Agriculture and Human Values (2005) 22: 235–242
DOI 10.1007/s10460-004-8283-z

The factualization of uncertainty: Risk, politics, and genetically modified crops – a case of rape

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Accepted in revised form October 23, 2004

Abstract. Mandatory risk assessment is intended to reassure concerned citizens and introduce reason into the heated European controversies on genetically modified crops and food. The authors, examining a case of risk assessment of genetically modified oilseed rape, claim that the new European legislation on risk assessment does nothing of the sort and is not likely to present an escape from the international deadlock on the use of genetic modification in agriculture and food production. The new legislation is likely to stimulate the kind of emotive reactions it was intended to prevent. In risk assessment exercises, scientific uncertainty is turned into risk, expressed in facts and figures. Paradoxically, this conveys an impression of certainty, while value-disagreement and conflicts of interest remain hidden below the surface of factuality. Public dialogue and negotiation along these lines are rendered impossible. The only option left to critics is to resort to claims of fear and to call for new risk assessments to be performed, on and on again. Science is allowing itself to be abused by accepting the burden of proof in matters more suited to reflection and negotiation. The specific challenge to science would be to take care of itself – rethinking the role and the limitations of science in a social context, and, thereby gaining the strength to fulfill this role and to enter into dialogue with the rest of society. Scientific communities appear to be obvious candidates for prompting reflection and dialogue on this issue.

Key words: Conflicts of interest, European Union, Genetically modified oilseed rape, Public dialogue, Risk assessment, Scientific uncertainty, Value-disagreement

Abbreviations: DKK – Danish Krone; EU – The European Union; GMO – Genetically Modified Organism

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A European Union framework for risk assessment

According to a European Union (EU) directive dating back to 1990, genetically modified organisms (GMOs) must be subjected to risk assessment prior to being released in the environment and, subsequently, being marketed.[1] A revised directive (European Union, 2002) on the deliberate release of genetically modified organisms has come into being after years of difficult discussions, and in a climate of public distrust of genetically modified crops and food. The debate, which has developed into an international deadlock, has been – and still is – characterized by partisanship and emotional appeals by all parties. Thus, genetically modified crops have been portrayed both as the solution to world hunger and as a sinister project aimed at doing away with nature for profit. No doubt, the aim of the revised EU directive is to open the door to reason. It is likely, however, that the results will turn out otherwise. The new directive may stimulate the very disease it was meant to cure.

The directive prescribes procedures, on a case-by-case basis, to identify, evaluate, and manage potential risks to human health and the environment from genetically modified crops. Principles and methods of the risk assessments required are thoroughly described. In the annex on the principles for the environmental risk assessment, it is stated, ''Any characteristics of the GMOs linked to the genetic modification that may result in adverse effects on human health or the environment shall be identified'' (European Union, 2002: 28). This is a huge task, a grand ambition – anything that may harm should be identified.

In practice, administrators and researchers must, for practical reasons, make use of the evidence at hand, in the form of results from laboratory tests and experimental releases. Which possible adverse effects should be addressed by means of scientific risk assessment? Answers will have to be produced from research reports, confined in time, space, and methodology. With respect to time – the usual duration of trials is no more than two to three years. With respect to space – trials take place in a small sample of environments. With respect to methodology – genetically modified plants in research plots have, for risk management reasons, as little interaction with the environment as possible. This precautionary measure complicates the task of identifying environmental interaction-related adverse effects to be included in the risk assessment. Usually the information available on the unmodified organism and its interactions with the environment is seriously limited as well, especially with regard to complicated interactions (e.g., trophic interactions, or who eats whom).

In short, instead of considering everything that may be harmful, the basis of the risk assessments must be a rather limited, more or less coincidental, supply of scientific information upon which administrators and researchers have to exercise their personal imagination – always a crucial factor in risk assessment – and their judgment as best they can.

A case of rape I: Probabilities cannot be estimated

To illustrate the kind of problems likely to arise from the risk assessments required under the revised directive we have chosen the case of a genetically modified oilseed rape (*Brassica napus*), and we have chosen to focus on the environmental risks assessed in relation to this crop. Rape is used for food and feed, and it is genetically modified to express tolerance towards glyphosate, the active component of the herbicide Roundup™. The oilseed rape contains no traces of the inserted DNA or its products.

According to the directive, risk assessments must identify possible harmful effects and then produce a scientific estimation of the likelihood of their occurrence. In the case of the herbicide-resistant oilseed rape some possible effects can be identified easily. Thus, sooner or later, gene flow will lead to the development of Roundup™-resistant weedy relatives or multiresistant oilseed rape volunteers, both of which will directly complicate weed management (Hall et al., 2000; Hansen et al., 2001; Orson, 2002).

To what extent such effects will be harmful to the environment or to agriculture is a matter of definition, necessarily tied to basic assumptions and value judgments regarding the nature of nature, the nature of society and man, and of the common good. Researchers cannot rely on consensus in society regarding the nature of ''harm to the environment,'' and harm is not a precise, scientific concept. To make it amenable to scientific investigation, it must be tamed and tied to a specific understanding usable in comparisons with actual scientific findings.

In any case, the possible development of glyphosate-tolerant weeds is a kind of effect actually covered by the directive, which means that it can and must be considered in risk assessments conducted under the regulation. It will, however, be very difficult to supply a credible probability calculation.[2]

Oilseed rape is one of the most studied crops with regard to gene flow. We know that the pollen flow data are highly variable. At a distance of 100 m from the transgenic oilseed rape field, the likelihood of pollen flow obtained from different pollen flow data sets vary by 10^9 (Gliddon, 1999). It is also known that the transfer of genes to the weedy *Brassica rapa* and volunteer oilseed rape will take place, but the frequency is extremely dependent on management procedures and on a number of environmental/genetic factors (Gliddon, 1999; Hansen et al., 2001; Pertl et al., 2002). The development of Roundup™-resistant weeds by selection will be highly dependent on the herbicide practice, which is claimed to be one of the most variable factors in the cultivation of herbicide-tolerant crops. It will not help to take possible risk management strategies – in this case guidelines for herbicide application – into account, as it is not known which farmers in which situations will or will not follow the guidelines.

In short, obvious problematic effects covered by the legislation can be identified. To what extent they should be regarded as harmful to the environment is a matter of interpretation. Credible probability calculations cannot be made.

A case of rape II: Excluded effects

Other sorts of easily identifiable effects are not covered by the directive. Organic farmers in Denmark have grown oilseed rape since 1996, and there is a demand for their product, with current prices being an extra DKK 3.00–5.00 per kg of seeds, if the production can be guaranteed organic. In order to be considered organic, the harvest must contain less than 0.1 of a percent of genetically modified product. Due to pollen transfer from neighboring fields, some organic rapeseed grown next to genetically modified rapeseed will invariably end up being "contaminated" with the *Agrobacterium* gene. This can be expected to take place to a major extent (Simpson et al., 1999; Hall et al., 2000; Hansen et al., 2001; Bock et al., 2002) but, as mentioned above, the pollen flow data are highly variable, making it impossible for practical purposes to predict where and when the limit of 0.1 of a percent will be attained.[3] Thus, it is equally difficult to predict the frequency at which organic farmers will suffer economic damage as a result of the "contamination" of their crops.

The possible effect of "contamination," however, cannot be considered in a risk assessment conducted in accordance with the directive, as the directive is limited to dealing with harm to human health and the environment. Only recently and after years of controversy has it been recognized in Denmark, for instance, that the co-existence of organic farmers and GMO-growers must be specifically regulated. The directive does not cover economic losses as it does not cover other socio-economic effects, effects on the society in broader terms, or the effects to humans as social and cultural beings. This limitation makes sense, as the directive is about risk assessment based on the natural sciences. Nevertheless, problems are posed by a whole range of public concerns outside the scope of scientific risk assessment. The "contamination" of organic production is only a rather straightforward instance of such concerns. At their core, these concerns are about differing values and conflicts of interest between different groups in society. They are political problems, but are largely ignored as such. As a consequence, they tend to live a life of their own in a vacuum between science and politics. In short, obvious problematic effects not covered by the legislation can be identified.

A case of rape III: Effects not imagined

Other potential effects are recognized, in principle, by the legislators, but may not be identifiable when the risk assessment exercise is performed. The legislators call for the identification of "possible immediate and/or delayed environmental impact resulting from direct and indirect interaction of the [genetically modified higher plants] with non-target organisms, ... including impact on population level of competitors, herbivores, symbionts..., parasites and pathogens" (European Union, 2002: 30). There is no indication of how these extremely ambitious demands can be realized in a situation – not likely to change – in which everything about complex biological systems is not actually known.

Regarding oilseed rape, it is only possible to identify a few non-target effects because very little is known about the interactions between oilseed rape and non-target organisms. For instance, the question has been asked: What will happen to populations of soil microorganisms and, thereby, to soil fertility in fields of genetically modified oilseed rape sprayed with Roundup™? This is a "known unknown." We are able to state the question. The answers, however, are blowing in the wind, as there is a lack of basic knowledge necessary to understand and predict the fluctuations in populations of microorganisms.

It should be kept in mind that there also will be what have been called "unknown unknowns." These allude to cases where we are not even able to state the questions as we are unable to picture the possible effects. Examples of such cases cannot be supplied for the very good reason that we really do not know. Risk assessments, nevertheless, are expected to take such effects into account. As an extra precautionary measure, the directive

demands monitoring after the release of genetically modified crops, but in the case of "unknown unknowns" it will be difficult to foresee what to monitor.

A machine of perpetual risk assessment

In conclusion, using oilseed rape as a case in point, we have found one easily identifiable effect that can be taken into account as required by the directive. In practice, however, it is impossible to estimate the likelihood of this effect occurring (i.e., the exposure). We have found another easily identifiable effect not covered by the directive and accordingly not manageable in this context. Finally, we have pointed to non-identifiable effects whose identification and estimation are legislatively required.

One of the pillars upon which the directive rests seems to be an unspoken and unexamined assumption about the nature of science. It seems to be presupposed that scientific methods will be able to assure the European public(s) that genetically modified organisms will only be released in ways not harmful to human health and the environment. This comes close to requiring that scientists prove a negative assertion – that the organisms in question are not harmful, or that they will only be grown under circumstances that will prevent harmful effects. At the same time, an unspoken assumption about the quality of public concerns appears to be at play. These concerns are perceived to be caused by a fear of any adverse effects of GMOs on human health and the environment. Both assumptions are problematic and in need of scrutiny.

First, it is scientific common sense that a negative assertion in an open system cannot be proven, and that uncertainty, therefore, is inherent to science conducted in open systems. To use Popper's terminology, a hypothesis can be *corroborated* if it is tested intensively over a wide spectrum of situations without being *falsified* (Popper, 1959). However, it is not possible to verify the universality of a hypothesis in an open system because it will always be possible to claim that something has not been investigated and that the falsification may be found there. Thus, specific and isolated potential effects can be looked into, more or less thoroughly, depending on time and cost constraints and on the amount of basic knowledge at hand. They cannot be ruled out, however (i.e., never say never). The question of overall harmfulness to health and the environment is vague, enormous, and amorphous – not suited for scientific treatment. An endless supply of possible harmful effects is inherent within the question. They are resting, waiting to become mobilized, but none of them can be totally ruled out after mobilization.

An important question in the risk assessment of GMOs is this: Should scientists be asked to demonstrate absolute safety or a level of safety equivalent to that presented by conventional crops? In response to the question, the concept of substantial equivalence has been put forth to narrow the scope of the investigations required of scientists. However, this does not eliminate the basic dilemma posed by and to science conducted in an open system. Just as it is not possible for scientists to demonstrate absolute safety, it is not possible for them to provide absolute proof of a level of safety equivalent to conventional crops. Some uncertainty will always remain.

The demand for an assessment of anything that may do harm is likely to turn the new European legislation into nothing other than a machine of perpetual risk assessment, with scientific uncertainty as the driving force. In a reflexive turn, science is being used against itself and against the products of science, with little hope of transcending its own methods of understanding and approaching reality. Thus, there is little hope of reaching a position from where reflection on the limitations of calculative, scientific methods might be possible.[4]

Second, the rather patronizing assumption that the public is only concerned about harm to health and the environment is not a very helpful reduction. With regard to our case study of herbicide-tolerant, genetically modified oilseed rape, one form of public criticism claims that herbicide-tolerant plants represent a step in the direction of a herbicide and pesticide-dependent, heavily industrialized and unsustainable agriculture, alien to values other than productivity and efficiency. According to this criticism, the likely effect will be a furthering of economic concentration and, thereby, the concentration of power in agrobusiness.[5] Now, whether or not this represents a problem is itself a value judgment focusing on socio-economic and cultural factors. While it does contain claims that can be tested empirically, it is based on certain assumptions, ideals, and visions regarding the development of society. It is perfectly possible – some would say very easy – to disagree and to subscribe to other assumptions, values, ideals, and visions for society. It is also perfectly possible – though, admittedly, not so easy – to conduct civil discussions and negotiations on value-disagreement and on conflicts of interest between GM farmers and organic farmers, between agrobusiness and independent farmers, or between patent holders and users of patented crops, etc. This is, in part, what politics is about. Political treatment becomes impossible, however, when disagreement and conflict of interest are framed as questions of risk to health and environment – when from the outset they are treated as scientific issues rather than as political issues.

Uncertainty as certainty

The concept(s) of risk, crudely defined as the likely occurrence of unwanted effects of some severity, is closely related to scientific uncertainty. If science was certain, there would not be unwanted effects from new technologies based on science. Science would know and be in control of all there is to know. As already mentioned, this is not the case. Uncertainty is inherent to science, but scientific uncertainties may, by means of risk calculation, be turned into scientific facts and paradoxically create the impression of certainty when brought to the public domain.

At this point, intervention by a skeptical and critical journalism, one dedicated to investigating and contextualizing research results on behalf of the public, might prove helpful. It could open up the procedures and the outcomes of risk assessments to public reflection and debate on a variety of consequences, uncertainties, values, and social interests related to the assessed subject. It is, however, more likely that journalistic intervention will lead to a naive dissemination of the risk figures as presented to journalists by scientific researchers. By convention, scientific facts are not to be disputed outside the scientific community of peers. Uncertainties are supposed to be sorted out within the scientific community. Thus, scientific results – including scientific estimates on risk – when leaving the domain of science and entering the public domain, are tailored to represent and to be understood as expressions of certainty. This is part of the social contract between science and society.[6] In so far as the contract has been accepted by science, the linking of science with certainty is not a concept alien to science. This is not simply imposed on science by the public and/or by politics and policy makers, as is so often claimed.[7] Journalists, disseminating unquestioned risk facts from science to the public, are dutifully paying their respect to the convention.[8]

In effect, the unquestioned ''factualization of uncertainty'' serves to conceal the issue of scientific uncertainty itself from the public. In the process, the unavoidable exercise of value-judgments in risk assessment becomes invisible as well, since scientific methods of factualization are expected to guarantee value-neutral, disinterested conclusions. So, when critics of a particular technology, frequently people with scientific backgrounds, go public and point to uncertainties and value-judgments in actual risk assessments, their claims appear to be instances of poor-quality assessment, that need to be replaced by high-quality assessment. Thus, new chapters in the never-ending story of the production of risk assessment are being introduced. Note that there is no claim here of sinister intentions on the part of anyone – researchers, journalists or political decision-makers. There is only a claim of effect.

This cover-up effect becomes highly problematic when compared to an ideal of open and frank public debate and negotiation about scientific uncertainties, values, and social interests. Invisible, seemingly non-existent phenomena cannot be made the topics of dialogue. To keep the debate going, one option remaining to concerned citizens is to resort to claims of fear concerning possible harmful effects not addressed by risk assessors. As the fragility of scientific risk facts is often rather obvious, another option is to call for counter facts, in case risk assessment has taken place. Thus, the very ''emotiveness,'' which the political demand for risk assessment was intended to put to rest, is perpetuated. We appear to have come full circle, reaffirming the initial assumption that there is a basic dichotomy between ''facts'' and ''feeling,'' between ''rationality'' and ''emotion.'' The result is that values and social interests can be reduced to feelings and emotions, and that this understanding is sufficient for an accurate mapping and demarcation of reason, the locus of facts.

Science and reason

By convention, the strength of science is that it adheres strictly to investigating ''reality'' as potential ''factuality.'' Calculation counts. Negotiation is ridiculed in the theoretical domain of pure truth (whether such pure truth exists in practice, and whether some negotiation actually takes place in scientific research is not up for discussion here).[9] Claims have to be proven or disproven. In principle, disagreement does not exist, only sound or immature science. The rest is presumed to be emotion.

However, it can be argued that there is more to reason than calculation and scientific facts. Reflection and negotiation on value-disagreement and conflicts of interest can be claimed to be reasonable. And, it can be noted, when science is presented with issues loaded with value-disagreement and conflicts of interest, its strength becomes a weakness.

Returning briefly to the case of the herbicide-tolerant oilseed rape, we can take a look at the options left to European decision-makers. These options are to manage likelihoods that cannot be estimated and effects that either cannot be established or cannot be taken into consideration. ''Contamination'' of fields of organically grown oilseed rape, as well as other potential socio-economic effects, cannot be taken into consideration. The existing framework of risk assessment does not supply remedies for a variety of such problems.

Effects of the interaction of the genetically modified oilseed rape with non-target organisms cannot be established because of a lack of basic knowledge. To some extent, further research might be a solution given no

time or cost constraints. In other words, decision-makers might postpone decision-making on the release of the genetically-modified oilseed rape for another decade and, in the meantime, agree to finance thorough, basic scientific research.

Probabilities of gene flow from fields of genetically modified oilseed rape to weedy relatives of oilseed rape cannot be calculated. One of the reasons for this is the possible dependency of gene flow on herbicide practice, the latter subject to huge variation among farmers. Again, further research into herbicide practices and weed control is an option, but more time and money would be needed as well as the recognition that total certainty would remain unachievable.

Decision-makers would have to consider whether such research projects would be worthwhile, whether they would be likely to put an end to controversies related to genetically modified crops and food. Politicians who are prone to look to science for solutions might consult the newly erected risk assessment framework for answers. They would look in vain, however.

Because of the uncertainty inherent in science, new technologies are unavoidably accompanied by the potential for unintended effects. Some of these will unanimously be considered harmful, while the harmfulness of others will be disputed. Scientific methods are useful when it comes to isolating specific, potential effects and making them tangible as facts and figures. Scientific methods, however, are of no use when it comes to distinguishing between important and less important risks and between matters of proof, reflection, and negotiation. In other words, science cannot distinguish among factual issues, value-disagreement, and conflicts of interest. Dissolving the fact-value dichotomy by repeatedly showing that science is not value-free does not suspend the need to differentiate among varieties of questions and problems – some of which are suited to quantifying and objectifying methods, to evidence and proof, while others, regardless of efforts to be transparent and inclusive, are not. Making these distinctions cannot be accomplished by means of scientific methods.

Denial of disagreement

It happens again and again. It happens not only in controversies on gene technology, but also, in discussions regarding energy production, health, traffic, etc. Science ends up with the heavy burden of proving or disproving risks at whose core can be found value-disagreement and conflicts of interest.

One of a whole bundle of reasons for this phenomenon may be embedded in the unreflective application and ''stretching'' of a basic principle of liberalism – the harm principle. This principle formulated more than a hundred years ago by John Stuart Mill, states that persons should be free to do whatever they like, unless it is harmful to others. The principle was intended to protect individual freedom in matters, for instance, of religion and sexuality. It has performed loyal service in these areas of life. But it has not been restricted to matters of personal convictions, beliefs, and behavior. It has been sent to work in other areas as well (Holtug, 2001, 2002).

One such area seems to be controversies regarding the application of new technologies. One result is that whenever somebody disagrees with a particular technological enterprise, the only legitimate grounds for disagreement is to prove its harmfulness. Opposition must be expressed in terms of risk. The concept(s) of risk becomes a container for all sorts of opposition. As non-risk arguments are taboo, the obvious option is to turn to the perpetual motion of science and call for risk assessments. But, turning to science and asking only for scientific calculation denies the very existence of substantial disagreement.

The implicit acceptance of yet another liberal idea – the principle of state neutrality – is likely to track in the same direction, inspiring authorities to look for seemingly value-neutral solutions from science. According to traditional liberalism, the state should be neutral with regard to particular attitudes and values (i.e., conceptions of good). Such conceptions are seen as private rather than public matters, and the law is not supposed to favor any particular conception. On the contrary, and curiously at odds with the classical notion that politics is a search for the common good, values are deemed to be illegitimate justification for political action.

Both principles are based on a distinction between what is private and what is public. The definitions of ''private matters'' and ''public matters'' were decided upon a very long time ago. Today it is obvious that society, like individuals, is confronted with new ethical challenges, so it seems to be time to reconsider the old definitions through public scrutiny and debate. Harmfulness does not suffice as the sole criterion of public concern surrounding the desirability of emerging technologies. To escape the political deadlock regarding genetic modification in agriculture and food production, unspoken assumptions and contradictions must be brought into the open. The regulatory debate must be extended beyond issues of harm to include a broader range of issues of ''governance.''

More than science

The present article is based on the assumption that applying more science – reflexivity – is an insufficient

reaction to the controversies surrounding genetically modified crops and food, and that more than science – reflection – is needed. The case has been made that at present, science is being abused by being presented with the burden of proof in matters more suited to reflection and negotiation than calculation only. It must be added that science is not only being abused, but is letting itself be abused. The question must be asked: Why does the scientific community allow this to happen?

The challenge to society is to stimulate ongoing dialogue and negotiation between science and the public about the sound use of science in public affairs under conditions of democracy. The absence of a thorough understanding of scientific uncertainty and of refined criteria for when and why to use methods of scientific risk assessment in public decision-making, the political system appears to be rather helpless. So does science. Rather than blaming politics, the specific challenge to science should be to take care of itself, to rethink the role and the limitations of science in a social context and thereby gain the strength to fulfill this role and to enter into dialogue with the rest of society. There is a need for open and open-ended reflection within science on fundamental questions like: What kind of questions is science able to answer and which not? What kind of answers is science able to question, and which not? Is the idea that science should provide society with certainty totally alien to science? Should science understand itself as the key intellectual resource of public policies, or would it be better to provide more room for other intellectual resources, other sorts of reason? Can the case be made that science is a threat to itself in so far as it does not try to delimit itself? How should demands for transparency, inclusion and participation be met – and why?

Scientific communities, founded to provide arenas for discussing, maintaining, and furthering science, appear to be obvious venues for prompting such reflection and dialogue. Maintaining them includes periodically reviewing fundamentals. This is the present challenge to science.

Acknowledgments

This article was written within the frames of the Danish Centre for Bioethics and Risk Assessment, an interdisciplinary and cross-institutional research platform, and two of its Danish, publicly funded research projects – one funded by the Directorate for Food, Fisheries and AgriBusiness and the other by the Danish Research Councils.

Notes

1. Legislation in the EU takes the form of directives negotiated between the European Commission (the highest administrative body of the union), the Council of the European Union (representing the governments of the 25 member states) and the European Parliament (elected by the populations in the member states). Member states must transform directives into national legislation. Thus, the directive on the deliberate release of genetically modified organisms into the environment is the EU legislation that states the requirements for growing, marketing, or otherwise releasing genetically modified organisms into the environment in the EU.
2. A vocabulary has been developed that makes distinctions between different types of uncertainty. According to these distinctions, the term "risk" characterizes a situation in which it is possible to calculate the probabilities of a well defined set of outcomes. The term "uncertainty" characterizes a situation in which it is possible to define a set of outcomes, but not the probability of their occurrence. The term "ambiguity" characterizes a situation in which probabilities have been assigned to poorly defined outcomes, and the term "ignorance" characterizes a situation in which there is neither a basis for defining a set of outcomes nor for assigning probabilities. For a further description of this vocabulary see, for instance, ESRC Global Environment Change Programme (1999). We do not use this vocabulary in the present paper because we are focusing on challenges related to the paradoxical relationship between ever-present scientific uncertainty and the expectation that science should provide certainty. How to understand and manage different types of scientific uncertainty is outside the scope of this paper.
3. In principle, organic farmers do not accept any amount of GMOs in their products. The 0.1 of a percent level is accepted only for technical reasons.
4. We find the distinction between "reflexivity" (i.e., scientific methods and thinking used towards science) and "reflection on science" (i.e., questioning scientific methods and thinking from without) to be a helpful one. For a more favorable understanding of reflexivity as critique and as a driver of social change, see Beck (1986).
5. See, for example, Danish studies of public attitudes (Lassen et al., 2002).
6. For a discussion on the contract between science and society see Gibbons (1999).
7. The assumption that a demand for certainty originates beyond science, and from decision-makers, in particular, and is alien to science proper can be found in a variety of writings (Rodricks, 1992: 193; Jasanoff et al., 1998: 62).
8. For further discussion on this topic, see Meyer (2003).
9. Latour (1987) provides one example of the many discussions on this issue. Jasanoff et al. (1998) give an excellent overview of science and technology studies focusing on the issue. In general, they conclude that science is not value-free and that negotiations do take place within science.

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