

ETHICS, SCIENCE AND PRECAUTION A VIEWPOINT FROM NORWAY

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This paper examines the question of how applications of the Precautionary Principle are interwoven with value issues and ethics. It takes as its starting point some recent discussions in Norway in order to highlight how ethics and value issues are unavoidable when the Principle is put into practice. A central claim is that some ambiguity and disagreement is inherent in the Principle as long as no procedural measures are taken to address these issues explicitly in suitable democratic fora. These considerations might be relevant also for other countries and cultures. In Norway the Precautionary Principle enjoys a wide public acceptance, even among many scientists, and it is already relatively well entrenched in the legal framework. The Principle has been actively discussed among scientists and large parts of government administration. Norway has also more than 10 years of experience with national advisory bodies in the area of scientific ethics. These bodies work with a definition of scientific ethics that makes it natural to include issues of applying the Precautionary Principle among the scope of their deliberations. In spite of these experiences, it seems fair to say that no unified approach to handle precautionary topics in science and technology has been reached. Instead of interpreting this experience as an argument against the principle in general, this paper makes the claim that the ethical and value dimensions that are part and parcel of the precautionary principle are as yet not adequately accounted for.

Expert commission reports

In Norway, the precautionary principle played a crucial role in two recent government-appointed expert commission reports within one year. One such report was on the health consequences of genetically modified products (NOU, 2000:29; hereafter referred to as the "Walløe-report"), and the other one was on xenotransplantation (NOU, 2001:18, hereafter referred to as the "Gjørsv-report"). While both are unusual in their explicit and lengthy discussion of the precautionary principle, they come roughly to opposite results with regard to the question whether all necessary conditions are fulfilled that would indicate that the precautionary principle needs to be applied to genetically modified food products or xenotransplantation respectively. For clarification, it is important to note that we distinguish between a) checking whether conditions for applying the precautionary principle at all are fulfilled (conditions that we shall outline in a later chapter), and b) determine what kind of precautionary measure is indicated once it is agreed that the principle should be applied. Norwegian expert commission reports are written for Government on the basis of an explicit mandate, are published and accessible for everybody (now also on the internet), and include both a presentation of the relevant scientific facts and findings, and the recommendations of the commission with regard to suitable regulatory measures. Normally one seeks to maximise the consensus of all commission members on specific topics, but it is not unusual that a commission has a split vote, be they of minor or major overall importance. The final report, normally drafted by a secretariat or by individual members of the commission, thus represents the viewpoints of all commission members.

The Walløe-report considers various potential health risks of genetically modified (GM) food, and nearly each time such a potential health risk is discussed in the report all but one member of the commission conclude that existing evidence to date provides no reason to apply the precautionary principle. For instance, concerning the question whether a new gene can be transferred from food plants to mammalian cells via the intestinal system of the body, the commission is unanimous that this is normally not the case. They state what is considered established textbook knowledge in this area. However, the commission also mentions that a number of new studies seem to suggest significant exceptions to this rule. There are apparently well-documented scientific reports that show that the rule is not without exceptions. The causes behind these exceptions are, however, not known. The group then mentions that the very few animal studies based on long term feeding with GM food have not considered the question of gene-transferral to body cells. Thus there is a clear lack of direct scientific evidence to show that genes from gm-food could enter mammalian body cells. The majority then concludes from

these observations that there is no reason to apply the precautionary principle in fear of genetically altering mammalian body cells, and that the few possible exceptions to the complete breakdown of DNA in intestinal tracts that we know of, would equally apply to traditional food (i.e. not genetically modified food). Only one member of the commission warns that we do not know the mechanisms behind these exceptions, that GM food might indeed stimulate these exceptions to established textbook knowledge and that the potential health risks are too significant to be neglected. This member therefore opts for applying the precautionary principle.

The philosophy behind the majority in the Walløe report is apparently that we need specific scientific studies that establish through accepted, proven methods that the risks are real. As a second step we may then consider whether the risks are too great, and whether we should apply the precautionary principle. It may be noteworthy that the report repeatedly criticizes the lack of independent studies in this area, but this had apparently no effect on the committee's conclusion that risks were non-existent or too small to justify applying the precautionary principle.

The commission preparing the Gjørsv-report had to address uncertainties that by and large were similar in kind to those involved in the Walløe report. The main risks of xenotransplantation derive from the possibility of xenosis - the transferral of infectious diseases from animals to humans via xenotransplantation. The porcine endogene retrovirus (PERV) is of particular concern. Similar to the case of GM food, to date no studies have demonstrated directly any transferral of PERV from primary (i.e. not grown in the laboratory) pig cells to primary human cells. But the report also identifies seven steps necessary for PERV-infections to become a health risk to humans, e.g. that infectious PERV must be able to infect human body cells, that the transplant organ might excrete PERV etc. The fact that 4 of the 7 steps were already shown to occur in laboratory studies, even though some of them only under idealised circumstances (e.g. with immune-deficient mice), is taken as indication that the risk might be real. Furthermore, the report referred to the development of HIV-infections as a relevant model for predicting potential xenosis. HIV-infections have developed as zoonosis from apes to humans. Thus the report concludes that there is a scientifically-based scenario of possible harm, though there is no indication about its likelihood. On this basis, the commission is unanimous in concluding that the precautionary principle should be applied to xenotransplantation. We shall return to the subsequent issue what this conclusion implies for regulatory measures later in the paper.

These examples illustrate how the vocabulary of the precautionary principle has entered debates about scientific and technological developments that are likely to have major social or environmental effects. In essence, they show that it is virtually impossible to separate science and its use in policy when dealing with complex, uncertain systems. There are significant inconsistencies in different people's understanding of how to interpret the conditions for the use of the precautionary principle in specific cases. Judgement is only in part a matter of science. In Europe, and at least in Scandinavia, the discussions are (for the most part) not about whether or not to endorse the precautionary principle in environmental and other policy. It is already written into several laws and international treaties, and some scientists and administrators claim that it basically expresses the "spirit" which has guided science and public policy for a long time before that, perhaps as far back as 1896 (cf. Harremoës 2001).

However, the really difficult questions relate more to the issues of how radical a break the precautionary principle is from standard procedures of risk assessment, what kind of information it demands from science, what truly precautionary measures are, and who is to be consulted in these matters.

Proponents of a narrow interpretation of the Precautionary Principle, like the Walløe-commission, typically base their arguments on what "sound science" has shown or what kind of "facts" have been proven by scientific studies. They ask for scientific evidence of the reality of possible harm based on indisputable direct studies. Others find it paradoxical that the very core of the Precautionary Principle, i.e. the existence of scientific uncertainty, needs to be described by "hard scientific facts". For these people, arguments from analogy and from model scenarios often seem sufficient ground to apply the principle. In the face of uncertainty and high decision stakes all available evidence needs to be considered and taken into account, also when the evidence is only of an indirect nature. This ambiguity is not related to the worry, sometimes

expressed by critics of the precautionary principle (cf. Morris 2000), that the principle might open the floodgates to all kinds of speculative "fundamentalist" worries or unrealistically aim for zero-risk. Rather, it is an ambiguity that persists even if all parties agree that applications of the precautionary principle must be based on some scientifically based harm-scenarios.

Scientific ethics: broadening the scope

In Norway we have three national committees for research ethics, established since 1991: one for medicine, one for social science and the humanities, and one for science and technology (abbreviated as NEM, NESH, and NENT respectively; cf. www.etikkom.no). These committees have operated with a wider notion of research ethics than is usually the case in the anglo-american countries. First, the field of research ethics is not limited to research with human subjects, but includes other entities such as the environment. Second, research ethics are not even limited to individual scientists' behaviour in a research setting; ethical considerations also include macro reflections on the behaviour and policies of larger entities such as scientific institutions. Third, research ethics are considered not only with regard to the process of doing research, but also with regard to the responsible handling, interpretation, and communication of research results. In fact, this last area has been dominant in Norwegian discussions about ethics of science and technology.

The rationale for this wide use of ethics is twofold:

1. Science is an important actor in translating scientific results into social reality.
2. Knowledge implies moral responsibility. In matters of policy all involved parties have some responsibility, but those with the most information on and best insights in possibilities and dangers have a special co-responsibility to utilise their knowledge (cf. Mitcham & Schomberg 2000).

Given this understanding of research ethics, the Committee for Science and Technology (NENT) undertook a close examination of the precautionary principle. The Committee produced a comprehensive report in Norwegian in 1997 (NENT 1997). The reason for the Committee's interest was that the precautionary principle might face the same fate as the concept of sustainability: policy makers wanted the scientist to say something about it, and scientists felt this was exclusively the decision maker's responsibility. In such a situation there is a real danger that both parties might overlook the novel challenges that this principle poses to each one.

What is the relationship between the precautionary principle and ethics? NENT argued, that the principle relates to ethics and ethical values in several ways (NENT 1997, chapter 4).

First, the Precautionary Principle is to a large degree based on or justified by a moral principle that has a long history in ethical theory. The principle is that of culpable ignorance dating back to Aristoteles. The committee discovered Ian Hacking's discussion of this principle (Hacking 1986), and found it very much in line with legal thinking. The law of many countries provides conditions for punishing individuals when it can be shown that they were in a position to prevent an accident and failed to act upon some available information that could have served as a forewarning of the danger ahead. This is usually referred to as negligence.

The concept of culpable ignorance is easy to grasp by way of example. Suppose you own a very old car. If you have an accident because another car suddenly pulls to the left without warning and hits you, then you were simply ignorant of the other driver's intentions and not to blame for the accident. However, if you have an accident because your brakes fail, then the case might look differently. Knowing that brakes in old cars tend to become faulty, you should have had them checked at regular intervals. Of course, you will be ignorant about the possible damage of the system until the brakes finally fail. But if you also have failed to check them regularly then you will also be culpably ignorant, and you bear some moral (and legal) responsibility for a resulting accident.

In general, one is culpably ignorant if on the basis of some general knowledge, one recognizes the need for certain supplementary specific information or measure in order to avoid harm, but fails to do so. This general knowledge will typically be such that it comprises types of situations rather than the specifics of a given situation. In other words, it reasons by analogy rather than proof. In the example above, this general knowledge would relate to what one should expect from a technical system after long-term use. Old cars should be checked for proper functioning; failure to check is negligent.

If this reasoning is sound for everyday behaviour, then there is good reason to assume that it also should hold for science and policy making. As we shall discuss below, the question then is to define what types of general knowledge place this burden of responsibility on us.

This is not the only way the precautionary principle relates to ethics and ethical values. In fact, when weighing uncertainties and risks, when deciding what methodological approach befits a subject, when evaluating several precautionary strategies, and when deciding who has a say in the decision process, values of some kind (other than purely epistemic values) play an important role. Since these values aspects tend to be neglected by both science and policy makers, NENT felt it was important to examine and point out these value-related issues.

As an illustration of this interdependence of science and ethics one may consider the discussion about statistical type I versus type II errors (cf. e.g. Lemons & Shrader-Frechette & Cranor 1997; Fjelland 2002). A type I error is rejecting a true null hypothesis, i.e. claiming an effect where in reality there is none. A type II error is accepting a false null hypothesis, i.e. to overlook a real effect. In statistical testing we investigate whether observed differences in a system are significantly larger than the probability of blaming chance variations for these differences. Normally there is a certain trade-off between type I and type II errors: increasing the one means decreasing the other. In standard significance tests researchers more often than not only control for type I errors. But when dealing with decision making about possible future harm, e.g. about some environmental matter, the really crucial information may be what the chances are of overlooking a real effect. Not finding statistically significant differences may mean that there were not found such differences and it is highly probable that one would have found a difference if there were one. Or it may mean that there were no such differences found, and even if there were any such differences in reality it is highly improbable that one would have them. The latter case highly reduces the value of the scientific information for decision-making. The focus on type I errors seems primarily oriented towards epistemic values (i.e. reducing the costs of making unwarranted claims), while focus on decision stakes bespeaks the explicit inclusion of type II errors. In overlooking this statistical insight in standard significance tests, science makes a value assumption not adequate for preventive measures in the light of possible harm.

Of course, the first result of such an inquiry into the relation of values, ethics and the precautionary principle could be considered negative: applying the Precautionary Principle is not simply a matter of "objective" standard science or routine administrative work. There is no straightforward objectivity attached to the principle. No science can deliver the "right" answers. One cannot avoid some kind of explicit stand on basic values (cf. also JAGE 2002). This is nowhere more apparent than when considering what kind of preventive measures to take. Before we shall discuss this point, we shall first say a bit more on the necessary conditions for applying the precautionary principle.

Applying the Precautionary Principle

Scientists often criticize the notion of precaution as being too imprecise; that there is no definition available that allows an immediate operationalisation of the principle (cf. Sandin 1999; Graham 2001; Goklany 2001; Morris 2000). This is, of course, true for all the diverse definitions and formulations that this principle has undergone over the years. None of these formulations allow for a mechanical application of the principle. All need interpretation. The scepticism seems to persist in many quarters of science, in spite of the many academic efforts to clarify

precaution further (cf. e.g. FoS 1997, JoRR 2001, JAGE 2002; Cottam et al. 2000; Freestone & Hey 1996; Raffensperger & Tickner 1999; see also Lemons & Brown 1995; Lemons 1996).

It was already in 1994 pointed out (O'Riordan & Cameron 1994) that the vagueness of the principle is by no means surprising, nor is it a drawback. In 1999 Jordan and O'Riordan state that "the application of precaution will remain politically potent so long as it continues to be tantalizingly ill-defined and imperfectly translatable into codes of conduct, while capturing the emotions of misgivings and guilt" (Jordan & O'Riordan 1999). The Precautionary Principle has a similar semantic status as moral norms or ethical principles (like human dignity, equity, and justice). It needs to be interpreted and specified on a case-by-case basis, and it will sometimes change its specific content according to the available information and current practices. With ethical principles it is well recognized that for instance the protection of human dignity sometimes calls for a certain measure of paternalism (e.g. when institutionalising certain patients) while paternalism in other cases might be the direct opposite of respect for human dignity. This is quite similar to precaution. In order to protect for instance the biodiversity of a given region it may be a wise measure simply to leave a disturbed or polluted river leading into this region to its further natural course, and stop all kinds of human interaction with the river. But in some cases it may rather be indicated to take active steps to bring this river back into a quasi-natural state again, e.g. by restocking fish species, reducing its salinity etc. We need to look at the case at hand in order to find out what precaution means in that specific case. Partly this is due to the complexity of the scientific facts that we need to relate to. But partly this is also due to the varying interests and values that enter such a case. Typically there will be competing interests (aside e.g. biodiversity) at stake, and sometimes these interests deserve indeed special attention (e.g. to preserve some cultural diversity by providing the economic basis for some human settlements). While the precautionary principle can remind us of our moral duty to prevent harm in general, it cannot prescribe what kind of sacrifice we should be prepared to make in each and every case. Thus the precautionary principle has the semantic status of a general norm rather than that of a detailed step-by-step rule of operation. It follows from this that it may make its occurrence in the guise of a multitude of different formulations and goal expressions.

This is well illustrated in the way the Precautionary Principle is included and described in the North Sea Treaties (Bremen 1984, London 1987, Den Haag 1990, Esbjerg 1995; cf. Ministerial Declarations 1995 & Esbjerg Declaration 1995). It appeared each time in a different guise and wording:

In the first ministerial declaration of 1984 the precautionary principle might be indirectly inferred from formulations such as the talk about ... "timely preventive measures ..." given "insufficient state of knowledge". In the next Declaration of 1987 there is now explicit talk that: "... a precautionary approach is necessary which may require action ... even before a causal link has been established by absolutely clear scientific evidence...". In 1990 the precautionary approach has advanced to a principle, e.g. when the Ministers declare that they want to "...apply the precautionary principle ... even when there is no scientific evidence to prove a causal link...". And, finally, in 1995 in Esbjerg the principle receives only passing mention, since the general goals of the policy have been agreed upon: "...the guiding principle ...is the precautionary principle ... - ...the goal of reducing discharges and emissions ... with the aim of their elimination."

It is certainly easy to conclude that the drafters of the Treaty were somewhat sloppy in their formulations of what is understood to be just one principle, or that the political circumstances demanded certain vagueness in order to reach consensus. However, one could also conclude that the principle was actually more or less implicitly guiding the whole series of negotiations, as some kind of intuition about the shortcomings of scientific expertise, and that only at the final set of negotiations (in Esbjerg) the negotiations were advanced enough to explicitly draw the conclusion to which all the negotiations had been leading, namely that emissions and discharges of non-natural substances into the Sea should be eliminated (for detailed discussion of cases the express the "spirit" of precaution see Harremoës 2001).

However, the semantic status of the Precautionary Principle should not prevent one from spelling out some of the crucial conditions for application. The conditions NENT (1997) embraced in the end are the following:

1. there exist considerable scientific uncertainties;
2. there exist scenarios (or models) of possible harm that are scientifically reasonable (i.e. based on some scientifically acceptable reasoning);
3. uncertainties cannot be reduced without at the same time increasing ignorance of other relevant factors; (i.e. attempts to reduce uncertainties by e.g. model-building or laboratory studies typically imply abstractions that lead away from the real system under study and there is no "adding back" to real conditions; cf. Fjelland 2002)
4. the potential harm is sufficiently serious or even irreversible for present or future generations;
5. if one delays action, effective counter-action later will be made more difficult.

While the NENT conditions for the application of the precautionary principle do not in any sense lay claim on expressing a widespread agreement, it is noteworthy that e.g. the EU communication on the precautionary principle (EU 2000) seems in part to express a similar spirit, for instance when it states that "recourse to the precautionary principle presupposes that potentially dangerous effects deriving from a phenomenon, product or process have been identified, and that scientific evaluation does not allow the risk to be determined with sufficient certainty".

It was on the basis of these criteria that the commission on xenotransplantation, previously mentioned, concluded that the precautionary principle should be applied in this case. It was on the basis of point 2, the lack of existence of scientifically reasonable scenarios of harm, that the majority in the Walløe-report rejected applying the principle. The difference lies in the fact that the xenotransplantation-group was willing to accept reasoning by analogy (such as the HIV experience, or basic research in laboratories under idealised circumstances), while the group on GM food wanted these scenarios or models to be based on feeding experiments directly relevant to the issue of GM food (and thus disregarding exceptions to the rule etc.). In other words, they operated on a narrow interpretation of what could fall under "scientifically reasonable scenarios of possible harm". .

The reason why the Gjørv group included research results not directly related to xenotransplantation, was that they deemed the risks to be too great for the general public to overlook or disregard evidence that signals caution. They were still looking for some positive scientific evidence – nor mere speculation on possible effects –, but the existence of one model-scenario of one kind of zoonosis, combined with partial laboratory evidence, was considered sufficient scientific reason to warrant caution. When the Walløe group concluded differently, they made a value judgement of significant importance.

Precautionary measures

Once one has established that the precautionary principle has to be applied, one normally faces the question of what to do about it. How precisely shall we act (including refraining from acting at all)? What measures should be counted as precautionary in some sense? This is the important question one has to address once the above conditions for the application of the precautionary principle are met. It is normally at this point that differences of opinion loom large.

Any action that can be assumed to effectively reduce the risks in question and that prepares us for handling future crisis could be counted as a precautionary strategy. However, choosing a strategy invariably involves taking a stand on basic value issues and, thus, ethics again.

The xenotransplantation group is most explicit about different kind of possible measures that could reduce risks. In this report four such possible strategies are mentioned explicitly:

1. a moratorium (refrain from positive action for a limited period of time)
2. a step-by-step strategy with pre-defined targets for research before development is brought another step forward

3. a go-slow strategy where practical use is restricted to few applications over a longer time
4. a monitoring strategy where a system is set up to report on occurring problems immediately and possibly affected individuals are contacted and isolated.

In the end, the report opted for a combination of all four strategies, with a limited moratorium in the beginning in order to establish a body of oversight, and then a combination of the other strategies.

The NENT report (1997) and Kaiser (1997) discuss possible precautionary strategies on a more general level via selected case studies, in particular the question of fish escapes from fish farming. Four types of possible responses are presented and discussed. Each of these strategies is based on implicit value assumptions. These have to do with the degree to which individuals tend to be risk averse or risk taking. To the extent that people believe that nature is very robust with regard to change, people tend to be more willing to take certain risks with nature. To the extent that people think nature is in a rather delicate balance, people tend to become risk-averse. The same can be said about society. Society, just like nature, has evolved over long time, and its institutions (e.g. its economical or institutional operations) are tuned to each other. Again, one may then believe that society is a very robust entity, which would incline one for risk-taking. Or one can believe that society with all its subordinate functions and workings is a rather delicate affair, inclining one to be risk-averse. Thus, when combining these attitudes, one ends up with what could be regarded as four ideal-types of risk-handling. It is important to note that none of the attitudes described above are directly inferred from science. They are pre-scientific matters of belief. They indicate where we might want to put our values when dealing with risks. It is not claimed that people in general do this in a very consistent manner. In fact, there may often be bias regarding the risks from which we ourselves benefit as contrasted to the risks from which others benefit but that might affect us. The important point to note is, however, that all positions seem to open for different precautionary strategies in the sense of measures to adequately reduce the risks, while there is no one strategy that can lay claim on being the "right" strategy. All depends on our individual values. None of these attitudes is based on hard science.

We have found that once it has been established that the Precautionary Principle should be applied, we are faced with a multitude of possible precautionary strategies. There is no one best strategy in any objective sense. We sometimes have to make trade-offs, for example between effects on nature and effects on society. If we decide, as the Walløe-report implicitly suggests, to go on with developing GM food and simply to monitor its further development carefully, then we put a much larger value on maintaining certain socio-economic processes than on protecting health or protecting the environment. This is certainly legitimate, but it is not a question of straightforward science. It is a value decision. In the xeno-case the situation is different. While the risks to nature are of minor importance in this case, it is the balancing of individual health benefits with public health concerns that seem to be the overall consideration.

Precaution and participation

When one is willing to accept that the Precautionary Principle implies value decisions of some kind or another and rests on basic ethical intuitions, what does one do with regard to the decision process pertaining to it? Who is in a legitimate position or in authorised office to make these decisions? In principle the answer could be easy: the democratically elected representatives in parliaments are justified to make these decisions. This is why they are elected in the first place.

However, in actual practice the situation may be, and normally is, much more complex. First, many of these decisions will involve long-term strategies, long extending the terms of individual elected decision makers. Second, many of these decisions are quite complex and need scientific expertise to be sorted out. That is why authorities and politicians expect scientists to play an active role in this decision-making. Very often, however, this means that scientific expertise provides all the information that goes into the decision process. Third, democratic societies are pluralistic societies, with a multitude of values and individual preferences. There are no expert

short cuts to this multitude of values. No ethicist has a higher authority in basic value matters than the people themselves. Fourth, those who are directly or indirectly affected by certain hazards should have a say in the management of these hazards. This is particularly relevant when risks affect minorities or other small groups without formal power. Risk-cost-benefit analysis in its standard forms, with its summation over individual preferences, is defective with regard to principal considerations of justice. When large burdens on few is contrasted with small benefits to many, very often the minority will loose out. Thus it has been suggested that if risk-cost-benefit analysis is to be employed at all, it needs to be supplemented by ethical weighting techniques (Shrader-Frechette 1991).

These considerations provide the basis for arguing that decision making with regard to the Precautionary Principle should be supplemented by policy tools that are participatory in character. This does not mean that our democratic institutions lack the formal powers to decide for or against a precautionary measure. They do have the power and in democracies it is a legitimate one. Furthermore, the claim is not that the decisions should be made by referendum instead of the established institutions. The final decisions will always rest with institutionalised decision makers. The claim is rather that from a moral point of view the decision makers should engage in a process where the public is extensively consulted and where input from this process is important for the final decision. When values and ethics enter the picture, pluralistic societies tend to oppose expert-based decision-making. This is the basic challenge in what is sometimes referred to as the new governance of science and technology. Apart from expanding the inputs on relevant values and evaluation of knowledge claims such a new form of governance also promises to provide for more robust long-term strategies. If the public is given a voice and listened to in the final decisions, then the public is also willing to take on co-responsibility for the outcome.

In this respect the application of the precautionary principle differs from traditional risk assessment methods. Very often risk assessments are conducted on a routine basis, in order to supply the standardised information needed for decision making. A new drug, for instance, does not necessarily involve problems of the kind that would call for a large public consultation. It is however worthwhile noticing that even risk assessors are now arguing for some form of public consultation as a supplement to risk analysis (cf. JoRR 2001), and they realize that both value-based motivations and interest-based motivations play a crucial role in implementations of the precautionary principle (Tait 2001; Stirling 1999).

There are a wide variety of participatory tools for decision-making in public policy. What kind of tool, what kind of procedure one adopts is obviously dependent of the kind of problem one faces. In Norway for instance we have some positive experience with the use of consensus conferences (with lay panels, the Danish model; cf. Joss & Durant 1995). For these conferences a panel of lay-people is selected (by advertisement in newspapers or by random draw from population register) and given a general theme for deliberation. They meet in two preparatory weekends and define specific issues to address and select the experts they want to hear. Then the three-day conference takes place. The first day is the day when the experts deliver their answers and papers to the lay-panel. The second day the group of experts is questioned by the lay panel and by the audience. Then before the third day the panel prepares its recommendations that are presented to the public and the press during the third day. These conferences seem to be an adequate tool when one deals with large-scale decisions affecting all society, such as GM food. In fact, NENT was co-responsible for arranging two such consensus conferences on gm-food, one in 1996 and one in 2000 (see www.etikkom.no, www.teknologiradet.no). They both provide an interesting footnote to the Walløe-report mentioned earlier: The 1996 lay panel referred to its worry that we know so little about the environmental effects of GM food, and the few independent studies done in this field. Many scientists "complained" about this lack of evidence to the panel. The second panel was even more troubled by the fact that the scarcity of studies on impacts had not changed significantly by the year 2000, despite undiminished assurances of safety by the same scientists. No wonder the lay panel recommended a strong precautionary strategy.

However, other matters might look different from a decision-theoretic point of view. One might meet well-defined and conflicting group interests, rather than general worries about

fundamental values at risk. In such cases NENT has used scenario workshops with interested parties (cf. Kaiser & Forsberg 2000; see also:

http://www.loka.org/pages/scenario_workshop_project.htm).

We still know too little about the possible uses and the impacts of participatory policy tools. In Europe we have started to assess some of them in larger European studies (cf. EUROPTA 2000; Fixdal 1998). All these participatory decision tools that seem part of the new governance of science and technology seem culturally dependent and topic sensitive. In that sense one cannot avoid experimenting with these tools. However, from the above it seems clear that the value basis and the more or less implicit value dimensions in the application of the Precautionary Principle imply the need for some such form of participatory decision tools to supplement institutionalised decision making. It may not be possible to specify the best tools in advance, and it may be that some participatory approaches have shortcomings in handling the complex issues involved. This should not distract from the observation that the precautionary principle because of its inherent value-dependency and ethics dimensions calls for a consultation with a wide section of the general public.

It is perhaps also noteworthy that the xenotransplantation report explicitly demanded that some form of public consultation – e.g., in the form of a consensus conference - should take place before the moratorium on xenotransplantation may be lifted. The commission preparing the report argued that the possible risks involved demanded an active public dialogue be established from the beginning that could enlighten the political decision makers about what kind and level of risks people find acceptable, given the positive potential of the treatment. It is then also noteworthy, that the Walløe-report provided no such recommendation about consulting the larger public about GM food.

Conclusion and recommendations

The Precautionary Principle is based on an ethical conviction that sometimes our very ignorance of possible future harm may be morally culpable. It assumes that we should actively look for information and knowledge that may have a bearing on uncertain, complex issues, and that in looking for that information we cannot apply too narrow a perspective. We need to consider and weigh knowledge and information that comes in from the sideline or enters by analogy. The precautionary principle is not based on pure imagination of remote and speculative possibilities. Just thinking or speculating that something might happen is not the kind of information that normally will trigger precautionary action, unless one indeed harbours some "fundamentalist" ambition of stopping all development and innovation. The principle, when placed in a realistic decision context, refers back to some scientifically relevant information. But where we find this information, and how we decide what is more or less relevant, may have to be decided on a case-by-case basis. Values will implicitly guide us when we pick the information we consider relevant.

To take the further step of precautionary action, we again have to make reference to values, since there is normally a multitude of possible strategies available to address suspected hazards. And often we have to make trade-offs between considerations concerning nature and considerations concerning society. Where we strike the balance in the end is dependent on what we value and what we believe about various trade-offs.

In order to translate these value dimensions into policy, especially long-term and socially robust policy, new forms of governance are called for. The characteristics of such governance are the wide use of participatory decision tools in one form or another. While these decision tools are normally not expressed as part and parcel of the precautionary principle, they should be seen as a direct consequence of the value base any application of the principle will be dependant on.

In the end the Precautionary Principle emerges as more closely related to other moral principles than we might have thought in the beginning: it is not the facts or the science or finding the range of possible strategies that poses the greatest problems. It is rather the consensus on the more or less implicit values that poses the greatest challenge.

One may ask what the upshot of this interrelatedness of the precautionary principle and ethics is for doing responsible science. What change is actually implied for scientific practice? When at one occasion, the present author was challenged to spell out these implications in a short list of recommendations for precautionary science, it was a list of six points that he presented as kernel of precautionary science. The list is indeed somewhat ad hoc, and it certainly does not amount to any complete set of recommendations. It might still be useful to add this list at this point, since it seems to relate nicely to some of the points made in the paper or other contributions to this volume.

When science is not self-conscious about its own potential pitfalls and shortcomings, when science assigns to itself a better track record than is justified by history, when science forgets the many idealisations and abstractions that are prerequisites for its model-building and testing procedures, and finally, when science portrays itself as unaffected by large commercial (or even political) interests, it stands in grave danger of becoming a socially irresponsible actor. Science, and in particular the scientific expertise that we might utilise in policy-making, is much more pluralistic, uncertain, divided, interest- and value-based than often appears in the portraits scientists present of their activity. Failing to concede this much may be seen as ethically defective. A truly precautionary science does not refrain from entering discussions and arenas where values and ethics are at stake, but contributes to these in a balanced and self-reflective manner. The new objectivity in science is not an attempt to stick to "hard facts" alone. It is the "hard decisions and soft facts" that pose the challenge of our times. Thus, the new objectivity of precautionary science amounts to new modes of organising and managing research, including new forms of quality control ("extended peer-reviews"; cf. Funtowicz & Ravetz 1999), with the aim of providing relevant information for policy-making that only scientific method can reveal, and that effectively contribute to a balanced picture of the various options that society has to consider. Present-day science does not in general fit this picture, but luckily it contains all the intellectual resources necessary to become precautionary science to the benefit of society and nature.

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