind of poorer economies will become an increasingly large disadvantage in the global market.

Summing up, the ethical gaze I have described is one that screens and scrutinizes the properties of a given nanotechnological product, process or activity, and that investigates its actual or potential effects. Normally, this ethical focus is *negative* in the sense that there is no need for ethics if there is no harm or threat to

2) See http://web.mit.edu/isn/ (accessed 16 November 2010).

anyone. The ethics consists in identifying problems and then figuring out what to do with them: if something should be discouraged or prohibited, or if special antagonistic measures should be taken. Exactly for this reason, this ethical gaze is closely related to legal and regulatory institutions and procedures. What I have described here is the kind of ethics that is a central part of what goes on in ethics reviews and ethics committees, as well as governmental reports.

16.3 Ensuring Ethical Nanotechnological Research, Innovation, and Production

A distinctly different, but equally important, ethical gaze is that which looks at the *actions* that lead to nanotechnological products. The question is then no longer if the product is unethical, but if the researchers, developers, and producers have behaved in ethically justifiable ways, and if their institutions and companies are organized in an accountable and responsible manner that allows, encourages, and ensures ethical behavior. This is important for all fields of science and technology, and not less important for nanoscience and nanotechnology, for two reasons. First, there is big money involved, with high expectations of profit. Second, as already mentioned, nanotechnologies may involve particular challenges with respect to detection, controllability, and unknown harmful effects. In other words, in particular in terms of sins of omission, there is what a television series crime investigator might call both *motive* and *opportunity*.

At the same time, the practices and institutions of research have changed vastly. Until World War II, science was a lifestyle choice and involved a small elite. Since 1945, the *gentlemen* have become vastly outnumbered by the *players*, and research is now ordinary work, not even particularly well paid or highly esteemed, at least not for the majority of the research workforce. In the natural sciences, many researchers do not enjoy the freedom to develop their own research questions, but rather work as "super-technicians" within large research teams. Many senior researchers have vested interests in the products of their own research. Without exaggerating the sense of vocation and ethical virtues of the scientists in the past, it is not difficult to understand that ideas of new public management and quality assurance found their ways into a research world with big expenditures, big workforce, and big safety challenges. Hence, to avoid fraud and corruption, researchers nowadays are required to store data in prescribed ways and to disclose their personal economic interests. Universities and research institutions produce ethical guidelines and demand that their employees and students comply with them; ethics courses are offered or even required; and there are ever more national and international research guidelines. The author's home country, Norway, passed its Research Ethics Act in 2006, actually making breaches of research ethics illegal.

To a large extent, this has been a matter of codifying and enforcing ideals and norms of research ethics that already existed. More than 60 years ago, Robert K. Merton [15] formulated his "ethos of science", arguing that efficient knowledge production depended upon open access to others' work, a disinterested attitude

(i.e., only interested in truth), and a methodically critical attitude ("organized skepticism"), and so on. Seen with this ethical gaze, good ethics is a prerequisite of good science; indeed, they are almost the same thing. Likewise, one may argue that there can be no functional economic market in a society where everybody is prone to lie, cheat or steal.

Nonetheless, the development of the institutional ethical gaze goes beyond the classical norms of the ethos of science, business ethics, and common morality. The clearest example of this is the high-level expert report to the European Commission called *Converging Technologies for the European Knowledge Society* (CTEKS for short) [16]. The CTEKS report acknowledges that ordinary honesty combined with the ethical gaze at products is not enough to avoid ethical problems with nanotechnologies. It is fair to see the report as a response to the US NBIC report [14] that to a large extent advocated human enhancement and only envisaged a *post hoc*, corrective role for ethics. The CTEKS question was accordingly: How can we ensure that nanotechnology development does not take a harmful, unethical, and dangerous direction? Formulated in the usual self-content European jargon: How do we ensure that the technology development is in accordance with European values?

One should appreciate how radical the reflection provided by the CTEKS report actually is. So far in this chapter, I have only discussed ethical gazes that look for anomalies – faults or sins – within a system that is never questioned *per se*. The CTEKS report, however, acknowledges the fact that researchers and developers with good intentions, complying with every ethics guideline there is, may still produce something dangerous or unethical. Of course, it may then be identified as such by an ethics committee – but then it may be too late. The world may already have changed, because something is introduced and dispersed into our ecosystem, or our bodies, or our space of possible ill-intended actions. Again, at the heart of the issue we find the power and the smallness of nanotechnology, potentially eluding detection and retraction.

The CTEKS report tries to solve this challenge by demanding that research shall be planned in accordance with European values. The convergence of sciences and technologies at the nanoscale does not happen arbitrarily and by itself, they argue, it requires that technical goals are set. The answer is therefore to organize broad political processes to define the social purposes to which these goals are to correspond. For instance, they mention reduction of obesity as a health problem, as a purpose that is in accordance with European values, while human enhancement is not. This value choice must then be translated into ethically responsible research policies.

16.4 Nano-Ethics as the Question of the Good Nanotechnology Society

The CTEKS report is a suitable departure for explaining a third ethical gaze, namely that which asks about the good nanotechnology society [17]. First, it is clear that CTEKS aspired to provide a road to that society. It is even possible that it could

do so in certain domains of nanotechnology development, perhaps also in the agri-food sector. The more applied and the less "fundamental" character of the research and technology involved, the more relevant CTEKS appears to be. It would be exciting to see attempts at democratic involvement of citizens in the design of novel foods, rather than treating the same people only as consumers whose behavior is predicted through focus group methodologies. A number of so-called upstream engagement exercises have been devised over the latter years, in particular with respect to nanotechnology (see also Chapter 15 in this volume). It remains to see whether such exercises have had significant impact and that this impact has resulted in a better nanotechnology society (see e.g. [18]). Moreover, when the research and development activities take on a more "basic", fundamental character, it is hard to see that a solution such as CTEKS could work at all. There is no one-to-one correspondence between the preset goal of a basic research project and its results; on the contrary, open-endedness is a defining character of science [19, 20].

What CTEKS clearly showed, however, is how close a relationship there is between the ethical and the political. This was explained in full by another European expert group in their report *Taking the European Knowledge Society Seriously* [21], which talked about *the unpolitics of ethics*. Ethics – in particular, in the shape of expert ethicist committees and reports – effectively serves to remove attention from and to depoliticize politically controversial issues: "Don't worry, we have a group of ethics experts working on it!" The original, broadly defined political issue, perhaps vaguely or just implicitly expressed as "But do we really need this novel food? Do we, as a society, really *want* it?", is transformed by the above-described myopic ethical gazes into questions of health risk, religious qualms about tampering with nature, or new "ethical accounting" practices in research and development. Accordingly, the political issue is reduced to a set of so-called ethical issues that are of a technical nature and have a technical solution, and the public can be reassured as everything is under the control of the ethical experts. The big question is, of course, whether the people *really* are reassured, and for how long, by such procedures.

In the introduction, I posed the question of what nano-ethicists discuss, and replied that the answer is complicated. By now the reader will know why. The choice of ethical gaze is in itself an ethical and political choice, and this is as true for the technologist and producer as it is for the ethicist. In my view, there is still a lot to learn from careful reflection upon the controversies surrounding genetically modified food. According to the European expert group cited above, ethics contributes to depoliticize controversial issues, in particular if the ethics is narrowly construed as expert deliberation upon limited questions of a more ethical–technical nature. This may be true, though the genetic modification controversies also show that the involvement of ethics and ethicists does not eliminate or preempt the political potential. In other words: Ethics projects, ethics groups, and ethicist advice do not make the real problems go away in cases where the public really has an opinion. A narrow approach to ethics accordingly runs the risk of failing to predict, prevent or prepare for a big controversy at a later stage.

In this respect, it is interesting to note the development of "codes of conduct" for nanotechnology. In February 2008, the European Commission published their

Code of Conduct for Responsible Nanosciences and Nanotechnologies Research [22].[3] The concept of ethics does not in itself play a prominent role in the document, although it is of course said that research should be in accordance with ethical principles and comply with ethics guidelines and ethical review. There is no doubt, however, that the entire code is consistent with – and perhaps informed by – the broader view on ethics and politics that I have described as the third ethical gaze. Indeed, the first principle of the code is called "meaning", and reads as follows [22]:

> ***Meaning*** N&N [nanoscience and nanotechnology] research activities should be comprehensible to the public. They should respect fundamental rights and be conducted in the interest of the well-being of individuals and society in their design, implementation, dissemination and use.

Furthermore, the code recommends an inclusive approach to governance [22]:

> Good governance of N&N research should take into account the need and desire of all stakeholders to be aware of the specific challenges and opportunities raised by N&N. A general culture of responsibility should be created in view of challenges and opportunities that may be raised in the future and that we cannot at present foresee.

"All stakeholders" is understood as "Member States, employers, research funders, researchers and more generally all individuals and civil society organizations engaged, involved or interested in N&N research" [22]. One may of course discuss how realistic such aspirations are, and to what extent soft regulation such as this recommendation by the European Commission will have any implications. Entering into the general discussion on soft regulation will go beyond the scope of this chapter; however, it should be recalled that the communication on the precautionary principle [23] and the White Paper on governance, two definitely influential texts from the European Commission [24], were both "mere" recommendations. The effect of such recommendations, guidelines, and codes depends on the creative work of facilitating (or averting) their implementation and use.

16.5 Conclusion: The Ethical Challenge Ahead for the Nano-Agri-Food Sector

In this chapter, I have described three nano-ethical gazes that ask the following type of questions:

1) What ethical problems (harm, injustice, inequity, threats to human self-determination and dignity, etc.) are raised by the nanotechnological *product* or process under scrutiny?

3) A UK non-governmental initiative along the same lines can be found at: http://www.responsiblenanocode.org (accessed 16 November 2010).

2) Are the *actions* of researchers, developers, and producers organized in an ethically responsible (benevolent, honest, accountable) way?

3) What would constitute a *good* society with nanotechnology, and what path leads to this society?

The multiplicity of these gazes corresponds to the eternal diversity of ethics, being concerned with *the morally right and wrong* as well as *the good life*. All three questions are important and, I would claim, necessary, and they are related to each other. I have argued that academic and applied ethics have directed too much attention to the two first-mentioned questions, while the third type of question appears to be on the rise, not always under the label of ethics, but also as the (political) issue of *governance of nanotechnology*.

Just as little as any other argument, the argument of this chapter cannot be politically neutral. Indeed, to insist on the relevance of the third gaze and third type of question, is to say that the objective of current innovation policies is not self-evidently good in the moral sense. There is a long and strong tradition, in particular in the industrialized world, to see scientific and technological progress as something inherently and unquestionably good. This is why ethics has been relegated to the minor role of avoiding what we could call moral adverse effects. The lesson from the advent of the nuclear bomb is that progress is inherently two-sided. The lesson from the genetic modification controversies, if not before, is that people know about the ambiguity of progress, and may actually say "no thanks" to new and technically speaking better products. Accordingly, developers and producers are left with two options.

The first option is to accept that judging the quality of new products – quality in the broadest sense, technical, ethical, political – is, and should be, a collective, societal task. If so, all three ethical gazes are necessary, and the industry needs slow and sincere dialog with the public.

The other option is not to accept this claim, and instead to develop more sophisticated knowledge of consumer behavior together with more effective means of persuasion, so that the public will not resist the introduction of what scientists, technologists, and industrialists believe to be rational technologies and better products. This option violates most of ethics' general principles, such as the respect for the self-determination and dignity of others. In other words, the ethical challenge for the sector is in one sense simple: to be ethical or not to be ethical, that is the question.

Acknowledgments

This chapter builds upon the countless discussions within the Nanoethics Group at the Centre for the Study of the Sciences and the Humanities, University of Bergen, in particular with Fern Wickson and Kamilla Lein Kjølberg, as well as the fruitful collaboration with Rune Nydal, Program for Applied Ethics, the Norwegian University of Science and Technology. The financial support from

the Research Council of Norway to the Nanoethics Group is gratefully acknowledged.

References

1 Hunt, G., and Metha, M. (eds) (2006) *Nanotechnology, Risk, Ethics and Law*, Earthscan, London.

2 Allhof, F., Lin, P., Moor, J., and Weckert, J. (eds) (2007) *NanoEthics. The Ethical and Social Implication of Nanotechnology*, John Wiley & Sons, Inc., Hoboken, NJ.

3 Royal Society and Royal Academy of Engineering (2004) Nanoscience and Nanotechnologies: Opportunities and Uncertainties. The Royal Society, London, UK. Available at: http://www.nanotec.org.uk/finalReport.htm (accessed 9 November 2010).

4 Tegart, G. (2006) Environmental, social, legal and ethical aspects of the development of nanotechnologies in Australia. A report from the National Academies Forum for the National Nanotechnology Strategy Taskforce, Department of Industry, Tourism and Resources, National Academies Forum, Parkville, Victoria, Australia.

5 National Science Foundation (2001) Societal implications of nanoscience and nanotechnology, Report from the *Workshop held at the National Science Foundation, 28–29 September 2000* (eds M.C. Roco and W. Bainbridge).

6 UNESCO (2006) *The Ethics and Politics of Nanotechnology*, United Nations Educational, Scientific and Cultural Organization (UNESCO), Paris.

7 Kjølberg, K., and Wickson, F. (2007) Social and ethical interactions with nano: mapping the early literature. *NanoEthics*, **1**, 89–104.

8 Strand, R. (2001) ELSA studies of nanoscience and nanotechnology, Memo to the COST Nanoscience and -Technology Advisory Group (NanoSTAG). Available at: http://www.stage-research.net/STAGE/nanotechnology/nanostag-elsa.pdf (accessed 16 November 2010).

9 Van de Poel, I. (2008) How should we do nanoethics? A network approach for discerning ethical issues in nanotechnology. *NanoEthics*, **2**, 35–38.

10 ETC Group (Action Group on Erosion, Technology and Concentration) (2003) No small matter II: The case for a global moratorium. Size matters! Available at: http://www.etcgroup.org/upload/publication/165/01/occ.paper_nanosafety.pdf (accessed 16 November 2010).

11 Friends of the Earth (2006) Nanomaterials, sunscreens and cosmetics: small ingredients, big risks. Available at: http://nano.foe.org.au/node/100 (accessed 16 November 2010).

12 Friends of the Earth (2008) Out of the laboratory and onto our plates: nanotechnology in food and agriculture. Available at: http://nano.foe.org.au/node/227 (accessed 16 November 2010).

13 Roco, M.C., and Bainbridge, W.S. (2002) Converging technologies for improving human performance: integrating from the nanoscale. *J. Nanopart. Res.*, **4**, 281–295.

14 Roco, M.C., and Bainbridge, W.S. (eds) (2002) Converging technologies for improving human performance, NSF-DOC Report, Arlington, VA.

15 Merton, R.K. (1942) The normative structure of science, in *The Sociology of Science: Theoretical and Empirical Investigations* (ed. N.W. Storer), University of Chicago Press, Chicago, IL, 1973, pp. 267–278.

16 Nordmann, A. (2004) Converging technologies – Shaping the future of European societies, Report for the European Commission via an Expert Group on Foresighting the New Technology Wave, European Commission, Brussels. Nydal and Strand 2008 probably to go in here

17 Nydal, R., and Strand R. (2008) God nanoetikk – god nanoteknologiutvikling.

Etikk i praksis (Nordic Journal of Applied Ethics), **1**, 33–51.

18 Gavelin, K., Wilson, R., and Doubleday, R. (2007) *Democratic Technologies? The Final Report of the Nanotechnology Engagement Group (NEG)*, Involve, London.

19 Pickering, A. (1995) *The Mangle of Practice*, University of Chicago Press, Chicago, IL.

20 Kjølberg, K., Delgado-Ramos, G.C., Wickson, F., and Strand, R. (2008) Models of governance for converging technologies. *Technol. Anal. Strateg. Manage.*, **20**, 83–97.

21 European Commission (2007) Taking European knowledge society seriously, Report of the Expert Group on Science and Governance to the Science, Economy and Society Directorate, Directorate-General for Research, European Commission.

22 European Commission (2008) Commission recommendation of 07/02/2008 on a Code of Conduct for Responsible Nanosciences and Nanotechnologies Research, C (2008) 424, Commission of the European Communities, Brussels. Available at: http://ec.europa.eu/nanotechnology/pdf/nanocode-rec_pe0894c_en.pdf (accessed 16 November 2010).

23 European Commission (2000) Communication from the Commission on the Precautionary Principle, COM (2000) 1, Brussels.

24 European Commission (2001) White Paper on European Governance, COM (2001) 428, Brussels.