2-1-2020

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Recommended Citation

Hugh Lacey. (2020). "A View Of Scientific Methodology As A Source Of Ignorance In Controversies About Genetically Engineered Crops". *Science And The Production Of Ignorance: When The Quest For Knowledge Is Thwarted.*
https://works.swarthmore.edu/fac-philosophy/582

10 A View of Scientific Methodology as a Source of Ignorance in Controversies about Genetically Engineered Crops

Hugh Lacey

1. Agnotology Mechanisms

The claims—that the agricultural uses of genetically engineered organisms (GEOs) and consumption of their products are safe, and using GEOs in farming practices is indispensable for meeting the food and nutrition needs of the world's growing population—play central roles in arguments defending the legitimacy of using GEOs. They are widely endorsed by mainstream scientists.

David Magnus maintains that those who challenge these claims deploy a variety of agnotology mechanisms. In particular, construct agnotology (exaggerating the degree and kind of uncertainty that mark certain scientific results) is commonly deployed "by anti-industry NGOs to oppose the creation of genetically engineered organisms," instigate doubts and maintain ignorance among the public about the credibility of the "mainstream view . . . that most GEOs are safe and that, in principle, the technology can be safely utilized," and propose a version of the precautionary principle that "largely rejects risk management and the very idea of a science-based regulatory policy" (Magnus 2008, 251, 258).

Philip Kitcher points to another agnotology mechanism: rejecting evidentially supported claims because of the interests they serve. The opponents of using GEOs, Kitcher (2011, 238–239) maintains, "dismiss scientific reports to the effect that environmental risks are minimal as reflecting monied interests," and he continues, noting that "opposition to GEOs is largely a European phenomena, not much heard in the land of the potential producers (North America), nor in those of its potential consumers (Africa, Asia). In fact, many of the spokesmen for the world's poor are impatient with what they see as the scruples of people who do not feel any threat of starvation." There are opponents of using GEOs who are properly criticized in these ways, such as those who—alleging religious reasons, adopting trivialized versions of the precautionary principle, displaying ignorance of scientific developments, or dismissing all proponents of GEOs simply on the ground that they are purveyors of capitalist interests—would remain opponents regardless of the scientific record. That said, the opponents are not all alike. In this chapter, I will discuss opponents whose posture toward GEOs derives from engaging in agricultural practices such as agroecology, and holding that there is considerable scientific support for the claim that there are ways to engage in agriculture that are more likely than GEO-oriented (and conventional) ways to be sustainable over the long term and ensure food security (and other human rights) for the poor.

I agree with Magnus and Kitcher that agnotology mechanisms are in play in the controversies about GEOs. Contrary to them, however, I locate the mechanisms principally in the arguments defending the legitimacy of using GEOs. I will contend that the two claims stated at the outset are not well supported by the available empirical evidence and should not be endorsed, and despite this, their widespread endorsement is made possible (in significant part) because an inadequate conception of scientific methodology has wide currency among mainstream scientists. Those who uphold this conception downplay the scientific credentials of methodological approaches that are apt for gaining knowledge about certain kinds of risks of using GEOs and the possibilities of alternative forms of farming. Hence they do not attempt to obtain such knowledge, or pay attention to the input of the opponents who emphasize sustainability and food security for all. Ignorance about these risks and alternatives is thereby fostered, and claims about them that lack proper empirical support are enabled to pass for scientific knowledge. All this functions to protect the legitimacy of using GEOs from empirically based challenges and mars the deliberations of many public regulatory bodies. Proponents of using GEOs, by treating all opponents as alike, end up only showing the fallacies of points of view that are also rejected by opponents who raise serious questions about the legitimacy of using GEOs. The latter opponents (contrary to Kitcher) are to be found largely in movements in poor countries such as Brazil, where I regularly engage with them (see, for example, Carneiro et al. 2015; Ferment et al. 2015). They are mainly linked with popular rural movements with strong international connections, such as the network La Via Campesina, which proposes that practices and policies of food sovereignty, in which agroecology has a central place, provide the best way to assure food security for poor peoples (Lacey 2015b).[1] They also have strong connections with certain nongovernmental organizations, public agricultural research bodies, agricultural researchers (especially those connected with agroecology), and international bodies that deal with agricultural policies. They do not reject biotechnological innovations out of hand, introduce some (not GEOs) into their agroecological practices, and advocate for "science-based regulatory policy" (see, for example, Traavik and Ching 2007), which (they maintain) should be sufficiently encompassing so as to be informed by empirical investigation of the causes, including socioeconomic ones, of problems like food insecurity (Lacey 2005, 2017b).

These opponents challenge the two claims that using GEOs and their products is safe as well as indispensable for meeting the world's growing food needs. That does not put them in conflict with claims for which there is consensus among the relevant scientists (or with any well-confirmed scientific knowledge). Despite repeated allegations, there is not consensus concerning the two claims among the relevant scientists (Ferment et al. 2015; Hilbeck et al. 2015; Krimsky 2015). Moreover, even if there were, that might not indicate that the claims have strong evidential support, for consensus might derive from values and interests shared among the scientists that (consciously or not) draw attention away from crucial matters that need to be investigated. Of course, just citing this possibility cannot ground responsible challenges to claims that many scientists endorse; rather, such challenges depend on demonstrating that the available evidence is not adequate to support the claims and putting forward evidence (or proposing specific further research projects) that is pertinent for evaluating them as well as identifying the factors that explain why they are widely endorsed. The opponents, whose primary preoccupations are with sustainability and securing food security for everyone, assume this threefold responsibility. They do not make use of the agnotology mechanisms indicated by Magnus and Kitcher. It is true that they often suggest that scientists, who put the

1 For more on La Via Campesina, see https://viacampesina.org/en/. Food First: Institute for Food and Development Policy regularly publishes material representative of such viewpoints in English. See http://www.foodfirst.org/.

authority of science behind using GEOs, are in the grip of the values of technological progress and of capital and the market. For them, however, that is not a ground for rejecting the claims of these scientists or ignoring evidence they may put forward but instead part of the explanation of why, despite inadequate supporting evidence, these scientists endorse the two claims, and why they are unaware of the agnotology mechanisms (including the one to be discussed below with roots in an inadequate conception of scientific methodology) at play in their arguments.

2. What Is in Dispute?

The controversies about GEO crops (and their products) principally have to do with the *legitimacy* and social value of using GEOs—growing, harvesting, and distributing them, and processing and consuming their products, in the agroecosystems in which they are planted and cultivated, and in the socioeconomic contexts in which they are developed, produced, marketed, processed, and consumed—and their intensive utilization and widespread diffusion throughout the world in the agricultural practices that produce major crops as well as the place that should be accorded to research, development, and implementation of GEOs in national and international agricultural policies (for details and documentation, see Lacey 2005, 125–147). Judgments concerning legitimacy draw on claims made about benefits, risks, and alternative farming practices.[2] Legitimacy presupposes *efficacy* (Lacey 2005, 2016), and although there are questions about the long-term efficacy of using particular varieties of GEOs and the risks that may arise when their efficacy declines, and some exaggerated claims have been made about what can be expected in the future (Lacey 2017a), efficacy will not be at issue in the present argument.

2.1. Risks and Alternatives

Arguments for the legitimacy of using GEOs draw on claims like the following:

> *No risk*: Current and anticipated uses of GEOs for agricultural and related commercial purposes occasion no significant risks to human health or the environment

2 Regarding the real and promised benefits of GEOs (not discussed in this chapter) and for whom, see Lacey 2005, 165–181, 2017a.

that cannot be (and normally are) managed adequately under scientifically informed regulations, and the GEOs currently being used have occasioned no significant harm.

No alternative: There are no alternative kinds of farming that could be practiced—in place of the currently deployed GEO-oriented ways and those being developed (including those being developed with new and more complex methods of genetic engineering)—that could be expected to produce comparable benefits connected with productivity, sustainability, and meeting human needs, and would not occasion unacceptable risks (for example, not producing enough food to feed the world's growing population). GEOs are necessary to feed the world, and will gain an increasingly important role in doing so.

The opponents, who emphasize sustainability and food security for all, make competing claims like the following:

There are risks: Available scientific evidence does not support endorsing "no risk," and in part this reflects serious shortcomings in the risk assessments that have informed regulatory deliberations. Furthermore, using GEOs has caused harm to human health as well as the environment and social arrangements (some of which may be irreversible), and further harm is risked by continuing to use them and expand their use—where the mechanisms involved include those linked with the necessity of using some GEOs in conjunction with agrotoxics, and others linked with the socioeconomic context of the research, development, and use of GEOs.

Better alternatives: Agroecological methods (among others) are being developed that enable high productivity of essential crops with less serious risk. They promote sustainable agroecosystems, utilize and protect biodiversity, contribute to the health and social emancipation of poor communities, and are particularly well suited to enable rural populations in developing countries to be well fed and nourished. Without their further development, the current patterns of hunger are likely to continue.

Values influence judgments about what is considered a risk, what risks are serious enough to require investigation, what are desirable properties of agroecosystems, and hence judgments about what the specific objects of scientific inquiries about risks and alternatives should be (Lacey 2005, 2017a, 2017b). The values that are incorporated into the opponents' stance (and also into the precautionary principle) include social justice, popular participation, empowerment of the excluded, ecological and social sustainability, respect for the full range of human rights, and equity within and between generations (Lacey 2005, 138; 2015b). There is tension between these values and those accorded highest priority by the proponents of GEOs: values connected with technological progress—including granting high ethical/social value to expanding the capacity of human beings to control natural objects especially as embodied in technological innovations, innovations that increase the penetration of technology ever more intrusively into ever more domains of human life, and the definition of problems in ways that may permit scientifically informed technological solutions (Lacey 2005, 18–24)—and with capital and the market, such as economic growth (Lacey 2005, 137).[3]

Contrasting "no risk"/"there are risks" and "no alternative"/"better alternatives" enables us to clarify the role of scientific research in dealing with questions of legitimacy and its interplay with values (Lacey 2016, 2017b). As indicated above, proponents of using GEOs often assert that "no risk" and "no alternative" are backed by scientific consensus. The opponents counter that while much remains open to further investigation, the preponderance of available evidence points toward "there are risks" and "better alternatives" (Lacey 2015b). Their argument, without foreclosing that there could be roles for GEOs under certain conditions alongside other agricultural methods, leads to the conclusions that they are not needed now and their current uses are (on balance) harmful. Furthermore, they point to the kinds of research that are needed to provide additional scientific input relevant for making sound judgments about risks and alternatives (Lacey 2005, 2015b).

2.2. Conceptions of Scientific Methodology

Behind the disagreements about risks, alternatives, and what is supported by scientific evidence lies a (usually unarticulated) disagreement concerning scientific methodology. To make this apparent, I will make use of the notion of *methodological strategy* (Lacey 1999, 2005). The principal roles of a strategy are to constrain the kinds of hypotheses, models, and theories that may be entertained in a research project, and so specify the kinds of phenomena and possibilities that may be explored as well as the conceptual resources that may be deployed, and select the kinds of empirical data that are relevant for appraising the hypotheses that are entertained.

3 "There are risks" refers to risks to social arrangements; "no risk" does not. Proponents of using GEOs tend to maintain that bringing social effects into the discussion reflects "ideology" or "politics"—perhaps relevant in regulatory deliberations, but not in "scientific" risk assessments.

To a first approximation, I consider scientific inquiry to be systematic empirically based inquiry, conducted under strategies that are apt for gaining and confirming knowledge and understanding of the phenomena being investigated (Lacey 2005, 64–65). This characterization leaves two matters open. First, the results of scientific inquiry may not all have the same cognitive status. When investigating the ecological and social complexities of agroecosystems—for instance, those connected with the disputes about the risks of using GEOs and alternatives to doing so—even extensive scientific inquiry, conducted within available time frames, will often not be able to produce results that meet the empirical and cognitive standards required to establish items of confirmed scientific knowledge. It may, however, provide sufficient evidence to *endorse* a hypothesis, that is, to judge—after taking into account the consequences of acting informed by it, if it were false, and their ethical salience—that the evidence supporting it is sufficiently strong to legitimate acting or forming policy in ways informed by it (Lacey 2015c). Second, different kinds of strategies may be needed to investigate different kinds of phenomena—for example, one kind to investigate the structures of plant genomes and ways to alter them, and others to investigate the environmental and social effects of using them as well as the possibilities of sustainable agroecosystems.

2.2.1. Decontextualizing Strategies The great success of scientific inquiry is often held to derive from the adoption in research of *decontextualizing strategies* (DSs) (Lacey 2016), and sometimes it is held that the products of research conducted under DSs satisfy superior cognitive standards, or that the nature of scientific inquiry is to privilege adopting DSs.[4] Under the most widely used DSs, theories are constrained to represent (or model) phenomena in relation to their (hypothesized) underlying structures, the processes and interactions of the structures and their components, and the laws that govern them.[5] Representing phenomena in this way decontextualizes them. It dissociates them from any link they may have with human agency, value, sensory qualities, and social arrangements, and whatever possibilities they may afford by virtue of their places in particular social,

4 For an elaboration on DSs, previously called "materialist strategies," see Lacey 1999, 2005.

5 These DSs are also *reductionist strategies*; causal interaction from higher to lower levels of organization of phenomena and systems is not entertained under them. DSs that are not reductionist are not relevant to the present discussion.

human, and (frequently) ecological contexts, including (in the case of GEOs) those they may afford by virtue of specific features of the agroecosystems in which they are planted and cultivated together with the socioeconomic contexts in which they have been developed, produced, marketed, and processed. Theories entertained under DSs dispense with the categories, including intentional and value ones, routinely deployed for describing and understanding what is experienced as well as deliberating when making decisions. Thus, for example, under DSs, GEOs are investigated for their genomic and molecular biological properties, and the effects that are triggered by these properties and changes of them, but not for the effects of using them that follow from their being objects to which intellectual property rights obtain. Complementing these constraints on admissible theories, empirical data are selected, sought out (often using mechanized surrogates for human observers), and reported (or mechanically stored, manipulated, and transmitted) using descriptive categories that generally are applicable by virtue of measurement, instrumental, and experimental operations. Data are not selected concerning, say, who owns and uses GEO seeds, and under what conditions, or the impact their use has on biodiversity, small-scale farmers, and worldwide food security.

Adopting DSs has been extraordinarily fruitful, and we may expect that it will continue to be so. Under DSs, knowledge and understanding of an enormous and varied array of phenomena have been obtained, and since DSs admit of considerable variety deriving from the different kinds of laws and explanatory models that may be incorporated into a strategy's constraints, they are also highly versatile. Their fruitfulness and versatility contribute to explain why many hold it to be of the nature of scientific inquiry to adopt DSs predominantly (if not exclusively), and why this view is so deeply entrenched that the possibility that there might also be other fruitful strategies is rarely entertained explicitly in the scientific mainstream.

When proponents of using GEOs insist that they have the backing of scientific authority, they are effectively taking for granted a methodological view like the following:

> *Primacy of DSs*: The adoption of DSs has primacy, perhaps virtual exclusivity, among the methodologies of scientific research.

For them, the research that has led to the development of GEOs and confirmed the efficacy of using them is exemplary of scientific research, since only DSs (those adopted in biotechnology and molecular biology) are adopted in it; and sound scientific risk assessment and research aimed at improving agricultural practices would be marked by the virtually exclusive adoption of DSs. The tradition of modern science has tended to foster "primacy of DSs," and upholding it is reinforced where economic growth and related values are considered socially preeminent, and technoscientific innovation is considered a driving force of economic growth (Lacey 2016), so that now the reach of DSs keeps expanding with no end in sight. Moreover, when it is maintained (as it widely is today) that engaging in research conducted under DSs is a principal and indispensable source for meeting human needs in general, and specifically, for making improvements in agricultural and other practices, there may seem to be no reason to look beyond "primacy of DSs."

2.2.2. Context-Sensitive Strategies The opponents of using GEOs who are also proponents of sustainability and food security for all recognize that many technoscientific innovations lead to generally available benefits, and hence that research conducted under DSs is often socially significant. They question, however, that there is factual support for the role claimed for that research in contributing to meeting human needs and improving agricultural practices (Lacey 2015b, 2016, 2017a). They point out that currently unmet needs (for example, for food security for many poor people) have social, economic, and historical dimensions and causes, as do other problems endemic to the current hegemonic food/agricultural system, such as unsustainable and excessively polluting practices, and the destruction of fragile ecosystems that accompanies efforts to obtain access to more farmland. If something is to be done about these problems, the fundamental causes of their origin and persistence need to be identified. But DSs do not suffice for investigating the causal networks in which the problems are enmeshed.[6] To this end, strategies that do not involve dissociation from the social, economic, and historical contexts of phenomena are also needed; I call them *context-sensitive strategies* (CSs).

6 That there is abundant food being produced today, more than enough to feed everyone alive now, may largely be attributed to the innovations of the green revolution that have been informed by research conducted largely under DSs. But as is now manifest, producing such abundant supplies of food is compatible with hunger and malnutrition persisting on a large scale, and the farming practices that enable it causing environmental and social devastation. Without CSs the causes of these phenomena cannot be investigated.

Furthermore, some kinds of evidence, needed for addressing the oppositions about risks and alternatives, can be obtained only from research in which CSs are adopted. Adopting CSs is needed to investigate the possibilities—which if realized, might help to redress the problems referred to in the previous paragraph—that may be open to alternative forms of agriculture not based on the intensive utilization of GEOs or other techno-scientific innovations, such as agroecology, the alternative highlighted in the statement of "better alternatives." The successes of agroecology are well documented and lend support to endorsing "better alternatives" (Rosset and Altieri 2017; Lacey 2005, 212–223; Lacey 2015a; section 4 below). Agroecology integrally incorporates an approach to farming, a body of scientific research and its results, and a social movement (Rosset and Altieri 2017; Lacey 2015a). In the scientific research of agroecology, CSs are adopted that enable agroecosystems to be investigated with respect to how they fare in light of such desiderata as productivity, ecological sustainability and the preservation of biodiversity, social health, and the strengthening of local people's culture and agency, frequently with a view toward discovering the conditions under which an appropriate balance of the desiderata may be brought about in particular agroecosystems (Lacey 2015a).

Certain kinds of risks of using GEOs also cannot be adequately investigated without adopting CSs as well as DSs, such as risks that may be occasioned by mechanisms that are grounded in GEOs being commercial objects whose uses are constrained by claims of intellectual property rights (Lacey 2016, 2017b). They include risks that may be a consequence of the inadequate enforcement of regulations designed to ensure the safety of using GEOs, and the risks (intensifying those they share with "conventional" capital-, input-, and machine-intensive forms of farming) of undermining alternative forms of farming, displacing and impoverishing rural workers as well as weakening the conditions for them to exercise their agency, and bringing the world's food supply increasingly under the control of a few market-oriented corporations, potentially intensifying food insecurity throughout the world (Lacey 2015b, 2017b). Noteworthy among the risks that cannot be investigated where only DSs are adopted are those that may arise when GEOs are introduced—with the stated objective of dealing with problems of small-scale farmers (for instance, production in precarious agro-ecosystems) and their communities (say, hunger and malnutrition)—under the same socioeconomic conditions that occasioned the problems in the first place and account for their persistence. Vitamin-enhanced genetically engineered crops, for example, are being developed with the aim of combating diseases caused by vitamin deficiencies, but the research involved disregards that currently developed GEOs fit into and generally require the same socioeconomic arrangements in which this problem came about and persists (Lacey 2005, 171–180), and that implementing such projects requires inserting farming practices into international market structures, and in doing so, that there might be harmful human, social, and ecological consequences and (above all) “better” alternatives.

The opponents, who are preoccupied with sustainability and food security for all, give high salience to the investigation of the possibilities of sustainable agroecosystems and agroecological practices, and the possible effects of using GEOs on the environment, people, and social arrangements. The strategies adopted in the research that led to the development of GEOs, however (and in general DSs), are insufficient to conduct this investigation adequately, for it requires adopting CSs as well as DSs. This research thus incorporates the methodological view:

> *Strategic pluralism*: The methodologies of science must allow for the adoption of CSs as well as DSs—in order to enable investigation of the full and diverse range of phenomena of which understanding may be sought.

CSs are complementary to DSs; they do not displace DSs from their roles in investigations for which they are apt, and all research conducted under CSs may be able to make use of some knowledge gained under DSs

To maintain that there are phenomena that cannot be adequately investigated exclusively under DSs is not to be “antiscience,” “ideological,” or “ignorant,” nor a rejection of “science-based” risk management and regulatory policy. Whether or not there can be systematic, empirically based investigation conducted under CSs—producing results that are positively appraised in light of the same cognitive criteria that are used for appraising results obtained under DSs—remains open to the test of the practice of a robust methodological pluralism. As indicated above, I think that research conducted in agroecology shows that this test can be passed. What is important is that unless CSs are adopted, it is not possible to confirm the kinds of knowledge needed to make sound endorsements about risks, alternatives, and the causal networks of unmet food needs. Denying the epistemic credentials of the results obtained under CSs on the ground of the "primacy of DSs" fosters ignorance about these matters, and when they are denied, holding "primacy of DSs" can function as an agnotology mechanism—and it currently does so when "no risk" and "no alternative" are endorsed.[7] Whether one holds "primacy of DSs" or "strategic pluralism," currently available empirical evidence does not favor endorsing "no risk" and "no alternative" (as will be elaborated in the next sections). If "scientific" research is restricted to adopting DSs virtually exclusively, "scientific" evidence that supports endorsing "there are risks" (except those investigated within standard risk assessments; see the next section) and "better alternatives" could not be obtained, but there could be such evidence obtained from systematic empirical inquiry conducted under CSs as well as under DSs. This has far-reaching implications for how to understand "science-based risk management and regulatory policy."

3. Risks

Although all parties recognize that there may be risks occasioned by using GEOs, there are disputes about their significance—their character, ethical seriousness, magnitude, extent, contexts in which they might arise, mechanisms, likelihood of the harm risked actually being brought about, manageability under well-designed regulations, the range of methodologies needed to investigate them, and whether using GEOs has already brought about significant harm. Empirical evidence supporting "no risk" would derive from the failure, after making appropriate efforts, to find empirical evidence supporting that there are significant risks—and its endorsement should depend on sufficient research of the appropriate kind having been conducted.

3.1. Standard Risk Assessments

Generally those who affirm "no risk" consider that the appropriate kind of research is that which informs standard risk assessments. This is research, conducted under DSs in laboratories or small-scale field studies, concerning

7 If one wants to limit the meaning of "science" to systematic, empirically based investigation in which only DSs are adopted, and so by definition not consider adoption of CSs to be "scientific," so be it. But then it would be disingenuous to maintain that risk assessment relevant to public policy deliberations should be exclusively "science based."

the anticipated potential health and environmental effects of using a variety of GEOs.[8] In it, the potential effects and the mechanisms that might occasion them are characterized using theoretical categories acceptable within DSs, and so the mechanisms considered are physical, chemical, or biological. “Risk,” “harm,” and “safe” are value-laden terms, however, and so they have no place among the categories acceptable under DSs. Hence in order that the results of the research may be pertinent for risk assessments, prior to conducting them, some of the anticipated potential effects are labeled “risks” (“ethically significant risks”)—in accordance with value judgments that effects of that kind would be harmful. Then the potential effects so labeled are investigated empirically in order to find out about their magnitude, the conditions in which they may actually be brought about, the probability of their occurrence, and the conditions for effectively regulating and thereby containing them (Lacey 2005, 2017b). Those who endorse “no risk” generally maintain that the main evidence for it has come from empirical studies concerning the potential significant risks of GEO varieties that have been released for agricultural and commercial use, and that “no risk” has been properly endorsed because sufficient studies have been conducted, and in light of them it has been judged that none of these varieties occasions risks (potential effects that have been labeled “risks”) of significant magnitude and likelihood of actually occurring that cannot be adequately managed under approved regulations. This point of view underlies the proposal that standard risk assessments, based on the kind of investigations just described, are constitutive of and sufficient for “science-based regulatory policy.” It also provides the rationale that supports legislation, obtaining in most countries, that no variety of GEOs may be released for agricultural and related commercial purposes, unless regulatory bodies certify that it has passed an appropriate and sufficient array of standard risk assessments that also provide the basis for approved regulations governing its use.

It is a value judgment, though, not a scientific result that sufficient properly conducted standard risk assessments are the appropriate basis for appraising risks and endorsing “no risk” (Lacey 2005, 2017b). In accordance

8 Risk assessments should be conducted case by case, and variety/environment by variety/environment. Using some varieties of GEOs may occasion serious risks, and using others may not, and in some environments but not in others.

with it, risks that cannot be investigated in these assessments (under DSs) need not be considered in science-based deliberations about the commercial release of GEOs. For those who maintain "primacy of DSs," this value judgment may be seen simply as a consequence of affirming that regulatory policy should be based on "sound science." But that affirmation is a value judgment too. Why are risks that require CSs for their investigation not relevant to science-based regulatory policy? The matter cannot be reasonably settled by fiat, and scientists qua scientists have no special competence to deal with value judgments. "No risk" cannot become an item of established scientific knowledge so long as judgments made about it depend on this value judgment. Furthermore, it could not become one, unless adequate rebuttals were made of the opponents' counterclaims that evidence (obtained in research conducted under CSs) challenges it and the risk assessments that have actually informed regulatory deliberations have serious shortcomings.

In light of the complexities, uncertainties, and time limitations surrounding risk assessments, and the impossibility of anticipating all the risks that might arise in the future, it is unlikely that a large stock of scientific knowledge can be established about risks. Even so, evidence may be obtained that convincingly supports endorsements about risks (see the "Conceptions of Scientific Methodology" section above). When making endorsements, value judgments are always implicated in some ways, including when endorsing "no risk" (and "there are risks") and making the judgment (in public policy deliberations) that the available evidence is sufficiently strong to endorse "no risk" (Lacey 2015c; cf. Douglas 2009).[9] "No risk" might become convincingly endorsed, if there were good reasons to hold the value judgment about the sufficiency of standard risk assessments, and (for some) commitment to the values of technological progress and of capital and the market may be considered to provide such reasons. Elsewhere I have argued that there are mutually reinforcing relations between commitment to "primacy of DSs" and holding values of technological progress (Lacey 1999, 2005). This often underlies taking efficacy to be (ceteris paribus) sufficient for legitimacy (Lacey 2016) and misidentifying endorsements as items of established scientific knowledge. Whatever agreement

9 The standard organs for scientific communication and evaluation are not well designed to take into account the role played by values in making endorsements.

may exist among mainstream scientists concerning the endorsement of "no risk" may be accounted for largely by the fact that "primacy of DSs" is widely held among them. "Primacy of DSs" also tends to be held among members of regulatory bodies that deal with GEOs. In both cases, this may be reinforced by their holding values of technological progress that, in turn, is reinforced by holding values of capital and the market (Lacey 2016). When regulatory deliberations about risks are informed only by evidence obtained in the course of standard risk assessments, they will be marred by ignorance that has been effectively generated and maintained by holding "primacy of DSs," and the consequent ignoring or downplaying of relevant research conducted under CSs (see "The Appropriateness of Relying Only on Standard Risk Assessments" section below).

Those who hold the opponents' values contest the value judgment that sufficient properly conducted standard risk assessments are the appropriate basis for appraisals of risks and are likely to endorse "there are risks." Of course, their values cannot provide a ground for rejecting "no risk." Holding them makes them aware, however, that the role played by "primacy of DSs" in regulatory deliberations is part of the functioning of an agnotology mechanism, and motivates their insistence on the importance of conducting the empirical investigations under CSs that can contribute to eliminating the ignorance. In addition to contesting the *value judgment*, the opponents challenge the apparent *factual claim* that properly conducted standard risk assessments have been carried out for the GEO varieties that have been commercially released.[10]

3.2. Shortcomings of Standard Risk Assessments Actually Conducted on GEOs

Consider first criticisms made of the *factual claim*. Critics have alleged that standard risk assessments—which have been made of the varieties of GEOs released for agricultural and commercial use, and have actually informed the deliberations of regulatory bodies—have been marred by a variety of

10 Rarely do advocates of using GEOs show awareness that the opponents question the value judgment as well as factual claim. Their efforts to rebut criticisms of the factual claim often appeal to the "technical" character of the studies conducted in standard risk assessments and the authority they accord to "technical" scientific experts concerning them; these depend on holding "primacy of DSs."

shortcomings.[11] These shortcomings include that (1) in many cases, they are not based on "sound science"; (2) typically they presuppose the principle of substantial equivalence; (3) they have not adequately taken into account all the sources and kinds of health risks that need to be investigated, and whether some of the risks that have actually been identified can be adequately managed; and (4) rarely are they subject to further testing in light of ongoing monitoring in the contexts of their actual use.

Regarding (1), the proponents of GEOs ironically often wave the banner of "sound science," which they take to involve the virtually exclusive adoption of DSs. Yet most of the standard risk assessments considered by regulatory bodies are based on research conducted by scientists employed or funded by agribusiness corporations; their results are restricted as "confidential," and in the name of protecting intellectual property rights, barriers are put in the way of independent review and attempted replicability. The point here is not just that confidential studies might be hiding something. Throughout the tradition of modern science, it has constantly been emphasized that "sound science" requires that transparency, public scrutiny, and independent replicability be the norm (Royal Society 2012)—which may be overridden in exceptional circumstances, such as wartime security—in order to counter possible conflicts of interest and agnotology mechanisms. Especially since agribusiness corporations have a strong interest in "no risk" being endorsed, public scrutiny is crucial for having confidence in the results of the risk assessments. Proponents of GEOs point out that independent studies have not provided evidence against "no risk," and they frequently insinuate that opponents, by insisting that such studies be conducted, are really just deploying the mechanisms of construct agnotology. This is disingenuous. It is true that independent studies have not provided *compelling* or *definitive* evidence against "no risk." There have been relatively few of them—in large part because agribusiness normally denies

11 I state the allegations selectively, summarily, and without appraisal, and only as they pertain to assessments of risks to human health. For a useful single source for documentation of the risks and the evidence backing them, and who makes them, see Traavik and Ching 2007. The alleged shortcomings are frequently said to involve the play of additional agnotology mechanisms (which I will not discuss), including lack of transparency, attributing scientific authority to claims that have questionable empirical backing, not attempting to acquire (or suppressing) relevant evidence and find out about relevant evidence that is not published in English-language scientific journals, and premature closure of investigation.

access to the seeds of GEOs needed to conduct them, it makes use of the legal mechanisms of intellectual property rights to restrict their use, and the contractually approved uses of these seeds do not include using them for scientific studies (Dalton and Diego 2002; Pollack 2009; Waltz 2009). This reinforces skepticism about the results of the confidential studies, especially since there is a growing number of independent standard risk assessments that do provide prima facie (albeit not definitive) evidence of serious risks (Ferment et al. 2015; Krimsky 2015). This skepticism is deepened in light of the response of scientists linked with agribusiness to these studies, for it tends to include campaigns aimed at discrediting the scientific quality of the studies and besmirching the scientific reputation of the independent researchers—without carrying out replications of the studies in a way designed to eliminate the unacceptable features that the independent studies allegedly have, and so bypassing the time-tested approach of the modern scientific tradition to resolving disputes (Krimsky 2015; Lacey 2017b).

In regard to (2), the principle of substantial equivalence, in the US Food and Drug Administration version, states that "in most cases the substances expected to become components of food as a result of genetic modification will be the same as or substantially similar to substances commonly found in food such as proteins, fats and oils, and carbohydrates." It is appealed to in order to build into regulatory deliberations that the default presumption (as with varieties grown in "conventional" farming) is "no risk," GEOs need no more stringent scrutiny than conventional varieties, and hence a high burden of proof needs to be met in standard risk assessments conducted on GEOs in order to override this presumption. This helps to explain why regulatory bodies tend to show little interest in rebutting the alleged shortcomings referred to connected with (1), (3), and (4). The status of this principle, however, is a matter of dispute. Many scientists question that it is empirically well based, and some maintain that it has been disconfirmed. Its role in regulatory deliberations, which frequently is required by legislation that is linked with international trade accords, does not have the support of empirically backed scientific consensus (cf. Traavik, Nielsen, and Quist 2007).

In regard to (3), growing GEOs requires the extensive use of inputs (that vary from variety to variety) that are often toxic and derived from petrochemicals, so that the risks occasioned by their use cannot be separated from the risks occasioned by using "packages" that contain the GEOs together with the inputs required for effectively using them (Lacey 2017a). Thus the risks to human health (and harmful effects that may have already occurred) include those that may arise from ingesting pesticide and herbicide residue as well the engineered genetic materials, and exposure to pesticides and herbicides used with the growing of GEO crops. These risks have physical, chemical, and biological mechanisms, and can be investigated under DSs (as they are in some of the studies cited below), and so they can be addressed in standard risk assessments. Nevertheless, the risk assessments concerning human health that have informed regulatory decisions about GEOs rarely go beyond investigating the risks of ingesting the modified genetic materials. They do not take into account (among others) risks that may be occasioned by ingesting the residue of the associated inputs (see, for example, Séralini et al. 2014), links between exposure to glyphosate (the herbicide to which many varieties of GEOs are resistant) and fetal and birth abnormalities that have been identified, for example, in Argentina (Antoniou et al. 2011; Paganelli et al. 2010), and possible links between increased exposure to pesticides and deaths from colon cancer in Brazil (Martin et al. 2018).

Finally, concerning (4), the alleged shortcomings already discussed motivate questioning the sufficiency of risk assessments that are not regularly revisited in light of the ongoing monitoring of the impact of consuming products containing GEOs (and chemical residues) along with the environmental and social impacts of growing them. Uncertainties are always likely to be present in risk assessments, and ongoing monitoring may provide further data, especially concerning potential long-term harm, that might lead to reversals of judgments, but the possibility of long-term epidemiological studies of the health risks of using GEOs, for instance, is severely inhibited by the opposition of agribusiness and many governments to the labeling of GEO-products.

These alleged shortcomings concern the risk assessments that have informed the decisions actually made about the commercial release and regulation of GEOs and their products. They could be eliminated by opening the assessments to scrutiny and replicability in independent studies, being responsive to problems raised in such studies, and complementing them with the ongoing monitoring of risks (and harm that may be actually caused) in contexts of use and then an openness to make revisions in light of the results of the monitoring.[12]

3.3. The Appropriateness of Relying Only on Standard Risk Assessments

Nevertheless, according to the opponents, even if the alleged shortcomings were taken care of and then the standard risk assessments actually carried out on a variety of GEOs provided no support for "there are risks," that would not amount to adequate support for endorsing that the variety can be safely used in the environmental/social contexts in which it is actually used. They maintain that adequate appraisal of "no risk" depends on outcomes of research conducted under CSs as well as those of standard risk assessments.[13] Hence their contesting the value judgment that sufficient properly conducted standard risk assessments are the appropriate basis for assessments of risks would be unaffected by taking care of the alleged shortcomings. For the opponents, the risks that need to be assessed are those that might be occasioned (or the harm that already has been occasioned)—taking into account all the causal mechanisms involved, socioeconomic as well as physical, chemical, and biological mechanisms—in the agroecosystems in which the GEOs are planted and cultivated, and the socioeconomic contexts in which they have been developed, produced, marketed, processed, and consumed.

The investigations that are part of standard risk assessments are conducted in experimental spaces that can deal only with the short-term impacts of using GEOs on health and the environment that are occasioned by physical, chemical, and biological mechanisms grounded in GEOs being biological and technoscientific entities (Lacey 2017a, 2017b). The opponents question not the necessity and value of conducting them well but rather their sufficiency. These investigations (since they only use DSs) do not take into consideration, for example, that some risks are likely to be magnified as GEOs are more widely used, they may derive from inadequate regulatory oversight of the actual uses of GEOs, it could take years before some harmful effects become apparent (Lacey 2017b), risks of occasioning irreversible harm may arise by virtue of the dominant place that GEO-oriented agriculture has assumed in the global food/agricultural and market system (Lacey 2015b), and some risks are occasioned by mechanisms that

12 Kitcher's (2011, 105–137) notion of "well-ordered science" might profitably be used to elaborate this suggestion.

13 I am using "risk" in its colloquial sense of "potential harmful effect," not in the technical sense (typically used in standard risk assessments) according to which the probability of a risk can always (in principle) be calculated.

are grounded in GEOs being commercial objects whose uses are constrained by claims of intellectual property rights. Short-term experimental studies, which are insensitive to potentially relevant variables that may be operative in the many and variable social and environmental contexts in which GEOs are used, can provide no evidence that harmful effects of the kinds mentioned are not being risked. Even if standard risk assessments were exhaustively conducted, the necessary and appropriate kinds of research still remain to be conducted under CSs.

The opposition (“no risk”/“there are risks”), therefore involves not just disagreement about which claim is best supported by the available evidence; it is implicated in the methodological opposition expressed in “primacy of DSs”/“strategic pluralism”). Holding “primacy of DSs” leads to discarding research conducted under CSs, and as such, fosters ignorance concerning evidence that is needed for reasonably resolving the opposition. Thus when “no risk” is endorsed on the basis of standard risk assessments, holding “primacy of DSs” functions as an agnotology mechanism. Of course, conducting the research under CSs, deemed crucial by the opponents, would be difficult, time intensive, controversial, and expensive, and curtailing the use of some GEOs, pending the outcome of the research (as required by the precautionary principle), would be costly to the corporations that have developed them for commercial use.

4. Alternatives

Even if, following research in which both CSs and DSs were adopted, “no risk” were routinely to become endorsed for the varieties of GEOs tested, it would not follow that GEOs should be given high salience in public agricultural policies—for there might be compelling reasons to endorse “better alternatives.” In many regulatory deliberations, “no risk” functions in concert with “no alternative.” The proponents of using GEOs maintain that currently proposed alternatives are not capable of “feeding the world” (in the long run as well as obviously in the short run), and thus endorsing “better alternatives” runs the risk that not everyone will be fed and nourished—a risk so momentous that compared to it, the risks that the opponents cite fall into insignificance. While this does not amount to establishing “no risk,” the fact that members of regulatory bodies tend to endorse “no alternative” helps to make sense of the casual attitude that they tend to display toward the criticisms referred to above, and their considering the research proposed to be conducted under CSs to be irrelevant and distracting as well as time intensive, costly, and "politically motivated."

Be that as it may, if there were good empirically derived grounds available to endorse "no alternative," that would indeed recast the argument toward endorsing a suitably qualified statement of "no risk" and justifying giving priority to using GEOs in public agricultural policies. Those grounds could not be available, however, so long as compelling rebuttals are not produced of the opponents' claims that the available evidence (obtained from research in which CSs as well as DSs are adopted) points toward endorsing "better alternatives," and without the further development of agroecology, the current patterns of hunger are likely to continue. Such rebuttals cannot ignore the growing body of research that suggests that if the current patterns of food insecurity are to be redressed, and the food and nutrition needs of everyone met, a variety of farming approaches needs to be consolidated, and it is a matter of priority and urgency to make funding available for research that contributes toward developments of agroecology (and other approaches that are simpler, cheaper, more sustainable, and locally appropriate), in which introducing technoscientific innovations (like GEOs) is not the driving force (see, for example, De Schutter 2010, 2014; Food and Agriculture Organization 2014; McIntyre et al. 2009; Pretty 2008; Pretty et al. 2006; Rosset and Altieri 2017). In most of these publications, agroecology is highlighted and its current successes are noted; it is indicated that further research needs to be conducted concerning the proper place of agroecology among the variety of needed agricultural approaches (and what its limitations might be), and how it may vary with the characteristics of local agroecosystems, the needs of different locales, and the cultures and values of their inhabitants; it is not foreclosed that there may be a role for using GEOs in the varied mix of needed agricultural approaches; and it is stressed that GEOs should not be prioritized at the expense of agroecology in current agricultural research.[14] Research that addresses these matters cannot be conducted without adopting CSs, so that sound empirically based

14 It is not preordained that research on alternatives that adopts CSs will lead to the conclusion that there is no role, or only a minor one, for GEOs. In a few of the publications cited, a significant role for using GEOs is anticipated; in others (see, for example, Rosset and Altieri 2017) it is argued that the research that has been conducted strongly supports this conclusion.

judgments concerning them cannot be made on the basis of empirical data obtained only in investigation that incorporates "primacy of DSs."

I am not aware of any writings by those who endorse "no alternative" and prioritize the research and development of GEOs that show awareness of these matters, or attempt to rebut the claim that current patterns of hunger are likely to continue unless agroecological and related methods are developed and implemented.[15] The research reported in those writings is conducted under DSs. It includes results that inform standard risk assessments and generalizations drawn from them. But mostly it addresses questions like, What traits, potentially useful to the objectives of agribusiness along with the related interests of governments, farmers, and consumers, can be engineered into crop plants using the techniques of genetic recombination? The answers contribute to strengthening and expanding the uses of GEOs in agriculture, and may inform decisions made by public policy bodies, encourage funding bodies to invest more in research on the possibilities of GEOs, and motivate individual scientists to engage in it. Yet they cannot provide support for "no alternative," or generally, apart from where the interests just mentioned are dominant, giving priority to developing and implementing GEO-intensive agriculture. In practice, the proponents of GEOs tend to take "no alternative" for granted, and adopt the attitude that if using GEOs is efficacious and viable, little more legitimation for developing and using them is needed other than that it serves their interests. Holding this view is reinforced by the widely held conviction that in modern democratic societies, the trajectory toward the future is largely determined by technoscientific innovations (developed in the course of research conducted under DSs) that may contribute to economic growth (Lacey 2016).[16] Moreover, the influence of agribusiness in regulatory bodies, governments, and the press ensures that there is little public awareness of the science-based questioning of the safety of using GEOs and possibilities of alternatives, and its dominance in agricultural (including seed) markets

15 Agroecology is occasionally mentioned in these writings, but just to dismiss its significance by suggesting that it is a kind of romantic throwback to an idyllic past, or perhaps an approach with a role in some limited niches.

16 Research conducted with DSs might contribute to support claims such as that "there are no alternatives to using GEOs within the current trajectory of capital and the market or within the hegemonic food/agricultural system" (Lacey 2005, 230–235), but "no alternatives" does not follow from this.

becomes a causal factor that is preventing the development of alternatives. Nevertheless, it remains the case that in the discourse of legitimacy of using GEOs, "no alternative" plays an important role in countering arguments that "there are risks" (Lacey 2017a), but having good grounds to endorse "no alternative" depends not on the power exercised by large agribusiness corporations and their allies but instead on successfully rebutting that the available evidence points toward endorsing "better alternatives."

The opponents, by virtue of upholding "strategic pluralism," advocate conducting research that deals with the possibilities for strengthening and expanding agroecological practices—and also with the limitations that they may have (Lacey 2015b) and so that research could lead to obtaining evidence that would put "better alternatives" in doubt. Moreover, although they may hold that prioritizing research connected with GEOs is misguided, their upholding "strategic pluralism" per se poses no impediments to engaging in research that explores the possibilities of producing and using GEOs. On the other hand, holding "primacy of DSs" impedes conducting research on the possibilities of the alternatives like agroecology. It thereby hinders engaging in the kind of research (conducted under CSs) that could produce empirical data relevant for testing "no alternative" (and permits ignoring results actually obtained in that research), and it is an obstacle to overcoming ignorance on issues that are at the heart of important policy decisions. Just as regarding matters concerning risks, holding "primacy of DSs" functions as an agnotology mechanism when dealing with questions about alternatives.

5. Concluding Remarks

I have maintained that in the discourse of legitimation that has accompanied the introduction and spread of GEOs, holding a particular view of the nature of scientific methodologies—"primacy of DSs"—functions as an agnotology mechanism. It leads to the fostering of ignorance about the risks that are occasioned by mechanisms grounded in GEOs being socioeconomic objects as well as the possibilities of agroecology: research that could provide knowledge about these risks and possibilities is not pursued; the scientific credentials of research conducted under CSs that might generate such knowledge are rejected; and claims (such as "no risk" or "no alternative") that lack adequate empirical support are effectively enabled to pass for scientific knowledge. A necessary condition for remedying this state of affairs along with the distortion of regulatory deliberations that it engenders is to adopt the conception of scientific research as systematic empirical investigation conducted under whatever strategies (DSs or CSs) are apt for gaining knowledge and understanding of the phenomena being investigated.

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