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DOSSIER

The many kinds of objects that technoscientific objects are

Os vários tipos de objetos que são os objetos tecnocientíficos

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ABSTRACT

Technoscientific objects are penetrating ever more profoundly into the socio-ecological systems that shape the contemporary lifeworld in ways that have brought about widely celebrated benefits, and also many kinds of risks for human health, the environment and society. There are many kinds of technoscientific objects, such as physical, chemical or biological objects that are outcomes of technical/experimental/instrumental interventions made in the course of research conducted in such areas as computer science, biotechnology, nanotechnology, neurosciences, geo-engineering, synthetic biology and artificial intelligence. Moreover, every technoscientific object is itself an object of many kinds, not only an object whose genesis, functioning and effective use are well understood in areas like these, but also a social, economic, ecological and cultural object; and, for each kind that the object is, there are associated specific causal mechanisms whose operations, when triggered in the course of using it in the lifeworld, may lead to effects on and risks for human lives, social arrangements and the environment (Section 1). I will illustrate these claims as they apply to the exemplary technoscientific objects, transgenics (GMOs) used in agriculture (Section 2). Then (Section 3), generalizing the discussion about transgenics, I will argue that appraising the value and legitimacy of introducing and using technoscientific objects adequately requires being informed by the results of scientific investigation that take into account all the kinds of things that they are, and (to the extent possible) all the causal mechanisms from which the effects and risks of using them may arise.

Keywords: Technoscientific objects, transgenics, ecological and social responsibility.

RESUMO

Objetos tecnocientíficos estão penetrando cada vez mais profundamente nos sistemas socioecológicos que moldam a vida contemporânea de maneira a trazer benefícios amplamente celebrados e também muitos tipos de riscos para a saúde humana, o meio ambiente e a sociedade. Existem muitos tipos de objetos tecnocientíficos, como objetos físicos, químicos ou biológicos, resultantes de intervenções técnicas/experimentais/instrumentais feitas no curso de pesquisas em áreas como ciência da computação, biotecnologia, nanotecnologia, neurociências, geoengenharia, biologia sintética e inteligência artificial. Além disso, todo objeto tecnocientífico é ele próprio um objeto de vários tipos, não apenas um objeto cuja gênese,

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funcionamento e uso efetivo são bem compreendidos em áreas como essas, mas também um objeto social, econômico, ecológico e cultural; e, para cada tipo de objeto, existem mecanismos causais específicos associados cujas operações, quando desencadeadas em seu uso no mundo da vida, podem levar a efeitos e riscos para vidas humanas, arranjos sociais e meio ambiente (Seção 1). Ilustrarei essas alegações na medida em que se aplicam aos objetos tecnocientíficos exemplares, transgênicos (OGM) usados na agricultura (Seção 2). Então, (na Seção 3), generalizando a discussão sobre transgênicos, argumentarei que avaliar adequadamente o valor e a legitimidade da introdução e do uso de objetos tecnocientíficos exige que se esteja informado pelos resultados da investigação científica que levam em consideração todos os tipos de coisas que são, e (na medida do possível) todos os mecanismos causais dos quais possam surgir os efeitos e riscos de seu uso.

Palavras-chave: Objetos tecnocientíficos, transgênicos, responsabilidade ecológica e social.

1. Technoscientific objects

1.1 Decontextualizing strategies[2]

The mainstream of the modern scientific tradition has fostered research that utilizes methodological approaches that involve adopting *decontextualizing strategies* (DSs). When DSs are adopted, the objects and phenomena being investigated are represented in dissociation from their human, ecological and social contexts and the possibilities they may afford by virtue of being parts of those contexts, and any links they may have with human agency, sensory experience, social arrangements and ethical/social value; the theories deployed and empirical data collected do not deploy categories, routinely deployed for describing and understanding what is experienced and for deliberating when making decisions, that are value-laden or needed for describing contextual or qualitative sensory properties. Under the most widely adopted DSs, theories, models and hypotheses are constrained so that they are able to represent objects and phenomena, and encapsulate the possibilities they afford, in terms of their being generated from their underlying structures and their components, their processes and interactions, and the laws governing them; and the empirical data that are selected to be sought for, recorded and analysed are largely quantitative, obtained by means of interventions made with measuring and recording instruments, and often of phenomena in experimental spaces. Thus, e.g., in molecular biology and biotechnology, transgenics 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 on the agroecosystems in which they are planted and cultivated and in the specific socio-economic contexts in which they have been developed, produced, marketed and processed, and thus not for the impact of using them on, e.g., biodiversity, the viability of small-scale farming and worldwide food security.

Throughout the modern scientific tradition, *DS-research* (i.e., research conducted under DSs) has been closely linked with "the control of nature," or with technological developments (Mariconda, 2010; 2018) and prioritizing *the values of technological progress* [V_{TP}]. Adhering to V_{TP} involves according high ethical and social value to exercising control over natural objects; to expanding human capacities to exercise such control (in technology) in more and more domains – including the very small and the molecular biological, overcoming communication barriers and going to new places in space; and to the definition of human, social and ecological problems in terms that permit solutions using innovations derived from DS-research (Lacey, 2010, p. 37-40).

While closely linked, the trajectories of DS-science and technological progress have a measure of independence, and some applications of knowledge obtained in DS-science serve interests that embody values that are in tension with V_{TP}. Nevertheless, within the historical trajectory of modern science, adopting DSs and adhering to V_{TP} *mutually reinforce each other* by virtue of relations obtaining between them, such as that technological developments are furthered by being informed by knowledge obtained in DS-research, and DS-research often makes use of instruments and equipment that are themselves adaptations of technological innovations made possible because of advances of DS-research (Lacey, 1999, p. 117). DS-science may be conducted *with the objective of* generating technological developments and furthering the social embodiment of V_{TP}. But, it need not be and often has not been. Perhaps its most valued results come from investigations in basic or fundamental research, which aims only to expand established understanding of the underlying structures, constituents, processes, interactions and laws of phenomena, where DS-science is thought to contribute to the common heritage of humankind available to be utilized (if and where it can be) in service to interests of all value outlooks and not favoring any of them at the expense of others. In addition, (e.g.) most of the research results compiled by IPCC [Intergovernmental Panel on Climate Change] on global warming

[2] This section summarizes ideas developed in Lacey (1999, 2010, 2012, 2014) and Lacey & Mariconda (2014).

and climate change, concerned with redressing the negative effects generated by using technological objects or engaging in the activities that produce raw materials needed for their construction and use, is conducted under DSs.

1. 2 Technoscience and technoscientific objects

Technoscience is DS-research that is conducted *with the objective of* generating technological developments and furthering the social embodiment of V_{TP}. It *aims* directly or indirectly: (i) to generate novel *technoscientific objects*, physical/chemical/biological objects whose existence is (or depends on) the outcome of technical/experimental/instrumental interventions made in the course of DS-research, and whose uses can be effectively controlled to produce specified effects. And/or (ii) to produce knowledge that can inform (and techniques and instruments that enable) the genesis, development and production of technoscientific objects, explain their functioning and identify the possibilities they afford for implementation in social practices to bring about specific effects under certain conditions – this is knowledge of events and states of affairs of novel domains and about new possibilities of what we can do and make; and generating it makes use of the most advanced technology to produce instruments, experimental objects, and new objects and structures. The aim (i) may be satisfied in the course of, e.g., space exploration, testing cosmological or basic physical hypotheses, and climate science, although not directly but as "spin-off" from research that needs to utilize objects and instruments that are products of technoscientific innovation (that often need to be devised as part of the research), and knowledge obtained in this research may also be adapted to contribute to realizing aim (ii). The science and technology (and basic and applied science) are effectively so entangled in technoscience that there is little point in attempting to separate them sharply. Furthermore, technoscientific objects are valued for their contributions to such areas as medicine, agriculture, communications, energy and military affairs that, at the same time, contribute to strengthening the embodiment of V_{TP} and – since nowadays interests that embody values of capital and the market [$V_{C\&M}$] have become the principal bearers of V_{TP} – also of $V_{C\&M}$. Thus, the horizons of practical, industrial, medical or military uses of technoscientific innovations, and of economic growth, competition and other values of $V_{C\&M}$, are usually clearly in view when the priorities of technoscientific research are being determined.

It has become commonplace in contemporary scientific institutions to prioritize technoscientific research and, for the spokespersons of many of them (and especially their funding bodies), to identify the trajectory of science with that of technoscience and even of *commercially-oriented technoscience*, i.e., technoscience conducted with the immediate aim of producing innovative technoscientific objects that can be used to strengthen $V_{C\&M}$ (Lacey, 2012).[3] Then, the value of gaining *understanding* of the phenomena of nature becomes subordinated to that of expanding knowledge of what we *can do* with the technoscientific objects that we *can make*, and of how (*using* them) we can *expand our powers to exercise control* over natural (and technoscientific) objects, especially insofar as they can contribute to furthering $V_{C\&M}$ and other interests of leading commercial bodies.

1.3 The many kinds of things that technoscientific objects are

Technoscience investigates technoscientific objects only *qua* outcomes of technoscientific research, and so objects that embody knowledge obtained in DS-research. The impact of using technoscientific objects, however, cannot be anticipated in all of its details for, when introduced into the lifeworld, they may obtain unanticipated uses sometimes in unanticipated environments; and it extends far beyond the direct outcomes of the mechanisms of their internal functioning and producing the specific effects desired by those who introduce them into the lifeworld and control their use. It includes effects on human beings and social and ecological systems – collateral effects of using the objects for the sake of producing the effects desired by their users – some of which may occur because their efficacious functioning depends on their being located in certain kinds of environments, whose creation and maintenance requires the constant insertion of external inputs and the destruction of earlier environments. Many of these effects, because of their ecological and social dimensions, cannot be investigated in DS-research. To investigate them, one must adopt strategies – *context-sensitive strategies* [CSs] – that do not dissociate from these dimensions. CSs have no place in science, when it is conceived as identical to technoscience or necessarily conducted under DSs, but they are permitted in science conceived of as *multi-strategic research* [M-SR] (Lacey, 2014; 2016).

In order to understand this multi-dimensional impact as fully as possible one must keep in mind that, in addition to being outcomes of technoscientific research (objects that have come into existence as outcomes of technical/experimental/instrumental interventions made in the course of DS-research), technoscientific objects are also social, economic, ecological and cultural objects. They are, e.g., components of social/ecological systems that embody V_{TP} and (most of them) $V_{C\&M}$, as well as values specific to the areas (e.g., medicine) of their intended use.[4]

[3] It is this tendency that explains the recent trend to evaluate the contribution of scientists in terms, not only of the empirical and theoretical results they have published but also of patents they have filed and gained (Oliveira, 2013).

[4] This statement deploys categories (e.g., referring to embodied values) that have no place in theories and hypotheses investigated under DSs, but it is clearly based on empirical evidence.

In order to identify all the types of objects that technoscientific objects are, it would be necessary to identify *their causal powers, tendencies, affordances, origins, effects on human beings and social/economic/ecological systems, and how they differ from natural, non-technoscientific objects and other kinds of technoscientific objects*. Much of this cannot be adequately done within DS-research and so within technoscientific research itself. It requires also engaging in CS-research. Thus, the knowledge that underlies the origins of technoscientific objects and explains their efficacy (and its limits) is not sufficient for understanding all the kinds of objects that they are and could become. And, technoscientific research does not utilize the strategies (CSs) needed to investigate the mechanisms, connected with technoscientific objects *qua* ecological and social objects (e.g., objects that embody $V_{C\&M}$), that bring about some of the effects of using them in the social/ecological systems in which they may be used. In the next section, I will illustrate the claims just made as they apply to an exemplary class of technoscientific objects: transgenics, transgenic seeds and plants that are actually being used (or whose use is anticipated) in agricultural practices that produce foodstuffs.[5]

2. Transgenics: exemplary technoscientific objects

2.1 The kinds of objects that transgenics are

The transgenics that are actually being used in agricultural practices are objects of at least the following kinds (cf. Lacey, 2010, p. 205; 2017a):

(1) Biological organisms, objects that under appropriate conditions will grow into mature plants from which grain will be harvested.

(2) Objects that incorporate scientific knowledge confirmed in DS-research in disciplines such as molecular biology, genetics and biotechnology.

(3) Objects whose existence is the outcome of modifying the genomes of plants by means of the experimentally-tested interventions of genetic engineering, *most* of which currently involve techniques of DNA-recombination.

(4) Objects that, when planted, are constituents of agroecosystems, whose other constituents include inputs many of which are also technoscientific products, e.g., herbicides and fertilizers[6] that embody V_{TP} and whose functioning depends on implementing conditions that embody $V_{C\&M}$, e.g., availability of the required inputs, access to credit so that farmers can purchase the needed seeds and inputs, legal enforcement of the conditions on their purchase and sale of agricultural products and of property rights.

(5) Objects that embody V_{TP}.

(6) Objects that embody $V_{C\&M}$, for the most part commodities, products of agribusiness corporations, brought into existence to serve their interests, commercial objects inserted in the market (with worldwide dimensions) whose uses are constrained by claims of intellectual property rights (Lacey, 2017a).[7]

It is by virtue of transgenics being objects of these kinds that they have the causal powers, tendencies, affordances, origins, and effects on human beings and social/economic/ecological systems that they have, and are different from natural, non-technoscientific objects and other kinds of technoscientific objects. The ontological view presupposed here[8] sharply conflicts with the reductionist neoCartesian view, according to which what objects are (what their characteristic properties are) can in principle be discovered in DS-research. The latter view tends to be accepted implicitly by producers of transgenics and their allies in government, agricultural practices, regulatory bodies and scientific institutions, who support the widespread use of transgenics and their central role in food/agricultural public policies. It holds that what transgenics are is fully captured by (1)-(3) (perhaps with additional similar items); and items (4)-(6) refer only to effects occasioned by contingencies of their human uses whose causal origin is not in the transgenics themselves.

There is further controversy connected with (4)-(6). Those who hold the neoCartesian view and treat (4)-(6) only as contingent generalizations question either their truth, or completeness, or significance in connection with appraising the value and legitimacy of using transgenics. They make claims like the following: The transgenics used in the agroecosystems (described in (4)) also embody the values of

[5] These transgenics are not the only kinds of genetically engineered organisms (GEOs). There are also, e.g., GE microorganisms and mosquitos that have nothing directly to do with agriculture, GE fish and animals that have to do with producing foodstuffs, and GE crops that produce, e.g., cotton or biofuels, rather than foodstuffs. Many *but not all* of my comments also apply to them.

[6] Transgenics are engineered so that the efficacy of their use requires that they be planted in such agroecosystems. E.g., glyphosate-resistant transgenics are engineered to be used in agroecosystems in which crops are appropriately sprayed with glyphosate.

[7] The plants whose genomes are modified (or ancestors of them) were already cultivated in agricultural fields or found in natural ecosystems; but genetically engineered possibilities could not have been realized by means of the mechanisms of natural selection or methods of crossbreeding used by traditional and indigenous farmers and conventional plant breeders. Many of them, thus, also incorporate the traditional and indigenous knowledge that informed the selection practices that gave rise to them. Note that it is by virtue of being objects of kinds (2) and (3) that intellectual property rights can be claimed to transgenics (seeds and plants) – although the knowledge obtained under DSs that they incorporate applies to only tiny fragments of their genomes, much larger fragments of which incorporate traditional and indigenous knowledge (Lacey, 2010, Chapter 6; 2017a).

[8] My formulation of this ontological view, which there is no space to elaborate here, draws on Bhaskar (2014).

preserving sustainability (e.g., reducing pollution of soils and waters) and reducing the health risks of agricultural workers (e.g., less exposure to agrotoxics); by virtue of embodying V_{TP} and being sources of food products that are consumed by many human beings and animals, they also embody such values as safely meeting the food and nourishment needs of those who consume them and furthering the realization of the right to food security throughout the world; and, by virtue of embodying $V_{C\&M}$, they are part of the socioeconomic system that furthers the embodiment of V_{TP} with its accompanying desirable consequences. Opposing these claims, proponents of agroecology and food sovereignty maintain that, in the agroecosystems and under the socioeconomic conditions in which transgenics are actually used, all other values are subordinated to $V_{C\&M}$, leading to destructive social and environmental consequences, including weakening the widespread realization of the right to food security and massive destruction of biodiversity.

DS-research lacks the conceptual/theoretical resources to resolve this controversy. Certainly the claims of the proponents cannot be supported within DS-research: the formulation of items (4)-(6), and of the contingent generalizations said to replace them as well as the claims stated in the previous paragraph, requires categories that have no place in theories and hypotheses investigated under DSs; and investigating the effects of using transgenics and their products (and the mechanisms that occasion them) on human beings, social arrangements and ecological systems in the contexts of their use is beyond its purview. Addressing the controversy requires conducting investigations under appropriate CSs that entertain theories and hypotheses that deploy categories (e.g., categories apt for describing what values are embodied in objects) that are not reducible to those of DSs. Thus, ***what transgenics are*** – all of the kinds of objects that they are – and the full range of the effects of using them cannot be grasped by means of the same kind of research (conducted under DSs in molecular biology and biotechnology) that generated them in the first place and that testifies to their efficacy. Neither can it be grasped that agricultural practices, like agroecology that embody competing values (of social justice, democratic participation and sustainability), would be undermined by introducing transgenics into them (Lacey, 2015a; 2015b).[9] In order to grasp these things, it is necessary to adopt CSs that enable the investigation of, e.g., the effects of using transgenics *qua* objects that embody the values of V_{TP} and $V_{C\&M}$.

Hence, the value and legitimacy of using transgenics cannot be adequately appraised when deliberations are carried out deploying only the conceptual framework (limited to categories permitted in theories developed under DSs) in which the research, development and implementation of transgenics take place – or from the demonstrated efficacy of using them in the conditions in which they are used, or from the stated objectives (or good intentions) of their producers and users. It depends also on (i) what their actual benefits are, who benefits from them, and whether the benefits can be shared evenhandedly; (ii) the safety of using them in the agroecosystems of their actual use and under the socioeconomic conditions of their production, distribution, processing and consumption – and, hence, on whether or not their actual use has occasioned harm, or is likely to occasion potential harmful effects (risks); and (iii) what the viable alternatives to using them may be, and how their likely benefits and safety compare with those of using transgenics. Appraising the value and legitimacy of using transgenics, therefore, requires investigation concerning these three issues. In this article I will focus on risks; investigating them requires adopting appropriate CSs, as well as DSs.

2.2 The many kinds of risks that using transgenics occasions

One of the key premises of arguments defending the legitimacy of the central role for transgenics in agricultural practices and policies is that the current (and anticipated) uses of transgenics – their production, planting, cultivation, harvesting, processing, distribution and consumption – are safe; i.e., that using them occasions no significant risks for human health, society and the environment (that cannot be managed and contained by implementing and enforcing scientifically informed regulations). I will label this claim "no risks." It is said to have a strong basis in empirical investigations of risks.[10] However, the proponents of transgenics and official organs, e.g., CTNBio,[11] which are responsible for making decisions about liberating varieties of transgenics for agricultural use, tend to hold the view that transgenics are essentially objects only of the kinds (1)-(3). Their risk analyses, consequently, do not take into account all of the kinds of risks that are potentially occasioned, but only those occasioned (in the words of some scientists who have served on CTNBio), by the "direct and specific impact of GMOs [transgenics] on nature" (de Andrade ***et al.***, 2015). This is the impact derived from using them considered only ***qua*** objects of kinds (1)-(3), that occasioned by mechanisms triggered by events within the modified genomes of the transgenics that can be described using categories utilized in DS-research. Investigating this impact, no matter how well the investigations may be conducted, cannot provide sufficient evidence to support "no

[9] For discussion of the CSs used in research in agroecology, see Lacey (2015a).

[10] It has been said that there is a scientific consensus supporting "no risks," at least insofar as it concerns consuming the products derived from transgenics. This is incorrect – see Ferment et al. (2015); Hilbeck *et al.* (2015); Krimsky (2019)

[11] CTNBio – Comissão Técnica Nacional de Biossegurança, the Brazilian body responsible for assessing the safety of transgenics before their release for agricultural use.

risks," but at most evidence to support the more limited claim: "There are no risks of using (especially consuming) transgenics and their products that are occasioned by the 'direct and specific impact of transgenics on nature."[12] But the more limited claim could be well confirmed, and at the same time "no risks" be disconfirmed by the results of CS-research conducted on the risks of using transgenics considered *qua* objects of kinds (4)-(6) – and the preponderance of available evidence supports that "no risks" is false.

To see this more clearly, consider a particular variety of transgenics – call it V (e.g., a variety of soy beans resistant to glyphosate). Suppose that it has been convincingly established that there are no risks (to health and environment) occasioned by the "direct and specific impact" of V on nature (by virtue of mechanisms triggered by events within V's modified genome). Since V is accompanied by inputs of glyphosate in the agroecosystems in which it is grown, however, that would imply nothing about the safety of planting, cultivating and harvesting V. There could be, e.g., health risks occasioned for consumers of the processed products of V because of residue of the agrotoxics that has not been removed, and for farm workers and their communities because of exposure to the agrotoxics. These are not idle possibilities. E.g., reports in Argentina and Brazil (and elsewhere) have documented serious health problems occasioned by exposure to glyphosate, the main active ingredient of the herbicide, Roundup, to which the most widely used transgenics have been engineered to be tolerant (Carneiro *et al.*, 2015; Gillam, 2017; Paganelli *et al.*, 2010; Ruschel, 2019). Even if it is well confirmed that there are no risks occasioned by events within the modified genome of V, that does not suffice to support "no risks," for there are risks occasioned by using V *qua* object of kind (4).

Thus, in order to test "using V occasions no risks," one must investigate the effects of using glyphosate as a herbicide in the fields where the glyphosate-resistant V is grown. It is not an adequate substitute to follow procedures that require analyzing the effects of using transgenics and glyphosate separately – where the effects of growing and consuming V are investigated in laboratory or small-scale field studies in which V is grown without using glyphosate, and the effects of consumption of and exposure to glyphosate in other investigations – unless there were empirical evidence supporting that there are no additional or interacting factors that might affect the safety of using V. V, used in contexts different from those of its normal agricultural use, may be safe; but that has no implications for its safety where it is encountered by human beings in the agroecosystems of its actual use. V was developed to be resistant to glyphosate so that it could be grown in agroecosystems in which glyphosate would be an active presence, and it has no agricultural uses otherwise; and glyphosate is present in those agroecosystems *because* V is being grown there; and any effects its use may occasion in them are a consequence of its association with V. V, in the agroecosystems in which it is actually used, is an object of kind (4). Nevertheless, according to De Andrade *et al.* (2015), the mandate of CTNBio is confined to analyzing the "direct and specific impact" of transgenics; appraising the effects of using agrotoxics (e.g., glyphosate) in managing transgenic crops is outside of its mandated purview; and risk assessment of using agrotoxics, a matter that has to do with "other aspects of the technology," needs to be (and is) conducted by other bodies.[13] Moreover, according to this article, separating the procedures involved in analyzing the two kinds of risks (those deriving from the direct and specific impact of transgenics on nature, and those from other aspects of the technology) is part of a "technical stance accepted and deployed throughout the world in accordance with international treaties and accords concerning commerce and protection of health and the environment" (author's translation), a stance that would be reasonable only if transgenics were objects only of kinds (1)–(3), and if safety studies of using them need only take into account risks that may be occasioned by virtue of transgenics being objects of these kinds.[14]

In addition to the risks of using transgenics considered *qua* objects of kind (4), there are also risks (and harm that may have already occurred) occasioned by mechanisms triggered by using them *qua* objects of kinds (5) and (6). They include environmental risks: e.g., loss of biodiversity due to planting transgenics in monocultures, and degradation of soils (elimination of microorganisms and fungi in them) and water supplies because of intensive and prolonged use of agrotoxics. And social risks: e.g., threats to the food security of those who lose their lands because of the expansion of agribusiness that fosters the use of transgenics, monopolization of the world's seed markets, and undermining of alternative approaches to agriculture (e.g., agroecology) and conditions that favor ensuring food security for poor communities (Holt-Giménez, 2019).[15] These risks are occasioned by growing all the varieties of

[12] Because of risks that were detected, some varieties of transgenics were not liberated for use. So, a more accurate formulation would be: "There are no risks of these kinds that cannot be detected in DS-investigations, and none have been detected concerning the varieties that have been liberated for agricultural use; and risk assessments of these kinds made before liberating new varieties are likely to detect in advance any serious risks, so that risk-incurring varieties would not be released."

[13] De Andrade *et al.* (2015) is a response to Lacey *et al.* (2015a), and is responded to in Lacey *et al.* (2015b).

[14] For those who identify "scientific" methodologies in terms of using only DSs, studies of this kind are considered to be "scientific risk (or safety) studies" and CS-research is not considered to have sound scientific credentials. It is sometimes maintained that the deliberations of regulatory organs should be informed only by the results of "scientific" studies. I have argued elsewhere (Lacey, 2019a) that this view of scientific methodology is a significant cause of maintaining ignorance about the serious risks occasioned in the light of transgenics being objects of types (4)-(6).

transgenics currently liberated for use, and exacerbated by the totality and extent of plantings of them and by the aggressive introduction of their processed products into the world's food system in programs shaped by agribusiness, food companies and policies of governments and international trade bodies (Lacey, 2017b).

When only the two-track procedure (described in de Andrade *et al.*, 2015) is followed, sound endorsements of the safety of using transgenics cannot be made. Even if it were soundly established that there are no risks deriving from the "direct and specific impact" of using them, that does not establish that it is safe to use them in the agroecosystems in which they are used under the conditions of their use, and to consume their products. Following that procedure, and effectively appraising the safety of using transgenics only *qua* objects of the kinds (1)–(3), may serve the interests of agribusiness and some of its clients that profit from the production and uses of transgenics, and governments that encourage the growth of crops for export. But it fails to address adequately issues of safety that arise in the agroecosystems of their use, e.g., about the harmful effects on the health of farmers and communities that become exposed to agrotoxics, and it leads to rejecting the rationale for taking precautionary measures aimed at preventing or minimizing the impact of the harmful effects (Lacey, 2019a).

Agribusiness and its allies sometimes point out that the risks occasioned by mechanisms connected with transgenics being objects of kinds (4)–(6) are also occasioned in "conventional" farming (based on using hybrids, agrochemicals including agrotoxics and intense mechanization) by essentially the same kinds of ecological and socioeconomic mechanisms; that these risks predated the introduction of transgenics; and that they are still occasioned in situations where "conventional" farming is not replaced by transgenics. Hence, they conclude, it is just "ideological" to attribute these risks to using transgenics. It is true that risks of these kinds are endemic to the hegemonic food/agricultural system, that in other (earlier) situations there are different mechanisms for occasioning them, and that the role that transgenics have come to play in shaping the trajectory of the system is explained by the interests well served by the system. Nevertheless, these facts do not challenge that currently mechanisms connected with using transgenics play the central role in occasioning these risks.

Furthermore, proponents of using transgenics have maintained that risks like these are more than counterbalanced by the benefits obtained, since (they claim) there are *no alternatives* to the agricultural use of transgenics (and their technoscientific successors) that would not occasion worse risks, e.g., the risk of not producing enough food to feed and nourish the world's population. But *no alternatives* cannot be investigated without adopting CSs, for to confirm it, research would have to be conducted on the possibilities of farming practices like agroecology whose core practices are not principally informed by knowledge obtained under DSs.[16] As things stand, *no alternatives* has not been established in the course of empirical investigations, and the preponderance of evidence (obtained in CS-research) is against it (Lacey, 2015b; 2017a; 2017b).

It matters that transgenics are objects of many kinds. Thinking of them as objects only of the kinds (1)–(3) helps to consolidate the myth that transgenics may be used to serve interests linked with virtually any values (Lacey, 2017a). Not recognizing that they are also objects of kinds (4)–(6) enables misleading judgments to be made about what can be expected from using transgenics on a wide scale (Lacey, 2017b); and it leads to ignoring the possibilities of non-technoscientific alternatives (e.g., agroecology) that embody, not V_{TP} and $V_{C\&M}$, but the values of social justice, participatory democracy and environmental sustainability (Lacey, 2015a; 2015b).

3. The value and legitimacy of introducing and using technoscientific objects

Transgenics are exemplary technoscientific objects (Lacey, 2017a); consequently, although most technoscientific objects are not biological objects, much of the discussion about transgenics can be generalized to technoscientific objects in general. Technoscientific objects being used in the lifeworld can be shown one-by-one to be themselves objects of many kinds, including ecological and social objects; and appraising their value and legitimacy requires considering and investigating them *qua* all the kinds of objects that they are.

Just as transgenics are not only objects of kinds (1)–(3), other kinds of technoscientific objects are not only physical/chemical/biological objects that have come into existence as outcomes of technical/experimental/instrumental interventions made in the course of DS-research. And, just as transgenics are objects of kinds (4)–(6), they too are objects of daily life, human experience, social arrangements, productive activities, and institutional practices. Moreover, since their functioning in social practices requires that certain material, ecological and social conditions be in place (e.g., availability of necessary inputs for their functioning, and the socioeconomic structures that ensure their continued availability), they are also components of social/ecological systems that embody V_{TP} and (typically) $V_{C\&M}$, as well as values specific to the areas of their intended uses. Establishing and maintaining the

[15] Also, recent increases in obesity and other health problems have been attributed to programs that lead to expansion of consumption of 'junk foods', programs made more efficient by processing transgenics (Jacobs & Richtel, 2017).

[16] Perhaps DS-research might suffice to establish "*no alternatives* within the trajectory of the hegemonic food/industrial system," but *no alternatives* does not follow from this. Agroecology, e.g., is an alternative in tension with this trajectory (Lacey, 2015b).

conditions, as well as using the technoscientific objects where they obtain, has material, ecological, human, economic and social effects. Many of them are of ethical significance, and so need to be taken into account in deliberations concerning the value and legitimacy of using technoscientific objects. This is especially important when they are introduced supposedly as parts of solutions to social problems – as introducing transgenics is said by its proponents to contribute to solving the problem of worldwide hunger – for maintaining the conditions might be incompatible with solving the problem. Critics of using the transgenics currently in use and development, e.g., have argued that agribusiness control of the food/agricultural system is incompatible with eliminating hunger in poor areas of the world (Lacey, 2015b; 2017b; see note 18). And many people directly affected by the consequences of climate change, pollution and destruction of biodiversity worry that maintaining socioeconomic conditions in which V_{TP} and $V_{C\&M}$ are highly embodied in the hegemonic institutions and social practices (to the detriment of the values of social justice, democratic participation and environmental sustainability) is incompatible with mitigating problems like these that threaten the future of humanity.

These matters cannot be investigated adequately in technoscience itself where only DSs are adopted, or discussed in ways that are informed by appropriate scientific input in contexts where technoscientific objects are considered only *qua* objects that are products of technoscientific research, and not also as objects *qua* constituents of social-ecological systems, objects that embody V_{TP} and typically $V_{C\&M}$. Since modern science privileges the adoption of DSs (leading to the virtual exclusion of CSs), these matters have not been adequately investigated in modern science. That partly accounts for the fact that climate change was not foreseen as a potential consequence of the widespread introduction into social practices of the technoscientific objects (given the economic conditions of their implementation and maintenance) whose uses occasion large greenhouse gas emissions; and how to mitigate the effects of climate change will not be adequately investigated so long as that trajectory of science is largely identified with that of technoscience (or commercially-oriented technoscience).

The privileged place granted to adopting DSs is linked with the widespread social adherence to V_{TP}, the profound embodiment of V_{TP} in modern social institutions, and not systematically subordinating V_{TP} to interests connected with ethical and social values other than (sometimes) $V_{C\&M}$ (Lacey, 2010, Chapter 1; Lacey & Mariconda, 2014). Thus, adhering to V_{TP} easily leads to according *prima facie* legitimacy to implementing demonstrably efficacious technoscientific innovations without delay (considering them only *qua* outcomes of technoscientific research) so that the expected benefits of using them may be obtained as quickly as possible, and even to tolerating a considerable measure of social and environmental disruption for its sake – provided only that, following investigations (conducted under DSs) of their "direct and specific impact" on health and environment, appropriate experts or official organs (like, in the case of transgenics, CTNBio) judge that they would not occasion serious risks (Lacey, 2016). This presumption of legitimacy – untested by the consideration of risks that need CSs for their investigation – is strengthened when V_{TP} are interpreted (in commercially-oriented technoscience) in the light of $V_{C\&M}$.

In the dominant social, economic and political institutions of economically advanced societies V_{TP} and $V_{C\&M}$ are often taken for granted. This helps to explain why it is largely ignored that technoscientific objects are objects of many kinds and that there are potential risks of using them that are occasioned by virtue of all the kinds of objects that they are, and why research conducted under CSs is marginalized. Nevertheless, this explanation should not disguise that it is reasonable to adhere to V_{TP} only if claims like the following can be endorsed following relevant empirical investigation (Lacey, 2010, p. 39): (a) On-going technoscientific innovation expands human potential and provides benefits that can be made available to all human beings. (b) Technoscientific solutions can be found for virtually all practical problems (in medicine, agriculture, communications, transportation, energy provision, etc.), including those occasioned by the "collateral effects" of using technoscientific objects themselves. (c) For most of these problems there are only technoscientific solutions. (d) The values of technological progress represent a set of universal values that must be part of any viable value outlook today – there are no viable alternatives.

Items (a)–(d) are not value judgments. They are claims open to being tested empirically in investigations that (given their social, historical and value aspects) would require the adoption of relevant CSs. Thus they fall outside of the purview of technoscience.[17] When technoscientific objects are recognized as being the many kinds of objects that they are, and the relevant CSs are adopted, available facts provide grounds for not hastily assuming that (a)–(d) would withstand systematic empirical scrutiny. Re (a): the benefits of technological "progress" to date have not been made available to many poor and indigenous peoples. Re (b): technoscientific solutions proposed to address world hunger (including using transgenics) have not delivered (Lacey, 2015b) and those proposed to mitigate climate change remain mired in ambiguity; and none are available to address the risks of using

[17] Ironically (and perhaps paradoxically), investigating presuppositions of marginalizing CSs requires adopting CSs.

[18] Accompanying (b) there is often the unarticulated assumption that to produce solutions to problems it is not necessary to know about the causal network that has produced them and sustains them. Those who propose that using transgenics is key to solving the problem of world hunger rarely address the socioeconomic causes of hunger, and so do not address how hunger can be redressed adequately without eliminating those causes.

transgenics considered *qua* objects of kinds (4)–(6).[18] Re (c): there is promising evidence that agroecology (an approach to farming whose essentials are not informed by technoscience) is the key to moving towards addressing the problem of hunger (Lacey, 2015a). Re (d): practices that embody the values of social justice, respect for the full range of human rights, environmental sustainability and democratic participation (embodied in agroecological and associated practices in other areas, as well as many popular social movements throughout the world, including in Brazil) constitute prospectively a viable alternative to those that embody V_{TP} and $V_{C\&M}$ (Lacey, 2015a; 2015b).[19]

All of these issues are obscured when it is ignored that technoscientific objects are objects of many kinds. In contrast, when it is recognized, items (a)–(d) and adhering to V_{TP} and $V_{C\&M}$ all become matters of contestation, and the ground is undercut for the casual assumption of the value and legitimacy of using technoscientific innovations, provided only that DS-scientific investigations show that their "direct and specific impact" does not involve seriously harmful effects. Then, it becomes apparent that appraising the value and legitimacy of using technoscientific innovations needs to take into account (to the extent possible) all the risks of using them, that risks might be occasioned by mechanisms grounded in any of the kinds of things that they are, and that the seriousness of the risks needs to be evaluated in the light of what alternatives are and could be available. This requires going beyond the limits of technoscience and being responsive to research conducted under CSs (as well as DSs). It also requires taking precautionary measures to ensure that an innovation is not introduced into the lifeworld unless a sufficient range of risks and alternatives has been investigated. These measures are needed to make time available in order to develop the conceptual resources required in the investigations, to deal with the threats of climate change (and other threats, such as those derived from using transgenics and their successors), and to allow for democratically supported alternatives to demonstrate whatever promise they might have – so that further harm that may be occasioned by using technoscientific innovations could be minimized (if not eliminated).[20] Thus (see Lacey, 2016; 2019a), responsibly appraising the value and legitimacy of using technoscientific innovations requires, on the one hand, that research conducted in technoscience be accompanied by commensurate research (deploying appropriate CSs) on the long-term, often worldwide, potentially irreversible ecological and social consequences of introducing the innovation into the lifeworld, taking into account all of the kinds of objects that the innovations are and the socioeconomic conditions of the planned introductions and the actual conditions of use; and, on the other hand, that adequate research be conducted that investigates the full array of alternatives that are proposed by participants in democratic societies.

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[19] Where V_{TP} are adhered to, it is not because (a)–(d) have been investigated and endorsed, although those who adhere to them tend to appeal to presuppositions like them. Rather, I conjecture, V_{TP} are adhered to because powerful interests embody them, and their high embodiment in dominant social institutions leads many to accept that they cannot be challenged; then (a)–(d) are endorsed because they are presuppositions of adhering to V_{TP}.

[20] See Lacey (2019a) for detailed discussion of such precautionary measures, the conditions in which they should be taken, what risks should be investigated, their possible outcomes (in some cases requiring delays or even prevention of introducing an innovation into the lifeworld, or requiring that their uses be submitted to ongoing monitoring), and the institutional mechanisms and personnel for making decisions about them.

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