Chapter 2
The Presumptive Case for Nanotechnology[1]

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2.1 Introduction

The United States 21st Century Nanotechnology R&D Act of 2003 simultaneously directs Federal agencies to undertake research and planning activities that will promote the development of nanoscale science and technology, while also mandating consideration of Societal and Ethical Implications of Nanotechnology (SEIN). The case for nanotechnology is implicit in the first component of this directive, and it is simple and direct. The tools and science we call nanotechnology can be employed to increase economic productivity, reduce negative environmental impacts, and to insure and improve human health. The record of products already on the market is mixed: nanoparticles in sunscreens may pose risks that have escaped the scrutiny of regulatory oversight, and who really cares about "nanopants" in any case? At the same time, less publicly visible nanotechnologies have been utilized in catalysis and packaging for many years with a record of solid (if unspectacular) success. A strong defense of nanotechnology's ability to deliver on broader criteria of social benefit has been mounted elsewhere. David Berube's book *Nanohype* documents a plethora of government and business prognostications that have been produced to promote the possibilities of nanotechnology (Berube, 2006). Products currently under development and promised to do wonderful things, and there are undoubtedly many more applications that are as yet undeveloped, unresearched and even unimagined.

On the other hand, Berube also documents a number of cautionary studies that indicate the need to study social and ethical issues in nanotechnology. The rationale for these studies often cites public opposition to so-called GMOs (genetically modified organisms) or to nuclear power. Berube's analysis suggests that the basis of this opposition lies in a generalized disenchantment with technology and modern life. When mobilized by media coverage and by the feeling that public interests have been neglected in key decision making processes, this disenchantment spawns

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resentment, public demonstrations and organized opposition in the form of publicity campaigns, lawsuits and regulatory activism (Berube, 2006). In the case of GMOs, public outrage has coalesced into a global social movement dedicated to blocking the application of biotechnologies in all but the most compelling biomedical applications (Gaskell and Bauer, 2002).

Should SEIN studies adopt the optimism of nanohype? Or should they proceed from philosophical premises that question the value or legitimacy of technology outright? This essay argues that the former approach is more defensible than the latter, but also that taking this perspective leads naturally to an ethical analysis focused largely on possible problems with nanotechnology. The possibility of producing desirable and beneficial environmental outcomes and improvements in human (and animal) well-being provides the basis of an argument for developing and deploying specific products of nanotechnology. That such beneficial products exist or can be conceived is a reason for developing the tools and techniques of nanoscience, but we should not regard such reasons as a sufficient rationale nanotechnology. Indeed, I will argue that the true philosophical significance of these examples and projected benefits lies in the framing for a more detailed discussion of nanotechnology, which should focus on the question, "Why not?"

2.2 The Logic of the Presumptive Case

To say that there is a presumptive case in favor of nanotechnology means that the burden of proof falls on the side of providing reasons to restrict, control, limit, regulate, or moderate the use of the technology, rather than the reverse. It is a "soft" argument in that it proffers reasons that buffer and support a favorable view of nanoscience innovations, and it is not specifically focused on enhancement. Philosophical, rhetorical, methodological and practical reasons conspire in forming the presumptive case. It is intended to establish a framework for ethical evaluations, and for burdens of proof, rather than a knockdown argument favoring any and all applications of nanotechnology. While none of the reasons adduced in developing the presumptive case provide a singularly adequate argument, the fact that each is made on independent grounds means that they are additively persuasive for the purposes of establishing further burdens of proof.

Why establish the burden of proof in terms that favor nanotechnology? Logic permits only three options here. In addition to the presumption for nanotechnology, there is its opposite—a presumption against it that demands argument to justify its pursuit—and a third choice that demands case by case evaluation for every proposed use of technology. While this third choice may seem appealing at first blush, it becomes surprisingly difficult to apply in practice. Putatively neutral case-by-case evaluation of technology (like any proposal for case-by-case evaluation of alternatives) actually imposes intolerable costs on our decision making. There is no area of life in which we weigh every possible option on a case-by-case basis, and we would clearly spend all our time weighing and deliberating if we did. Instead

we rely on "filters" to determine which cases demand more careful scrutiny and deliberation. Such filters often take the form of biases that implicitly structure the burdens of proof that we impose on others and ourselves. Although we can certainly review and rethink when faced with any given case, the idea that we will thoroughly consider every possibility is not really a viable one. The question can thus be limited to two cases: should our cognitive filters be set for or against technology?

An argument intended to reset the filters of the people that Berube describes as being resolutely opposed to modern technology would have a different shape from the one that I will develop in this essay, where I will not discuss Heidegger or disenchantment with processes of modernization or global change. Nevertheless, it is useful for everyone to admit that bias exists, that it is not all bad, and that having one's cognitive filters set in a particular direction does establish an ethical responsibility to test one's bias from time to time. Having a bias in this sense means that we are predisposed to regard situations and proposals in a given way. People tend to assume that unless some contradictory evidence is presented, or unless reasons for thinking otherwise are apparent, a habitual practice or a standard operating procedure (SOP) is adequate. Being predisposed this way does not mean that there are no considerations that can overturn our inclinations, but it does mean that our evaluation of situations and proposals has an implicit logical structure: *unless* there is evidence or reason to behave differently, we are inclined to act in the manner in which we are predisposed. Acting ethically then requires that we give due consideration to the evidence and reasons that could contravene our inclinations.

A broad set of philosophical considerations in support of a presumption favoring any new technology can be derived from the confluence of utilitarian and libertarian philosophy, as discussed at some length in my book *Food Biotechnology in Ethical Perspective* (Thompson, 2007). A succinct summary of that rationale goes as follows. If we are inclined to favor human freedom on libertarian grounds, we should allow technology developers to exercise their freedom to develop technology. The history of technologies that have increased the efficiency of our ability get things we want in exchange for a given expenditure of resources and effort suggests that the utilitarian maxim to promote the greatest good for the greatest number would also support technological innovation. Both libertarian and utilitarian rationales come with qualifications and possible concerns but nonetheless, this confluence of rationales means that we begin with a broad philosophical mandate for viewing technological innovation favorably.

Critics such as Jeffrey Burkhardt (2001) and Robert Zimdahl (2006) have argued that current scientific culture disinclines bench researchers from undertaking the reflective evaluation needed for new technology to realize its promise. They suggest that scientists are unlikely to be very attentive to qualifications and possible concerns. But the broad mandate we derive from utilitarian and libertarian philosophy can be further strengthened with respect to nanotechnology because the uncritical cognitive filters within science are to a considerable degree counteracted by social and governmental filters (that is, institutions) that weed out a lot of bad ideas without our having to pay much attention to them. A scientist who has a "great idea" for nano-encapsulated rutabaga-flavored chewing gum except for that unfortunate

side-effect (people who chew it break out in an uncomfortable rash) will not get far in the real world of food technology. The mere fact that most products won't be developed unless there is a chance of making money from them weeds out lots of bad ideas, though unfortunately, as has been the case with GMOs, some good ones as well (see Thompson, 2007). The market is a filter. Environmental protection and food safety agencies within government provide additional filters. The threat of a liability lawsuit may be the ultimate filter for many individuals and firms that contemplate introducing new technology. An awful lot of the bad ideas in nanotechnology will be eliminated from consideration whether working scientists *or* ordinary citizens adopt an ethical predisposition against food biotechnology, or not. These economic, regulatory and tort-based legal filters are a part of the SOP for new technologies. Of course it is possible that these institutions have gone awry, so noting them is *not* to say that they are working perfectly. Nevertheless, the belief that our society is institutionally oriented to the promotion of certain technologies rather than others must be tempered by the recognition that any technology faces a significant set of hurdles as a matter of course.

Thus, the weak presumptive case from political philosophy is strengthened by economic and legal institutions that govern nanotechnology, but there is more. Given the range of potential beneficial applications for nanotechnology, one would expect that many cases will be presented for our consideration. Given the economic and regulatory filters that are already in play, many applications will never see the light of day as practical technologies. It is thus reasonable to expect that applications of nanotechnology able to work their way through the economic and legal filters described above will be favorable more frequently than they are unfavorable. There is thus a purely *methodological* reason to adopt a presumptive view favoring nanotechnology: our cognitive filters should be on the alert for bad outcomes and products, rather than the reverse. It is thus entirely appropriate that philosophers spend most of their time worrying about how nanotechnology can go wrong. This reasoning may sound contrary to technology boosters and latter-day Luddites alike. If they are *for* nanotechnology, why are philosophers spending all this time on problems? Or contrarily, if we are concerned about problems, why do we adopt an outlook presuming that nanotechnology will be good? The answers to these two questions (like the questions themselves) may seem to run at cross purposes.

Conducting a due and careful ethical evaluation of any given technological product or group of technological methods requires weighing the good and the bad, as all proponents and opponents of the technology must admit. A truly *neutral* view of technologies, I have argued, is a seductive illusion. If we presume *against*, we demand that advocates *for* overcome our bias by presenting arguments in favor of a specific application. What we would get is an endless, repetitious and ultimately numbing recital of benefits, much on the order of those recited in David Berube's summary of nanohype. It is thus *methodologically* much more effective to simply assume that there will be benefits from those products or applications that work their way through institutional filters, and then to give due consideration and review to the possible problems or objections. Proponents of technology spend a lot of time in the public arena extolling its benefits and combating its critics. It is thus,

perhaps, natural for them to see philosophers who proposes to discuss ethical problems with nanotechnology as an ally of the critics, so it is reasonable and appropriate for philosophers to begin the discussion by not only taking the likelihood of benefits as a methodological starting point, but also by making an explicit and detailed statement of the way that likely benefits provide a presumptive bias for favoring nanotechnology. This is, of course, what this essay is all about.

An answer to the neo-Luddites (I am using the term affectionately) also notes that review of negatives is logically and conceptually more effective when done against the background of presumed benefits. To readers skeptical of nanotechnology, I also repeat again that an argument engaging the extensive philosophical and social criticism of technology that has taken place over the last 200 years would have a very different structure and approach than the presumptive case for nanotechnology. Nevertheless, while expressing some sympathy for the line of criticism that has produced sophisticated critiques of technology such as those by Albert Borgmann (1983, 1999) or Andrew Feenberg (1991, 1999), I must insist that the methodological reasons for developing an ethical review of any particular technological domain by taking the likely beneficial outcomes of developing that domain for granted are sound. Indeed, the work of Borgmann and Feenberg points us toward a hard look at specific tools and techniques, and that look will be more focused and penetrating if we concentrate on those applications where we think there may be trouble.

Finally, it is a social fact that a strong presumptive case in favor of technology still exists within industrialized and industrializing economies. Late twentieth century culture is organized such that people expect change, and even if they do not expect it to be as uniformly beneficial as they once did, the traditional, static social structures, with their rigid social hierarchies and their lack of social mobility, are a thing of the distant past. This social fact may imply that most individuals in late twentieth century society are inclined to favor technological change, but even if it does not, it shows that establishing a moral presumptive case *against* any broad form of technology will be very costly. It will be the life's work many dedicated people, and they will have to be very persuasive. Furthermore, it will compete with other large social issues such as opposition to racism and gender bias, as well as environmentalism and world peace. As such, the case *against* nanotechnology needs to be pretty compelling to justify a social movement to reverse the *status quo*. If the case against this new technology is, in other respects, a close call (and the list of potential benefits from nanotechnology already cited is a reason to think that it is), the sheer costliness of campaigning against it tips the deck in its favor. Elsewhere I have argued that the campaign against agricultural biotechnology has been too costly for environmentalists and supporters of social justice (Thompson, 2003a). The people who have dedicated themselves to opposing agricultural biotechnology would have better expended their time and energy on more pressing issues in the food system. This, however, is not the place to pursue that theme.

One would expect that nanotechnology's boosters will be pleased with this starting point, but the logic of the presumptive case for nanotechnology does have implications that are the frequent subject of complaint from that quarter.

Both boosters and more neutral or objective scientists have been heard to complain that talk of "ethics" is too frequently critical. Why is there not an ethical argument for technology, they say? Well, they have a point, of course, and one purpose of this chapter is to acknowledge it. Yet the point bears repeating: if one presumes in favor of biotechnology, then most of work in conducting an ethical analysis will consist in entertaining the objections to that premise. This means that most of what one says on the ethics of nanotechnology is a review of reasons to oppose, qualify or constrain the technology. Ironically, it is the strong presumptive case for nanotechnology that will lead ethicists to concentrate their first round of analysis on negatives, on reasons to resist and oppose. In many instances, the presumption for technology survives attack unscathed. In a few cases, it must be modified or constrained. The best case for nanotechnology is the one that takes the reasons against it most seriously. That is the thesis of the presumptive case.

2.3 Making the Case for Nanotechnology Badly

Unfortunately, many of the attempts to recite a case *for* biotechnology and GMOs were unconvincing even to mildly critical ears. Sometimes the problem is simply a lack of sophistication or a poor choice of words. During the first half of the 1980s, scientists, venture capitalists and university fund-raisers became highly practiced at making the case for both food and medical biotechnology in economic terms. They convinced funding agencies, administrators, state governments and private investors to place large sums of money at their disposal on promises of impressive financial returns and great wealth for all (Teitelman, 1989). Some of the ethical fallout from those promises is discussed in my book (Thompson, 2007), but what is significant here is that biotechnology's boosters became habituated to making their case in terms of economic gain. Biotechnology was good because it was going to make everyone (or everyone who got on board soon enough) very rich. Needless to say, this is not a compelling ethical argument for biotechnology *or* nanotechnology. Although the importance of economic returns and benefits should not be underestimated in ethical assessments, too much of the "case for biotechnology" consisted only in economic boosterism and whining about the negativism of the critics.

Biotechnology's boosters did even more serious damage to their own case by offering several singularly bad arguments. The balance of this chapter will take on four bad arguments that seem to have many proponents among the scientists and decision makers who were involved in the development of GMOs. They are presented here as object lessons for how *not* to argue for nanotechnology, as well as to dissociate such fallacious reasoning from the presumptive case that I have outlined above. The first of these appeals to an outdated and naive notion of technological progress, and will be called the Modernist Fallacy. The second fallacy assumed an inappropriate reference group for making comparisons about the relative risks of genetic engineering, and the error will be equally tempting for boosters of nanotechnology. It is a version of the Naturalistic Fallacy, the common moral

mistake of claiming that because something is natural, it is therefore good. The third fallacy also addresses risks of technology and is an instance of the Argument from Ignorance. The final argument emphasizing world hunger may have been more particular to GMOs than to many of the applications foreseen for nanoscience, yet it is worth considering as an example of how even legitimate benefits from technology can be overplayed by advocates.

The first three bad arguments are examples of fallacious reasoning that one hears repeatedly at scientific meetings, both from the podium and over coffee. Anyone who has been present at such meetings has heard them, and it serves no positive purpose to single out any particular individual for attribution. Casual conversation is not a propitious setting for the production of an informed and rigorous ethical argument; however it is quite likely that most of the people offering these arguments actually believe that what they are saying is establishing an important point about the ethics of food biotechnology. The following criticisms are offered in the spirit of improving the quality of debate, rather than embarrassing individuals who may hold these views.

2.4 The Modernist Fallacy

One easy way to dismiss any and all ethical concerns that might be raised about virtually anything is the reply "That's progress." Advocates of nanotechnology have not resisted the temptation to deploy this reasoning, if it can actually be called reasoning by any decent standard. The universal applicability of this strategy is a good reason for giving it a harder look. Other similarly universal replies to criticism ("That's politics" or "That's life.") signal one's reluctance to discuss the matter further without also conveying one's moral approval of the state of affairs. "That's progress" implies that whatever ethical concerns or consequences have just been brought forward, they are the price that must be paid for progressive social change.

Now, it may be correct to conclude that some social, animal, environmental or even human costs are a price that must be paid for ethically compelling reasons. If so, it is important to state those reasons and to justify the need to accept certain costs in order to achieve them. If a new rice or potato variety really does end hunger in a region of resource poor farmers that result may indeed be worth some loss of local cultural institutions. If nanosensors for detecting pathogens decrease the risk of food or airborne disease significantly, it may indeed justify changes in the configuration of meatpacking or other inspection procedures that costs some jobs. There may also be ways to mitigate some of these costs, so the matter does not end here. Nevertheless, there *are* circumstances where it is appropriate to rebut an ethical critique by pointing out the compelling reasons for accepting certain costs in exchange for progress on other fronts.

The Modernist Fallacy consists in presuming that science, technology, capitalism, or maybe just history is inherently progressive, so that any change brought about by these forces is always good. Alternatively, one may believe that any resistance

to science, technology, etc., is a form of traditionalism or irrationalism that must be overcome. A strong and often justified faith in the power of science to alleviate harms, encourage democracy and promote social justice characterized the period in philosophy and economic history that is now known as Modernism. It had a good run, beginning with the philosophical writings of Francis Bacon and René Descartes, and becoming socially effective during the industrial revolution. During this period, the open and skeptical pattern of scientific inquiry was indeed both a force and a model for the democratization of hierarchical societies, and the technologies of the industrial revolution led to the expansion of European civilization across the expanse of the globe.

People will be debating whether Modernism was a good thing for some time to come. Certainly it was less good from the perspective of conquered peoples than it seemed to Europeans who wrote much of the history for the period, but perhaps it is too much to lay the blame for colonial oppression at the feet of science and technology. The point here is that surely no one can take such an attitude of unalloyed optimism toward science and technology today. If the scientific and technological achievements of the last five centuries are *on balance* good, they can still be made much better by attending to environmental consequences, human health consequences, and social consequences that are the unintended accompaniment of science-based technical change. While only a few intellectuals challenged the philosophical basis for modernism until recently, much of the twentieth century consisted in discovering the health and environmental consequences of the old smokestack industries and of chemical technologies. These discoveries were accompanied by social movements and intellectual developments that undercut the supreme self-confidence of European culture, the culture in which the scientific attitude was historically grounded (Harvey, 1989; Beck, 1992). While science and the scientific attitude are capable of thriving without the social and cultural background of European expansion and colonialism, it is not surprising that scientific and technological achievements of the past have been tarred by some of the less savory aspects of the social and intellectual milieu from which they emerged.

The modernist fallacy was particularly relevant to the GMO debate because many critics of biotechnology made rejection of modernist philosophy an important component of their argument. Jeremy Rifkin includes a popularized diatribe against Bacon and Descartes in his books *Algeny* (1983) and *Declaration of a Heretic* (1985), as does Andrew Kimbrell in *The Human Body Shop* (1993). More scholarly versions of the same argument can be found in Mies (1993), Shiva (1993), and McNally and Wheale (1995). The argument is echoed in the more biologically oriented critique of Mae Wan Ho (2000). Finn Bowring (2003) has produced book-length version of it that interprets developments in medical and agricultural biotechnology as part of a grand pattern in the history of science. It is not unreasonable to anticipate that similar claims will be raised in connection with nanotechnology. While I do not claim that the "presumptive case" being made here is an adequate reply to this anti-modern literature, either, to reply to such criticisms with "That's progress" is to beg the question, to commit the logical fallacy of assuming precisely the point that needs to be proven.

The late twentieth century *may* have been a period of overreaction, and biotechnology may have fallen victim to an obsessive fear of science and technology. Yet even if one believes that, an advocate for nanotechnology should not blithely maintain the sort of faith in the progressive nature of science and technology that would permit one to simply dismiss concerns about unwanted consequences without giving them their due. The presumptive case given above is thus about as far as one can go without beginning to take some specifics of critical argument on board. A less critical faith in progress is indeed blind faith, and the sort of faith that has been the enemy of science in the past. How ironic that some scientists become the least scientific in their willingness to dismiss concerns and objections to technology! The Modernist Fallacy is a truly bad argument, and one that should be expunged from even coffee table conversation.

2.5 The Naturalistic Fallacy

Philosopher G.E. Moore described the Naturalistic Fallacy in *Principia Ethica* (1903). It has since entered the philosophical lexicon as the logical mistake of concluding that something is good merely from the fact that it exists, that it is part of nature, of SOP or the *status quo*. The fallacy is likely to be committed by certain types of conservatives as well as by those who detest change. It is given a religious backing by those who believe that the world as it is embodies God's design, but scientists are capable of the Naturalistic Fallacy, too. The instances of the Naturalistic Fallacy that occurred in debates over biotechnology are subtle and a defensible argument could have been made by exerting a little more care and precision of language. They involved making comparisons between natural phenomena and the behavior of transgenic organisms. Such comparisons are not in themselves problematic, but if the point of the comparison is to argue that the behavior of transgenic organisms is unproblematic or in some sense "acceptable," because the behavior of non-transgenic (or natural) organisms is similar, then the natural phenomena are being invested with normative significance. Such arguments often involve claims about risk, and it is very reasonable to expect that a similar pattern of thinking and speaking may be applied to risks from nanotechnology. Here are two arguments that exemplify the problem.

1. The kind of alterations that molecular biologists are making in plants and animals just like those that occur as a result of natural mutation. They are, therefore, an acceptable risk.
2. Modern biotechnology is just like plant or animal breeding. Since the risks of plant and animal breeding have been acceptable, the risks of biotechnology are acceptable.

The first version seems to state that because risks of biotechnology are consistent with risks from natural mutation, they are ethically acceptable. The second version states that because they are consistent with historical risks of plant and animal

breeding, they are acceptable. Analogs in nanotechnology might state that: because some nanoparticles exist in nature, risks associated with nanoparticles are acceptable; or that the similarity between nanotechnology and prior chemical or material technologies entails that the risks of nanotechnology are acceptable.

The first argument is a clear instance of the Naturalistic Fallacy. Moore's discussion has given this logical mistake its name (though his analysis was both more subtle and more philosophically ambitious than the account given here), but John Stuart Mill called attention to this logical mistake some years before Moore. Mill's essay *Nature* noted that we can derive nothing of ethical significance by comparing intentional actions performed by human beings to acts of nature. "In sober truth," he wrote, "nearly all the things which men are hanged or imprisoned for doing to one another are nature's everyday performances," (1873, p. 426). The mere fact that humans must live with the risks of mutation tells us nothing about whether it is ethically acceptable for some to act in such a way as to intentionally bring about such risks. The second instance at least compares like and like. Plant and animal breeding are intentional actions. However, it is not clear that society at large has ever undertaken an informed debate on whether these risks are acceptable, either. Indeed, stories of mistakes in planned introductions—Chinese carp and killer bees—are a commonplace theme in literature that raises concern about the environmental risks of genetic engineering for plants and animals. More informed critics note that plant and animal breeding are often associated with increases in fertilizer or pesticide, creating risk through an indirect mechanism. It is likely that any well-publicized change in food and agricultural technology like biotechnology would have brought on a new debate over risk. German theorist Ulrich Beck has argued that many social issues once debated in terms of class conflict are now debated as issues of risk (Beck, 1992). Given the dramatic changes in technology and social organization that have occurred since World War II, simply assuming that historical trends on risk levels provide evidence for contemporary criteria of risk acceptability is unwarranted.

It is possible that what people who offer arguments like (1) and (2) above were trying to say is that the probability of harm from GMOs is quite low. This is not an ethical claim. It is an attempt to infer the probability of harm from biotechnology by analogy to a distinct but relevantly similar sample population for which experience provides good (if not statistically quantified) information about the probability of harmful environmental or food safety consequences. There is nothing fallacious in this general pattern of inference, though inference by analogy can be tricky when examined case by case. Some of the philosophical problems that have arisen in plant scientists' attempts to use this pattern of inference are discussed in Thompson (2003b). If one is careful in stating the point, however, there can be no objection to using such analogies in estimating risks. But low probability is not *in itself* enough to prove that a risk is acceptable. When consequences are sufficiently high, when risks are unnecessary, or when people are needlessly prevented from participating in a decision process, even very low probability risks can be socially unacceptable.

2.6 The Argument from Ignorance

Philosopher Kristin Shrader-Frechette is well known for her studies of faulty arguments used in developing the case for nuclear power, for geological disposal of nuclear waste, and for radiation technology in general. She notes that a persistent and disturbing fallacy in that literature that "occurs when one assumes that because one does not know of a way for repository failure or radionuclide migration to occur, none will occur. Such inferences are examples of the appeal to ignorance" (Shrader-Frechette, 1991, p. 105). Technical disparities between radiation issues and risks of nanotechnology notwithstanding, virtually anyone with knowledge of the arguments that boosters of biotechnology brought forward (especially in informal settings) will find the pattern of conduct disturbing enough to warrant a caution for SEIN. Because people cannot imagine how bad things can happen, they infer that bad things cannot happen.

Another and more dishonorable version of the fallacy occurs when boosters of technology reported that there is "no evidence of harm (or risk)" associated with early uses when in fact there is no evidence of any kind because no one has bothered to look. Some types of harm would also be very difficult to detect, so the fact that none have been reported needs to be placed in proper context. Failing to do this is apt to be misleading. The fact that the argument from ignorance can be used to mislead links its use to the public's lack of receptivity toward GMOs. Here is how that link gets made: replete with assurances about the safety of chemical technology and nuclear power, boosters of those technologies forged ahead. Many of their beliefs about the probability of an accident may have been well founded, but the public has become suspicious of such assurances in the wake of accidents at Bhopal at Chernobyl. While biotechnology and nanotechnology may differ from chemical and nuclear technology in many ways, the conduct of the science community is, from an outsider's perspective, distressingly similar. The appeal to ignorance has failed before; perhaps it will fail again.

As in the Naturalistic Fallacy, there are valid inferences that can be drawn from the fact that one cannot imagine how a harmful consequence could materialize. Risk assessment is a process that begins with a systematic attempt to imagine the scenarios and mechanisms that can end in harm. It is inevitable that the scenario no one thinks of will be omitted from the estimate of risk that such exercises produce. Nevertheless, when scientists work diligently to anticipate the full complement of risk, it is reasonable to conclude that unanticipated scenarios are either unlikely or at least not a proper basis on which to reject the technology as a matter of public policy. When researchers have diligently looked for evidence of environmental or health impact it is unreasonable to neglect that work in public decision making. It is not reasonable to think (and no judicious scientist would claim) that the unanticipated scenario does not exist, though this is what the appeal to ignorance effectively does claim. Complacency arises easily when appeals to ignorance go unchallenged, and complacency can result in the exercise of risk analysis being

pursued less diligently than it should be. If biotechnology is to be pursued in an ethical manner, the appeal to ignorance must be expunged from both daily practice and the public defense of biotechnology.

2.7 The Argument from Hunger

While modernist, naturalist and ignorance fallacies circulate over coffee whenever scientists congregate, a more complex and insidious bad argument for biotechnology became firmly entrenched in public discourse. This is the claim that GMOs are the solution to world hunger, generally accompanied by the claim that those who oppose them are themselves ethically irresponsible in virtue of the misery from disease and starvation that their opposition is alleged to cause. While this argument is, perhaps, tangential to nanotechnology, it is worth reviewing as a case study in how debates over science can go sour.

There has always been some hope among agricultural scientists that rDNA techniques would be useful in developing new crop varieties for the developing world. This hope started to emerge as an explicitly developed argument for biotechnology as developed country GMOs began to encounter serious opposition in the 1990s. Advocates of biotechnology began to look for a "poster child": a biotechnology that was so appealing it could be used to silence the critics. The one that eventually achieved public notoriety was Ingo Potrykus's "Golden Rice," the vitamin-A enhanced rice variety intended as a partial response to a widespread nutritional deficiency. Potrykus appeared on the cover of *Time Magazine* in July 2000 and the accompanying story touted his work as an important advance in the battle against the ills of poverty (Nash, 2000). The story precipitated a continuing series of exchanges between boosters and knockers debating the value of Golden Rice for meeting nutritional needs.

The argument from hunger surfaced again in the summer of 2002 when several African countries refused US food aid because it was not certified as "GM free." The story received substantial play in the US media, where it was generally portrayed as a case of moral insensitivity on the part of African and European leaders, allowing people to starve for fear that future export markets would be lost. While there is little doubt that African rejection of even milled cornmeal (maize) broached the level of paranoia, these stories failed to note that the US routinely takes pains to satisfy purely aesthetic preferences in the delivery of food aid (e.g., delivering white rather than yellow maize), and that since large maize producing regions in the US *do not* grow GM varieties, it would have been fairly easy for the Food for Peace program to have satisfied a preference for non-GM food aid, as well. If anyone was actually starving while all the dawdling was going on, US officials could be blamed for it as surely as African leaders. In May of 2003, the food aid episode became the centerpiece in a US trade action against the European Union's continuing reluctance to accept GM crops, (Zerbe, 2004). The argument from hunger has been imbedded in cynical and strategic manipulations from the outset, and it is tempting

to write it off entirely as a particularly odious form of deceit perpetrated to defame honest critics and dismiss legitimate concerns.

Nevertheless, the argument from hunger is complex because for the first time in the history of agricultural science, the developing world *is* broadly positioned to make substantial use of cutting edge techniques. The much-maligned Green Revolution was largely an attempt to adapt agricultural technologies from the sphere of European influence to growing conditions in Africa, Asia and Latin America. For a variety of reasons, scientists in these areas have a much greater capacity to use biotechnology in response to their own problems than has been the case for agricultural technologies that depend heavily on traditional chemical, mechanical and even breeding expertise, though they continue to work closely with developed country science. As such, it is really true that agricultural biotechnology might well be deployed in response to some genuine problems faced by poor and hungry people in the developing world (see Rosegrant et al., 2001; Nuffield Council, 1999, 2003).

It is, however, a rather large leap in logic to move from this carefully stated claim to the claims that biotechnology holds the solution to hunger, or that opposition to biotechnology is morally irresponsible, much less the even stronger claim that opponents of biotechnology are committing acts tantamount to the murder of starving people. Yet all these immoderate claims are heard in defense of agricultural biotechnology. Biotechnology cannot be said to hold the solution to world hunger because as Amartya Sen demonstrated in the path-breaking book *Poverty and Famines: An Essay on Entitlement and Deprivation* (1981), the misery and suffering of the poor is never due simply to a lack of food. While the techniques now in the hands of developing country scientists might increase yields and will almost certainly help developing country farmers reduce losses from disease and insect pests, solving hunger involves a reform of social institutions that deprive poor people of secure economic and political resources. Lacking these, there will still be hunger, even when there is plenty of food. In fact, some portion of the opposition to biotechnology comes from people who are arguing that social reforms must accompany technical change in developing countries. This claim is at the root of Vandana Shiva's argument against biotechnology (Shiva, 2000) and is stated repeatedly in grass roots literature coming out of India. To tar biotechnology's critics broadly as being unconcerned about the poor is either ignorant or cynical in the extreme.

The argument from hunger is also insidious because even those who reject it often do so with an equally fallacious and irresponsible reply: the problem is not a lack of food, but a matter of distribution. Like the argument from hunger itself, this comeback has a grain of truth. Sen's analysis supports the claim that hunger is a problem of distributive justice, but to say this is not to say that the problem would be solved by redistributing food, as if what we need are more boats and trucks. To think that hunger will be solved by exporting surplus production from industrialized countries to the developing world is just as naïve as thinking that a new potato or rice variety is the answer. Many critics of biotechnology underestimate the need to maintain and continuously improve humankind's capacity for biologically-based responses to problems in agriculture. The productivity of

industrial agriculture cannot be regarded as a permanent achievement. Not only does it involve levels of water and energy use and forms of pollution that are themselves creating problems, but diseases and pests are constantly evolving and will eventually become resistant to technologies that hold them in check. The case for any new technology in the developing world must be built upon this more subtle and valid foundation, rather than on a simplistic and ultimately misleading portrayal of its ability to "feed the world."

The argument from hunger is a bad argument not because there is no truth in claiming that rDNA techniques will be an important part of the toolkit for agricultural scientists who work to improve food production in the developing world. Once one has witnessed starvation, the imperative for change becomes paramount and impatience starts to look like a virtue. Nevertheless, the main thrust of my research on the GMO debate is that meeting the concerns and criticisms of opponents is among the ethical responsibilities that scientists and decision makers must accept. Telling people to buzz off because we are busy helping the poor simply will not do. While it is certainly possible to take a different view of how far scientists, government officials and industry leaders need to go in meeting the views of critics, it is something else again to promote a simplistic view of poverty and deprivation in order to bring about better public acceptance of biotechnologies that are being used in industrial agriculture today. The argument from hunger is a bad argument because it has been deployed shamelessly and cynically in a manner that promotes continued misunderstanding of the problems of global hunger and of science's role in addressing them. As proponents of nanotechnology see similar opportunities to alleviate suffering or help the poor, they must resist the temptation to offer arguments that oversimplify and ultimately harm our collective ability to address the problems of suffering and poverty.

2.8 Conclusion

The presumptive case for nanotechnology is strong. In part it issues out of the presumptive case that must be assumed for all technology at this point in history. Technology has always been with humanity, of course, but in the post industrial age it has taken on a systematic character reflected in the organizations—corporations, government agencies and universities—that have been built to develop it and in the agencies—regulatory bodies, legal systems and financial institutions—that create our social filters for picking and choosing which technologies ultimately succeed. The existence of these social filters creates an expectation (at least among those who work with and develop technology) that the applications of nanoscience that run this gauntlet are more likely to be beneficial than harmful. All of which may simply be to say that at present, technological change (including nanotechnology) is a social fact.

The most favorable evaluation that follows from the presumptive argument is this: if the broad set of tools and knowledge known as nanotechnology can be

deployed for good, our ethical responsibility is to support the development and training in the tools of nanoscience *in general*, and to make assessments of *specific* products or applications when there are good reasons to suspect that there may be problems, or that costs and unwanted consequences outweigh benefits in a particular case. This orientation to nanotechnology is modest and reasonable, but defending it is philosophically significant not only in light of anti-technology arguments that will inevitably be leveled against all forms of nanotechnology, not simply those that deal with human enhancement, but also because it will help explain the general strategy of SEIN research to scientists and engineers engaged in developing applications of nanotechnology.

It will also become practically significant if such philosophical sentiments stimulate public resistance comparable to that which surfaced in the GMO debate. The larger aim of my work has been to evaluate the conditions and particular arguments that have been proposed to limit the presumptive case for biotechnology, discarding some, endorsing others. Something similar will need to happen for nanotechnology. This means that much of the discussion will be focused on criticisms and negatives. Scientists and engineers must learn to accept the fact that although much of what gets said is critical and questioning, the ethics of nanotechnology is *not* simply a matter of limits and constraints, for the promise technology is real, substantial and should not be ignored.

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