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ARTICLES

Reconstruction of the Ethical Debate on Naturalness in Discussions About Plant-Biotechnology

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Abstract This paper argues that in modern (agro)biotechnology, (un)naturalness as an argument contributed to a stalemate in public debate about innovative technologies. Naturalness in this is often placed opposite to human disruption. It also often serves as a label that shapes moral acceptance or rejection of agricultural innovative technologies. The cause of this lies in the use of nature as a closed, static reference to naturalness, while in fact "nature" is an open and dynamic concept with many different meanings. We propose an approach for a dynamic framework that permits an integrative use of naturalness in debate, by connecting three sorts of meaning that return regularly in the arguments brought forward in debate; cultural, technological, and ecological. We present these as aspects of nature that are always present in the argument of naturalness. The approach proposes a dynamic relation between these aspects, formed by gradients of naturalness, which in turn are related to ethical concerns. In this way we come to an overview that makes it possible to give individual arguments a relative place and that does justice to the temporality of the concept of nature and the underlying ethical concerns stakeholders have in respect to innovation in agriculture.

Keywords Naturalness · Biotechnology · Genomics · Agriculture · Public debate · Ethical values

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> High impact innovations set the whole system of society in movement. They influence economy, threaten values, and mandate to recalibrate and sometimes reformulate goals. Life sciences not only change our understanding of life and expression, but with that also the higher order that fundamentally regulates our relationship with nature, with ourselves and between ourselves, as spiritual, natural, cultural and communal beings.[1] (COGEM 2004)

Introduction: Naturalness, a Problematic Argument

Discussions about agricultural innovation have become more and more polarized over the last 50 years, especially since the introduction of Genetically Modified Crops (GMO's). Many kinds of arguments have been brought forward to support diverse opinions about the way agriculture should develop towards the future. One characteristic and regularly recurring argument concerning the quality of agricultural innovation is whether or not it can be considered to be "natural."

Since the 1960s global output has multiplied, and the yield per hectare of the most important crops has almost doubled or more than doubled. With growth, however, many increasingly problematical side effects have appeared. Agriculture contributes to climate change and a degradation of natural resources. It forms a threat to biodiversity, occupies most of our arable land, is increasingly vulnerable to diseases and uses up water resources (IAASTD 2009). As a result, the (green revolution) goals of increased productivity and economic efficiency are slowly shifting towards sustainable growth and mitigation of the negative consequences for the environment (Smith 2000).

Agricultural reform seems unavoidable and, with a growing global population, plant biotechnology and genomics as a tool for innovation will likely play a principle role in this reform. New developments in genomics, such as Marker Assisted Selection (MAS), now promise to offer solutions that make agriculture sustainable and environmentally responsible. They open up possibilities for targeted breeding in ways that simply were not feasible in the past because genotype selection makes it possible to cross wild distant relatives without too much loss of the beneficial characteristics of the used cultivar (Collard and Mackill 2007; de Vriend and Schenkelaars 2008). In current discussions about the future of plant biotechnology however, these developments are hardly noticeable. The controversy and stalemate that resulted from the debate over Genetically Modified organisms (GMO), produced a dichotomy amongst stakeholders that has had long lasting effects and is expected to percolate through to debates about the further use of genomics (Nap et al. 2002). We see that debate is not moving forward with the developments in genomics and that the same stakeholders are still entrenched in their positions, repeating the same kind of arguments over and over again (Calkins 2002; de Vriend and Schenkelaars 2008).

Agriculture is unique in the sense that it has a natural and an unnatural side united in its core. Without human intervention there would be no such thing as modern

[1] Translated from Dutch, Dutch text see page 21 of the report.

agriculture, but we remain dependent on very natural and given systems too since otherwise no agriculture would be possible. There is no such thing as completely artificial agricultural production, just as there is no agriculture without human intervention. With the increasing fall-out from agricultural expansion, it has become clear that the very success of technological innovation now seems to threaten the natural systems that agriculture depends upon. It is no surprise then that in discussions about biotechnology nature and the question of natural boundaries play a crucial role in trying to find a way forward in agricultural innovation.

In the case of GMO's, the questions were raised of whether this specific technology is, or no longer is, "natural" and whether the creation—or introduction into the environment— of living organisms that are "unnatural" can be accepted as a means to reach the end: sustainable and responsible agriculture. Whereas in the public opinion many believe genetic modification is artificial (Vogel 2009), most plant scientists maintain that the technique is a mimicking of a very natural process, not much different from hybridization through classical breeding (van Wordragen and Dons 1992). Genetically modified organisms are legally defined in the European Union, as: "genetically modified organism (GMO) means an organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination" (EU 2001). In the public debate about genetic modification a similar reference to naturalness is used and endlessly repeated too. In this case, however, it is not a legal but rather a *moral argument* for objecting in principle against the use of genetic modification in general.

Naturalness not only functions as a defining instance in legislation but it also functions as a normative moral concept in public debate; this makes it possible for stakeholders to polarize the issue and to typify genetic modification as an irresponsible technology, thereby blocking debate. The stalemate in the debate about GMO's demonstrates that naturalness and the portrayal of nature as a moral category can quickly become untouchable, overruling arguments (Smits 2002, 2006). Naturalness thus serves as a normative marker to underpin the ethical concerns of stakeholders but it does so in different guises and contexts referring to different standards and phenomena. But what does it mean when naturalness is used as an argument in discussions and why is it such a powerful argument that can stall debates?

The discussions on agricultural innovations consist of many debates including the ethical debate about naturalness. In this debate people express ethical concerns and use different arguments to clarify or explain these concerns.

The aims of our paper are to describe and analyze:

(a) The different kinds of ethical concerns in the debate;
(b) The different kinds of arguments about naturalness;
(c) The connection between these kinds of arguments;
(d) The connection between the ethical concerns and the arguments.

In our attempt to reconstruct the arguments of the debates on naturalness we will first describe and generalize the ethical concerns in the discussions on agricultural innovation (a). We will next look for kinds of arguments in the philosophical literature (b). After determining the connection between the kinds of arguments from the philosophical literature (c), we will be able to determine the connection between the different kinds of ethical concerns and the different kinds of arguments (d). This will give us the framework to develop an approach that can help to clarify the debates on naturalness between people who use these different kinds of arguments and the dynamics between them. Hopefully this approach can help to lift the stalemate in debate about genomics in agricultural innovation.

Agricultural Innovation Under Discussion

A brief overview of agricultural developments over the last decades provides us with an idea of how references to naturalness have changed with the historical context and with the information we need to generalize the different ethical concerns. In the late 1950s and throughout the 1960s the concept of the green revolution developed. Seed banks, developments in genetics and public–private partnership, quickly led to greatly improved technologies for targeted breeding (Kloppenburg 2004). New cultivars multiplied productivity in agriculture in a way that had previously been unforeseen by concentrating breeding on yield characteristics and by compensating for the lack of "natural" robustness of these crops with synthetic chemical inputs for nutrition and disease control. The development of bumper crops in combination with the chemical approach also marked the conversion from a rural to an industrial and capitalized production process. The success of this approach was clearly visible. For most crops, yield figures per hectare more than doubled between 1960 and 2000. Moreover, the proportion of hungry people in the world declined from about 60% in 1960 to 17% in 2000 (Borlaug 2007).

During the 1970s and 1980s, however, the downside and limitations of this "industrial" in comparison with the "natural" approach became more and more apparent too. The green revolution produced a growth of large-scale agriculture at the expense of small holders, affecting the livelihood of smaller producers and producers in developing countries (Goodman et al. 1987). The increased use of fertilizers, herbicides and insecticides led not only to environmental degradation and pollution (Murphy 2007) but also to the concentration of agricultural power in the hands of big companies suspected of neglecting environmental and social issues (Shiva 1991). The focus on production and quantity was found to be leading to a loss of quality as well. During the 1980s, consumers started to complain that these industrialized products had lost their taste and texture (Harvey et al. 2002). Next, the spread of disease caused by mono- cropping became a cause for concern. Resistance to pesticides quickly became an issue (Murphy 2007). By that time, however, the genetic base of popular cultivars had become so narrow that breeding efforts to improve quality became difficult, giving rise to yet another set of concerns, this time about biodiversity (Juma 1989).

This fall-out gave rise to modern environmentalism, which criticized the over-exploitative and chemical approach in agriculture (Carson 1962; Tilman et al. 2002). As a reaction to the environmental problems and other problems that arose from the green revolution and the industrialization of agriculture, the counterculture that originated in the 1960s embraced alternative, more "natural" forms of agriculture. Some ideas for organic agriculture stem as far back as the 1920s–1930s, when a naturalist reaction to a mechanistic worldview caused an interest in a peaceful, natural way of life based on corporal culture and respect for the healing effect of pure and organic processes (Weiner 1992; Lotter 2003). However, the full connection between this tradition of thought and agricultural production was not made until the 1970s, when environmental degradation stimulated the rise of the ecological movement. Under the modern ecological movement, critical theory, anthroposophy, and environmentalism came together in one radically different approach towards agriculture (Weiner 1992). Organic (ecological) agriculture presents itself as a more equitable alternative compared to the industrial, capitalist approach. The organic approach aims at being holistic, giving weight to systems of internal self-regulation through non-appropriation, agro-biodiversity, stability and resilience (Lammerts van Bueren et al. 2002; Lammerts van Bueren and Struik 2004). The technology used is intended to be in line with principles of fairness and care, and production takes into account that natural resources are not exploited and depleted because production adapts to what is available in a sustainable way. Organic agriculture thus carries anti-biotechnology, anti-capitalist, anti-exploitative, and small-scale tendencies with it (Lammerts van Bueren and Struik 2004).

In the 1990s, the advance in molecular biotechnology made it viable to market genetically modified crops that offered highly attractive commercial qualities. This development was later presented as a solution to the lack of genetic diversity for breeding new cultivars, but it is important to note that it was initially a development meant to enhance industrial production in agriculture (Murray 2003), this being the image that has persisted in the public's eye. The new crops that were developed were mainly for industrial-scale agriculture (directed at yield and efficiency). BT-cotton, corn and soya and Round-up ready corn and soya are examples of this (de Vriend and Schenkelaars 2008). These genetically modified crops quickly met with opposition from a variety of societal groups, ranging from environmentalists to religious groups to consumers (Campbell 2006). Opponents feared that the introduction of artificially modified plants in a natural environment would have negative consequences (Murray 2003). Many argued that genetic modification would cause a further decline in biodiversity and further degrade the environment (Rifkin 1998). As research into the long-term effects of GM crops was and still is meager, the unknowns could be translated into environmental risks. There was a fear of contaminating existing varieties or disturbing the ecological equilibrium (de Vriend and Schenkelaars 2008). GM food would harm health. It was thought that the characteristics of the technology itself would again create the opportunity for a further commodification and appropriation of plant material (McMichael 2000; Kloppenburg 2004). The industry insisted that GM crops were safe and that they had major social benefits, but this was met with distrust. This distrust was further aggravated by (anti)globalization and IPR issues in which corporate control and protection measures were thought to lead to injustice and the unfair distribution of appropriated natural wealth (Heffernan 1999; Pasternak 2007).

After the turn of this century, the industry started to focus on naturalness and the environment too. After years of opposition, attention has begun to shift from efficiency only to production characteristics in combination with input-saving characteristics such as resistance to abiotic stress and diseases. GM is also now regarded as an opportunity to create better variety: specialized crops for local and regional production. Now nature and economic sustainability have become conceptually linked as a moral argument used not to criticize genomics-based biotechnology but rather to stress its importance to sustainable agriculture. GM offers a solution for our problems with "nature", following the argument that being eco-friendly and sustainable is following the rules of nature (Smith 2000; Karafyllis 2003; Amman 2008). Modification is presented as the timely solution to battle the negative effects of agricultural production on the environment. GM crops would offer tangible benefits in reducing the use of resources since they would use less water and fewer chemicals and energy inputs, thus saving the environment. They would also address problems arising in relation to global warming (Lobell and Field 2007).

As the knowledge of genomics and molecular tools has progressed, alternatives to GM have appeared and are presented as "more natural." Marker Assisted Selection (MAS), as compared to GM, is neutral in respect to the problem of species' boundaries.[2] It is still based on traditional crossbreeding. It does not involve gene isolation, direct modification or the asexual insertion of genetic material. In addition, genomics also promises the possibility of tapping into new sources of germplasm to increase the gene pool of cultivars (Lee 1998).

In the organic movement, discussions are now underway about the boundaries of the organic concept of "naturalness" as the growing need for improved cultivars for organic agriculture cannot be met by current breeding schemes with the limited and flawed varieties that are available (Lammerts van Bueren et al. 2002, 2003) However, there is a need to raise production to higher levels in order to serve a growing market, and the question is how this will influence the principles of organic farming (Alroe 2008). Critics of organic agriculture point to the problem that the available varieties currently used as stock are mostly derived from conventional agriculture and were developed for a production system in which, for crop protection and growth characteristics, chemical input has taken precedence over natural resilience. Ipso facto, these varieties also stem from a breeding process that for ages effectuated chromosomal rearrangements in cultivars. This exact argument is used by Amman (2008) to say that there is a suspected ideological bias in the values of organic agriculture. Organic agriculture thus suffers from the lack of appropriate cultivars to develop a real "organic" breeding program for new cultivars that also meet the modern requirements. Under certain preconditions, organic agriculture is now considering MAS as a possible technological opportunity to enhance cultivars for production. But, this is only in an organic breeding program, only if "clean markers" are developed and only if marker screening is performed without enzymes originating from genetically modified microorganisms and without radiation. (Lammerts van Bueren et al. 2003; Verhoog et al. 2003;

[2] For a better understanding of the differences between the various techniques of genetic modification and marker assisted selection, see: Collard and MacKill (2007), Dupré (2004), van Wordragen and Dons (1992), Verhoog, (2004).

Lammerts van Bueren and Struik 2004; Verhoog 2004; Backes and Ostergard 2008). However, other issues remain. To develop the markers themselves, genetic modification is still needed. The interest of breeders and researchers working on MAS still seems to be aimed at isolated quality traits and not at the plant as a whole. (Chagné and Batley 2007; Collard and Mackill 2007) Also, MAS cannot escape from the suspicion that it is still a technology that enables a system that treats genetic data, combined with biotechnology inputs and outputs, as ordinary tradable factors under a global IPR system. (McAfee 2003).

Biotechnology is seen by some as the product of developments in a wider context in which for decades moral and ethical standards were thought less important than scientific and economic interests. Brown et al. (Browne et al. 2000) point out that there is now a considerable degree of overlap between ethical and organic, with both stemming from the growing awareness of global issues as well as concerns about the environment and social justice. When debating the new innovations in genomics and agriculture, the question must become how to balance the advantages and disadvantages of genomics in biotechnology in such a way that genomics sets a path for a mode of agriculture that is acceptable and sustainable over a longer period, a path in which technology meets public concerns about the consequences of innovation. We should avoid allowing one specific aspect of innovation (the technique) to again become isolated and judged as unnatural, thereby high jacking the whole debate. Gaskell (2001, 3), who can definitely be considered sympathetic towards biotechnology, summarizes issues connected to biotech innovation as follows: Biotechnology enters into discussions about world trade, intellectual property rights and trade, patenting of life forms, privacy and uses of genetic information, the funding of research and development, the role of science in society, public participation in science and technology, animal rights, biodiversity and environmental conservation, the future of the common agricultural policy, organic farming, agriculture in developing countries, the vertical integration of the food chain and global capitalism, consumer safety, product labeling and source identification, and the "risk-society- to name but a few." These are the issues that deserve to be discussed and put into perspective in the light of naturalness and innovation in agro-biotechnology. (Buchanan. 2000; Gaskell 2001; Goven 2006; Inglis and Bone 2006; Devos et al. 2008). We believe that these past issues remain current in contemporary debates about agricultural innovation.

In summary, in the discussions about agriculture and innovations in plant biotechnology, we have encountered different ethical concerns. We conclude that these revolve mainly around three kinds of ethical concerns about naturalness. The first questions whether humankind, given the perceived risks, should be allowed direct intervention in "natural" biological processes; the second focuses on how society can use and control the potential of an innovation that will have a significant impact on our "natural" socio-economic environment; the third relates to the mode of agriculture we imagine for the future and the permissible degree of exploitation of "nature" and "natural" resources. To reconstruct the kinds of arguments that are used to back up these three kinds of ethical concerns about naturalness we will now turn to philosophy.

Three Kinds of Arguments

Much has already been written about the concepts of “nature” and “naturalness”, ranging from romantic countryside associations and ideas of the good, pure and pristine, arcadia, to a resource for surplus use, a biological or ecological system that can be uncovered, a threat that must be mastered, a self-healing wholeness, or a gradient scale of interrelations, to name just a few. (Williams 1983; Soper 1995; Lovelock 2000; Stephens 2000; Verhoog et al. 2003; Anderson 2005; Gremmen 2005; Hansen 2006; Siipi 2008). In the discourses on agriculture we described earlier, naturalness seems to appear as one kind of argument describing the relation between technology and the effect it has on nature. In fact, however, naturalness includes references to very different themes and aspects, such as the environment, production schemes, plant-integrity, technological control, ownership, quality, etc., and not necessarily so simultaneously. On top of that, the meaning of these aspects seems to shift along with the (historical) context in which they are used.

The following example illustrates a shifting relation between nature and plant integrity. It seems hard to imagine now, but in 1910 an American corn breeder referred to inbreeding as a method for hybrid crossing as “doing violence to the nature of the plant” (Kloppenburg 2004), a statement even organic agriculture would not subscribe to nowadays. The concept of nature and our standard for naturalness shift in dimension and meaning, together with the life-world that we know and together with the changing (technological) environment we live in (Weiner 1992; Soper 1995). Nature in this is not only a concept that signifies the separation of our cultural and technological selves from the natural, but it also functions as a deontological standard (if something is unnatural, it is not right) that sets boundaries to human intervention and disruption.

There is one big problem with this standard, however. If we recognize nature as a temporal, social construction (cultural), it automatically follows that nature can no longer be regarded as an objective standard since it changes together with the way culture itself is changing over time and under the influence of our own interventions in the surrounding world. Thus, while on the one hand nature is regarded as an objective reference point for this deontological standard (naturalness), on the other hand it remains an ideal, subjective notion. Where does this leave us in respect to the validity of naturalness as an ethical argument in debates about (agro) biotechnology?

Arguments are structured by a general first proposition P (1), a specific second proposition P (2) and a conclusion C. For example: P (1) nature is x; P (2) Biotechnology is non-x; C. Biotechnology is unnatural. In an attempt to summarize the different meanings of nature found in literature throughout history, Williams presents us with three principle definitions of nature: (1) the essential quality or character of something; (2) the inherent force which directs either the world or human beings—or both; (3) the material world itself, including or not including human beings (Williams 1983). We interpret these three principle definitions as three kinds of general propositions P (1)’s in the arguments on naturalness. In line with those we are now able to reconstruct three kinds of arguments on naturalness.

The first kind of argument is linked to references made to culture, i.e., the respect of or the relation to the essential quality we recognize in entities (i) These are the arguments that have to do with the symbolic sphere of language, beliefs, metaphysics and worldviews. Crossing species' borders, for example, is deemed irresponsible, and the asexual insertion of genetic material can be seen as unnatural without needing scientific proof to support this. Direct intervention at the cell level can be seen as overstepping given natural boundaries. There is the notion that organisms are more than just the addition of molecular building blocks (Cronk 2002; Dupré 2004; Sulmasy 2006) and that the genetic makeup of organisms is determined by a given and defined order in which human interference is considered unethical and unnatural. Organic breeding/farming, for example, works from the respect for the integrity and autonomy of life forms (Lammerts van Bueren et al. 2004).

The second kind of argument is linked to references made to technology, i.e., the complex of techniques, know-how and organization that we use to manipulate, manage and exploit the (material) world, including living things (ii). Views are brought forward that technology (and capital) has taken over from the more natural production systems. There is the idea that it automatically follows from the internal logic of (bio)technology, -not its use, but its mere existence- that (bio)technology now needs to appropriate life and/or its building blocks as a requirement for its continuation. The only antidote to technology would be to reinforce natural systems. As such, genomics is seen (by some or by many) as the ultimate technological reduction of natural life, explaining it solely in terms of interactions between genes and molecules (Heffernan 1999; Cronk 2002; Desai 2005; Keller 2005).

Finally, a third kind of argument links up with references made that point to ecological arguments, i.e., biological and environmental systems governed by an inherent force (iii). When attacking the introduction of GMO's in the environment in the 1990s, safety for the environment became an important argument within the organic movement. While the industry claimed there were no scientific risks in introducing GMO's, the organic movement took a holistic approach and argued that, when looking at the risk of introducing alien material, the whole system is involved and not only the likelihood of immediate danger in a specific area caused by the introduction of the one specific –modified- plant; therefore, the issue was too complex and difficult to evaluate. "We don't know the risk." (Verhoog 2004). The naturalness of the plant refers here to inherent nature, wholeness, completeness, species-specific characteristics and being in balance with the environment, all through evolutionary adaptation. Natural boundaries are thus to be respected in order not to throw the whole system off balance. With regard to genomics, Greenpeace now advocates support for MAS since the technique makes use of the "natural systems" that were established and refined by the mechanisms of evolution (Vogel 2009). Clearly, the use and exploitation of those evolutionary mechanisms are seen as less disturbing and invasive than the attempt to change them by direct modification. Opposed to this, there is the notion that biotechnology can help to improve and reinforce the same existing natural systems through alteration and intervention (Ammann 2008; Potrykus 2009). In this view, genetically modified plants are beneficial to the environment since there is the promise of plants and crops that are more resilient, require less external input such as pesticides, fertilizers, water, and soil and therefore put less strain on environmental resources and systems.

In his attempt to summarize the different meanings of nature Williams also remarks that nature is perhaps the most complex word in our language. We believe that this complexity lies in the fact that these three definitions are actually three aspects of nature that are always more or less present. The essential quality of something is included in the inherent force and is part of its material existence. Consequently, a change in materiality will cause changes in the other two aspects as well. In practical terms, the essential quality of a plant that grows in the wild changes when we start cultivating it for a certain purpose. The wild plant, for example, becomes a cultivar dependent on human input for growth. It becomes a commodity and stands in a different (domesticated) relation to the environment. Our conclusion is that the three kinds of arguments are interrelated because they represent the three aspects of nature as a complex concept. This means that the arguments are not isolated but that a change in one of them could mean a change in the others as well. How can we develop an integrative view on these interrelated arguments on naturalness?

An Integrated Approach on Naturalness

How do these three kinds of integrated principle definitions of Williams, which we consider to be three general propositions in arguments on naturalness, match with the three kinds of ethical concerns we have identified in the above discussions? The ethical concern about whether humankind, given the perceived risks, should be allowed direct intervention in "natura" biological processes matches with the principle definitions of culture and ecology; the second ethical concern, in how far society can use and control the potential of an innovation that will have a significant impact on our "natural" socio-economic environment, matches with the principle definitions of culture and environment; the third ethical concern relates to the mode of agriculture we imagine for the future and the permissible degree of exploitation of "nature" and "natural" resources and matches with the principle definitions of technology and ecology.

How do we interpret the links between the ethical concerns and the arguments? Much can be won by interpreting the links between the three kinds of arguments as gradients of naturalness in the way that Siipi proposes. Siipi presents us with sets of comparative relations that form gradient scales of naturalness that express whether one thing is considered more natural than another. We have grouped the criteria Siipi proposes as follows: (a) subjected to more or less human interference/disruption; (b) more or less fitting images of normality and biological/genetic-based action; (c) being more or less in accordance with human nature/purpose (Siipi 2008).

The first gradient we distinguish, the amount of disruption humans cause through interference (a), can be seen in the relation between the ecological and technological arguments. The use of chemical inputs balanced against resistant diseases and/or pollution, bumper crops related to biodiversity/resilience and a relation between crop quality and quantity seem directed towards perceived (or expected) natural balances or boundaries that follow from a logic that connects technological exploitation with images of how the ecological complex works (Rifkin 1998; Lovelock 2000). Genomics-based biotechnology is also portrayed as an opportunity to battle the negative effects of conventional agriculture that we saw following the green revolution. Innovation and rationalization form the input that we need, not to negatively exploit natural resources but to develop sustainable, non-exploitative agriculture. (Ammann 2008; Potrykus 2009) Too much emphasis on one of the poles in this relationship, ecology or technology, will raise the concern that agricultural production is threatened either by insufficient yield or by environmental degradation. This is related to one of the three ethical concerns we mentioned above, the permissible degree of the exploitation of nature and natural resources affecting "our sense of a 'natural' balance between exploitation and caretaking" (Rifkin 1998; Levidow 2000; McKibben 2005).

The second gradient (b) (more or less fitting images of normality and biological/genetic-based action) we find in the interaction between the cultural and ecological arguments. Nisbet (2005) describes how developments in genetics initially received favorable media coverage until in the 1990s the media debate about cloning started to focus on ethical issues and brought about a sudden controversy. The idea of cloning was upsetting strong convictions about natural order and spirituality. Suddenly, it was felt that biotechnology was tantamount to playing God. Humankind, it was argued, should not cross this line because this would fundamentally change the relationship between humankind and the rest of nature (Hallman 2000). The naturalness of the plant refers here to inherent nature, wholeness, completeness, species-specific characteristics and being in balance with the environment, all through evolutionary adaptation. The intervention by introducing artificially created life forms is thought to interfere with or infringe upon natural schemes and to create an unbalance that has negative consequences (Levidow 2000). Natural boundaries between species should be respected. As proponents of biotechnology see a world of opportunity and benefits, the argument of naturalness expresses the reluctance of people to allow science in this domain because they cannot comprehend the extent to which it could lead to changes that upset our lives and society. This fundamental change is something we already see in the strongest Western myth that deals with upsetting this relationship, the book of Genesis, in which eating from the forbidden tree of knowledge not only sets the path for self-determination and development—the snake's promise that man will become as powerful as God— but, more importantly, also removes humankind from Paradise, where it had lived in perfect harmony with nature, thereby subjecting the human race to chaos, violence, disaster and unhappiness. A similar contemporary image of existential transition and its consequences was presented by Fukuyama (2003), who said that the knowledge of genomics opens the door to altering ourselves and our society beyond recognition. Too much emphasis on one of the aspects in this relationship, culture or ecology will create the concern that we will endanger our existence by either destroying the environment or losing our cultural rooting and ability to change. This refers to the second ethical concern: whether humankind, given the means, should be allowed direct intervention in given biological processes thereby affecting "our sense of the 'natural' order of things" (Soper 1995; Lovelock 2000; Baird Callicot 2001; Eden 2001; Lammerts van Bueren et al. 2002).

The third gradient (c) (more or less in accordance with human nature/purpose) that comes forward is found in the interaction between the technological and cultural aspects. Critics argue that genomics in agro-biotechnology is simply the latest incremental intensification of agricultural production created by an exploitative industrial system that has steadily built up momentum over many decades. They question the integrity of commercial actors and their role in influencing the trajectory of the agricultural system. The notion that new technologies mostly benefit the techno-industrial complex that is already so ill-regarded returns with regularity. It is affecting trust in the morality and objectives of actors in biotechnological innovation. This idea seems to be underpinned by several surveys and studies. Consumers seem to have become more cynical of technological innovation, especially when they already have wider concerns about its impact, because they have started to believe that such innovation only serves the interests of the producers and manufacturers (Frewer et al. 2003). Tait sees the underlying problem that caused so much resistance against GMO's as "the Faustian bargain we have made, putting science, technology and the industries that control them in charge of world food production systems […] that lack democratic control"(Tait 2001). There is a need for proper representation in the social institutions that have control over the benefits of genomics technology to assure that a fair distribution remains more than just a well-meant intention (Buchanan et al. 2000) And there is severe doubt about whether in the globalizing world the gen-tech developments could contribute to food security in developing countries. IPR-related issues could hamper rather than foster the downstream development of biotechnology. For biotechnology to contribute to food security, "the conflicts between breeder rights, farmer's privilege, biotechnology patents and the genomics data base, will need to be resolved first" (Desai 2005). A system that treats genetic data, combined with biotechnology inputs and outputs, as ordinary tradable factors under a global IPR system leaves the distribution of its benefits to the market forces. This would be in stark contrast to the image of biotechnology presented as an innovation benefiting the poor farmers and the hungry (McAfee 2003). Neither life nor its building blocks should be appropriated by private enterprise because they belong to the commons (Hardt and Negri 2009). Too much emphasis on one of the poles here will steer the concern that the well-being of society in general is threatened by either a lack of redistribution of wealth or a lack of incentive for economic growth. This relates to the third ethical concern: decision-making, control and ownership of a new technology that can have a significant impact on our life and society, affecting "our 'natural' sense of fair ownership and distribution of wealth" (Dyson and Harris 1994; Murphy 2007; Hardt and Negri 2009).

Conclusion: Towards a New Approach

In the debate about GM that landed in a stalemate, nature and naturalness were in opposition to other core categories such as culture, human disruption, technology, management and so on. These oppositions are problematic because they leave little space for negotiation: something simply is or is not natural. In the tool we propose, we see that three aspects appear in concurrence, which takes away the antagonism caused by a dualistic view. In analogy with Williams, we regard technology (exploiting and working the world), culture (attributing quality) and ecology (understanding and using the system—inherent force) as the most important aspects in relation to agriculture. Other than Williams, however, we conclude that all three of these aspects are always present and that they affect each other when changes take place. The essential quality *is* included in the existence of the material world as is the force that controls its existence. This inherent force *is* logically also included in the material existence since it must be in the essential quality of something. Likewise, for Siipi's relational gradients of naturalness, the degree to which something is humanly affected will affect the degree to which it serves human purpose and how it is attributed normality or remains biological in action. In summary, biological origin and normality are attributes derived from both cultural values and examples from ecology as we know it, representing the order of things as it should be. Serving human purpose is related to both what we find culturally relevant to consume/produce and how it is allocated for use, representing the sense we have for fair ownership and distribution. Finally, the degree of interference/ disturbance is related to our technological intervention and the degree to which this affects our environment, represented in the sense we have to balance exploiting the environment and taking care of it. The approach we propose intends to replace nature and naturalness as references to one specific and static binary with a triangulated relation that integrates the multiple aspects of nature. The different meanings of naturalness are then joined to a changing relation between nature and naturalness themselves. This provides an approach that can enable stakeholders to arrive at a standard for naturalness that is dynamic, doing justice to basic ethical concerns.

Scientists and policymakers are increasingly convinced that technological innovations need to be accompanied by a dialogue between science and society that is true to the context and content of the developments. It is thereby important not to ignore the results of previous dialogues and consultations and to come to an integrative approach (Goven 2006). What we thus propose is to separate these different forms and put them in a relational gradient with each other. In our approach, naturalness is then defined as an appropriate balance between them. This balance in turn sets a dynamic standard for a new ethical approach. The interaction between the cultural, ecological, and technological aspects forms an alternating relationship in which three basic concerns express the expected negative consequences of an overrepresentation of one of those aspects in new technologies, i.e., innovations in agriculture.

We conclude that these dialogues are not only limited to the advantages and disadvantages of just one specific innovation but that this innovation must be placed in the context of the historical developments in agriculture. They have to include the core ethical concerns that result from the articulation of cultural, ecological and technological values and principles. Naturalness will become a final argument when innovation is only evaluated in isolation, when debate only functions to divide new techniques into natural and unnatural ones. Most of the different meanings and associations of naturalness we have come across in debate come up in similar forms and in every discourse about biotechnology in agriculture. But they do appear in different contexts and timeframes and they are used to underpin different opinions. However, when we allow ourselves to see how the different aspects of naturalness work in concurrence and in relation to the collection of arguments given, it could become possible to compare them in an integrative way that does justice to temporality as well as to the more structural concerns that live behind the question of what the consequences would be when we allow ourselves to go across boundaries that we now consider to be determined by nature?

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