Debating the Precautionary Principle: "Guilty until Proven Innocent" or "Innocent until Proven Guilty"?

Henk van den Belt*

Applied Philosophy Group, Wageningen University and Research Centre, 6706 KN Wageningen, The Netherlands

On May 20, 1999, *Nature* published a brief report on an experiment performed by researchers at Cornell University that indicated that pollen from genetically modified (GM) Bt corn (*Zea mays*) could kill the larvae of monarch butterflies (*Danaus plexippus*). In laboratory tests, caterpillars fed milkweed (*Asclepias curassavica*) leaves dusted with pollen from a Bt corn hybrid showed retarded growth and increased mortality. "These results," the authors stated, "have potentially profound implications for the conservation of monarch butterflies" (Losey et al., 1999). In a press release announcing the publication in *Nature*, the principal investigator on the Cornell study, John Losey, had expressed due caution: "Pollen from *Bt*-corn could represent a serious risk to populations of monarchs and other butterflies, but we can't predict how serious the risk is until we have a lot more data. And we can't forget that Bt-corn and other transgenic crops have a huge potential for reducing pesticide use and increasing yields. This study is just the first step, we need to do more research and then objectively weigh the risks versus the benefits of this new technology" (Cornell News, 1999). Such caution was wasted on Greenpeace International. The day the findings of the Cornell study were published it already demanded that authorities in the United States, Argentina, Canada, and the European Union take immediate action and prohibit the growing of genetically engineered maize crops. The environmentalist nongovernmental organization (NGO) reiterated its earlier call for a ban on all releases of genetically modified organisms (GMOs). Less than a month later, in a media-oriented action, members of Greenpeace dressed up as butterflies confronted a meeting of European Union environment ministers held in Luxembourg, carrying banners demanding "Give butterflies a chance." In Europe, their campaign apparently found resonance among the authorities: The European Commission decided to freeze the approval process for new Bt maize varieties.

The Cornell study did not show that monarch butterfly populations in the wild were actually endangered by Bt corn. However, when Monsanto and Novartis, the companies that sold Bt corn at that time, correctly pointed out that the detrimental effects had so far only been shown in the laboratory, Greenpeace branded them as irresponsible. A spokesperson declared: "Such reactions are the precise opposite to precaution and follow the same pattern of denial these companies have employed for decades, when health and environmental effects of their chemical pesticides were exposed. However, in the case of these GMOs we are talking about living toxins that can reproduce in nature and transmit their dangerous traits to wild species. We cannot consider GMOs harmless until harmful effects are fully proven (sic)" (Greenpeace, 1999a). (The last sentence is obviously a—Freudian?—slip of the tongue and should be read: "We cannot consider GMOs harmless until the absence of harmful effects is fully proven.") For Greenpeace, not just monarchs were supposed to be endangered. The NGO drew up a list of over 100 species of butterflies that it believed could be harmed by GM maize. It accused biotech companies and regulatory authorities of fully ignoring these risks (Greenpeace, 1999b). More recent field research performed in the American Midwest, however, seems to indicate that monarch butterfly populations are hardly affected, if at all, by the large-scale cultivation of Bt maize in this region (Ortman et al., 2001).

The monarch butterfly case is only one among many occasions in which the so-called Precautionary Principle (PP) has been invoked to advocate preventative action to forestall possible harm even before the likelihood or the possible extent of the latter has been scientifically well established. This principle is highly contested. With many other environmentalist NGOs, Greenpeace champions its adoption as a central principle of international law against tenacious opposition from the United States, Canada, and Australia (Greenpeace, 2002). The principle is also at issue in recent World Trade Organization trade disputes between the United States and the European Union. But why does the PP play such a central role?

PRECAUTIONARY PRINCIPLE

The PP is an outgrowth of increased environmentalist awareness since the 1970s. The conviction took hold that humanity finds itself in a historically unprecedented situation in which our technological capacity and the potential scale of our actions far exceed our predictive knowledge. According to the

* E-mail henk.vandenbelt@wur.nl; fax 31–317–485453.
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German philosopher Hans Jonas, this discrepancy between the ability to foresee and the power to act itself assumes ethical importance and asks for humility and responsible restraint on our part. Jonas maintains that it is possible to extract from this situation of profound scientific uncertainty a rule or principle of decision making that is itself not uncertain at all, namely the rule "to give in matters of a certain magnitude—those with apocalyptic potential—greater weight to the prognosis of doom than to that of bliss" (Jonas, 1984). The supreme moral imperative in the new age, Jonas holds, is that humankind may not put its own existence and survival at stake in the wager of technological progress.

If we want to find a philosophical basis for the PP, we must look for it in Jonas' book on the imperative of responsibility (although he himself did not use the expression PP). Environmentalists often hold that modern biotechnology has "apocalyptic potential" because it tampers with the basic processes of life. If we release GMOs into the environment, the ultimate consequences for the natural flora and fauna are extremely hard to predict but may well be irreversible. However, many environmentalists, just like Jonas, believe that we possess a decision rule or principle for dealing with fundamental scientific uncertainty that is itself not the least uncertain. That rule is the PP. Thus, in almost any debate, it seems that the PP can be brought in as a trump card to override all other considerations and arguments. But what exactly is the PP?

Proponents of the PP assert that the principle is already "enshrined" in such international agreements as the Convention on Biological Diversity and the Cartagena Protocol on Biosafety, but existing definitions of it are at best partial and incomplete. In the context of dealing with environmental hazards, the Rio Declaration of 1992 presented the following formulation of what a precautionary approach entails: "Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation." A well-known definition of the PP was spelled out in a January 1998 meeting at Wingspread in Racine, Wisconsin. The *Wingspread Statement* summarized the principle thus: "When an activity raises threats of harm to human health or the environment, precautionary measures should be taken even if some cause and effect relationships are not fully established scientifically" (Raffensberger and Tickner, 1999). Definitions such as these beg many questions. Is there ever full scientific certainty? Do we need a minimal threshold of scientific certainty or plausibility before we may (or should) undertake preventative action? And do we really know how to prevent harm if we are so much ignorant about the underlying cause-effect relationships? The definitions that are currently on offer fail to spell out the precise conditions that have to be fulfilled before the PP may be invoked or the nature of the preventative action that has to be taken. The types of action suggested range from implementing a ban, imposing a moratorium while further research is conducted, allowing the potentially harmful activity to proceed while closely monitoring its effects, to just conducting more research. The PP does not have a very precise meaning as long as such crucial aspects are left largely unanswered.

In practice, however, the PP is often given a more definite meaning by reducing it to an absurdity. Normally, no minimal threshold of plausibility is specified as a "triggering" condition, so that even the slightest indication that a particular product or activity might possibly produce some harm to human health or the environment will suffice to invoke the principle. And just as often no other preventative action is contemplated than an outright ban on the incriminated product or activity. The intervention of Greenpeace in the monarch butterfly case seems to fit this pattern.

Closely linked to various versions of the PP is the idea of reversing the onus of proof. Thus, the adherents of the Wingspread Statement declare that "the applicant or proponent of an activity or process or chemical needs to demonstrate that the environment and public health will be safe. The proof must shift to the party or entity that will benefit from the activity and that is most likely to have the information" (Raffensberger and Tickner, 1999). Greenpeace also holds that effective implementation of the PP requires a shift in the burden of proof (Greenpeace, 2001). Shifting the burden of proof seems a fairly straightforward way to ensure, as Jonas demanded, that greater weight will be given to the "prognosis of doom" than to the "prognosis of bliss."

THE LOGIC OF PASCAL'S WAGER

Before looking into the proper assignment of the burden of proof, we must first examine more closely the underlying justification for the strong version of the PP. Why should the prospect of harmful effects of a new technology take precedence over the prospect of beneficial effects, quite apart from the inherent likelihood of each of these possibilities? The obvious answer seems to be that such a priority is defensible only when the harmful effects are of such magnitude that they carry catastrophic (or, as Jonas would say, "apocalyptic") potential. The infinite costs of a possible catastrophic outcome necessarily outweigh even the slightest probability of its occurrence.

This type of reasoning exhibits a remarkable resemblance to a well-known example of a "zero-infinity dilemma," namely Pascal's famous "wager." When it comes to wagering on the existence of God, the 17th century French philosopher argued incisively in his *Pensées* that it is better to be safe than sorry (Haller, 2000; Graham, 2002; Manson, 2002). Given an un-

known but nonzero probability of God's existence and the infinity of the reward of an eternal life, the rational option would be to conduct one's earthly life as if God exists.

Alas, Pascal's reasoning contains a fatal flaw. His argument is vulnerable to the "many gods" objection (Manson, 2002). Consider the possible existence of another deity than God, say Odin. If Odin is jealous, he will resent our worship of God, and we will have to pay an infinite price for our mistake. Never mind that Odin's existence may not seem likely or plausible to us. It is sufficient that we cannot exclude the possibility that he exists with absolute certainty. Therefore, the very same logic of Pascal's wager would lead us to adopt the opposite conclusion not to worship God. Pascal's argument, then, cannot be valid.

If the wager argument is not valid, the strong version of the PP (which Manson dubs the "catastrophe principle") cannot be valid either. Take the application of this principle to the problem of global warming. Environmentalists often argue that even if it is not conclusively established that the emission of carbon dioxide and other gases causes an enhanced greenhouse effect, the mere prospect of an ecological catastrophe due to such a scenario should lead us to drastically curb our emissions of greenhouse gases now. By the same logic, however, one could conjure up the possibility of a coming ice age. The mere prospect of this equally catastrophic scenario should then induce us to avert this outcome by stepping up the emission of greenhouse gases. Thus, the strong version of the PP would lead to contradictory recommendations (compare with Graham, 2002). In a similar way, it could be argued that this principle commits us to each of two contradictory policies: (a) We must not develop GM crops, and (b) We must develop GM crops. The first alternative is argued vehemently by many environmentalists who appeal to the PP. To support the second possibility, Gary Comstock conjures up a dramatic scenario in which people are forced to seize upon the remaining reserves of nature in a desperate effort to overcome food shortages resulting from global warming. He then argues, in the style of the environmentalists, that "lack of full scientific certainty that GM crops will prevent environmental degradation shall not be used as a reason for postponing this potentially cost-effective measure" (Comstock, 2000).

BURDENS AND STANDARDS OF PROOF

Therefore, the strong version of the PP is untenable. But what about the proposed shifting of the onus of proof toward those who advocate a new technology or activity? Reversing the burden of proof would amount to substituting the maxim "guilty until proven innocent" for the age-old legal principle "innocent until proven guilty." Biotech enthusiasts and antiregulationists resent this departure from what they consider time-honored legal sanity (Miller and Conko, 2000). They are prone to counter the frequent invocation of the PP with an equally insistent demand of "sound science." The same opposition is also at the center of the present World Trade Organization trade disputes between the United States and the European Union and their disagreement on the regulation of GM crops. One side claims the moral high ground, whereas the other side attempts to seize the scientific high ground. The situation is highly polarized because various economic and political interests are at stake (Fig. 1).

The critics of the PP assert that the burden that environmentalists and regulators want to impose on the proponents of new technologies tends to be unbearable (Miller and Conko, 2000). In the name of

Figure 1. Wheat (*Triticum aestivum*) fields in the Palouse region of the state of Washington in the United States. The polarized discussion about the PP and the adoption of GM crops has become a proxy for everything that Europeans and environmentalists in other countries don't like about modern agriculture. The rejection of agricultural biotechnology may perhaps be tolerated as a European indulgence but hardly makes sense on a global scale.

absolute safety, the latter are asked nothing less than to demonstrate conclusively that the new technologies they advocate offer no possible harm. This is a formidable, perhaps even logically impossible, task. You cannot prove a negative (compare with Wildavsky, 1995). Moreover, a risk-free world is not a real option. Thus, a consistent application of the PP would in the final analysis stifle all innovation.

A closer analysis of what is involved in applying the classical principle "innocent until proven guilty," however, reveals that the situation need not be as black and white as it seems at first sight. Take the paradigm case of criminal justice. There are two main ways in which a miscarriage of justice can come about. Either the suspect did not commit the crime, but the verdict found him guilty; or the suspect did commit the crime, but the verdict found him not guilty. In a civilized system of justice, the risks of the first type of error are minimized as far as possible. That is what is meant by the phrase "innocent until proven guilty." The system contains safeguards and precautions in the form of high standards of proof so as to ensure that a suspect will be condemned for a certain criminal offense only if it has been established "beyond reasonable doubt" that he in fact committed the alleged offense. Alas, there is a price to be paid for this cautious and civilized approach, namely the possibly large number of wrongdoers who have to be acquitted due to "lack of sufficient proof." To a certain extent, the risks of the two types of error are inversely related. We may try to reduce the risk of condemning an innocent person by demanding ever more exacting standards of proof but only at the expense of increasing the risk of acquitting culpable offenders. Therefore, we must recognize that there is an inevitable trade-off involved in the design of our system of criminal justice. We may attempt to set our standards as high as we can, but somewhere a balance must be struck, lest the system will become unworkable by making it too difficult to pass sentence on the majority of wrongful offenders. (In statistical testing, there is a similar trade-off to be made between the chances of committing a type I or a type II error, i.e. rejecting the null hypothesis of "no effect" when it is in fact true or failing to reject the null hypothesis when in fact it is false. By selecting a significance level, we implicitly strike a particular balance. Ideally, this balance should depend on our estimation of the costs—economic and other—associated with either of the two types of error.)

The above analysis shows that the matter at issue is not just where to place "the" burden of proof. As soon as we allow for more or less exacting standards of proof, an extra dimension of variation immediately becomes visible. In other words, the burden we want to put on the shoulders of one or the other party becomes more or less heavy depending on whether we set our standards of proof more or less highly. This consideration may help us to escape from the unduly polarized opposition of PP versus sound science.

In most countries, companies aiming to commercialize GM crops have to submit their products to scrutiny for health effects and environmental impacts. This scrutiny can be more or less searching. The ideal of those who swear by "sound science" is a fully quantified risk assessment. However, it is only possible to meet this objective in more limited contexts, where direct and short-term hazards such as toxicity or pathogenicity are at issue. Even then the expression "sound science" is disingenuous because it obscures the extra-scientific value judgments that necessarily enter into the whole exercise (e.g. identification of hazard types, baselines of acceptability, and trade-offs between type I and type II errors). In other contexts, where indirect, cumulative, or more subtle ecological effects are at issue, the format of the fully quantified risk assessment is unattainable. Adherents of "sound science" will be tempted to downplay such less straightforward hazards as purely hypothetical, conjectural, or theoretical risks that can safely be ignored. However, as the proponents of the PP are never tired in pointing out, lack of evidence of harm is not evidence of lack of harm. If we are really concerned about such hazards, we can put in additional investigative effort to learn more about their plausibility or likelihood. It would be absurd to halt our inquiries with an appeal to "sound science."

THE FUTURE OF WORLD AGRICULTURE

A recent European directive on the deliberate release of GMOs into the environment lays down that any company that wants to introduce or commercialize a transgenic crop should carry out a "full" environmental risk assessment taking into account "direct, indirect, immediate and delayed effects" (EC, 2001). This new regulation of GM crops goes much further than current US registration requirements, although some American biologists also argue for a more comprehensive approach (Obrycki et al., 2001).

The new European Directive surely places a heavy burden of proof on biotech companies intending to introduce GMOs. Whether or not they are able to take that burden on their shoulders will partly depend on the definition of a standard protocol or methodology for conducting environmental risk assessments. The danger to be avoided is that the obligations imposed on these companies will become "open-ended," putting them entirely at the mercy of regulatory agencies and NGOs asking for ever-escalating assurances of environmental safety. This suspicion will be enhanced by the fact that the drafting of the Directive has avowedly been informed by the PP and that regulatory authorities may give consent to the introduction of GMOs only after they have

been satisfied that the release will be safe for human health and the environment.

The fairly comprehensive scope of the required environmental risk assessment need not be offensive in itself, if rules of fair play for the regulation of GM crops can be developed. More clarity is also needed about the societal values that have to be taken into account in evaluating risks. The outcome of the assessment is clearly contingent, for instance, on whether or not chemical-intensive methods in agriculture are taken as a normative baseline or whether or not a strong commitment to organic agriculture as a viable option is maintained (Levidow, 2001). The pros and cons of a *Bt* maize hybrid or any other transgenic crop might be quite different in Europe than in the United States. Europeans are usually strongly attached to farmland because their countries lack vast tracts of national parks and other "wilderness" areas. Willy de Greef, head of regulatory affairs at Syngenta Seeds, holds that the debate in Europe on GM foods is not fundamentally about safety, but is in fact a proxy for a larger debate on how farming should be done (Hileman, 2001). GM crops have become a symbol for all that Europeans don't like in modern agriculture.

Although a passion for organic farming and a rejection of agricultural biotechnology perhaps may be tolerated as a European indulgence, the prospect hardly makes sense on a global scale. Yet, this is precisely what Greenpeace International offers us as a worldwide "solution." I think the NGO owes us a deadly serious answer to the difficult question of how to feed a growing world population and sustain natural biodiversity without using the tools of modern biotechnology (compare with Trewavas, 1999). We can even press the environmentalist organization by invoking the PP!

Thus, it appears that the polarized debate on the PP is just a proxy for a larger debate on the future of world agriculture.

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