Staff Paper

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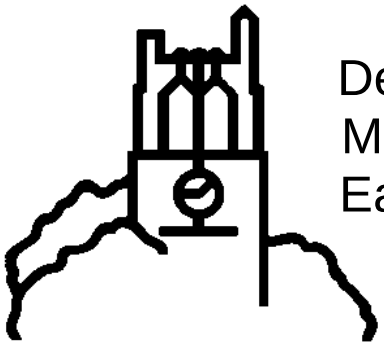
Staff Paper 2001-17 **June 2001**



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THE ROLE OF SCIENTIFIC AND BUSINESS INTEGRITY IN THE FUTURE OF BIOTECHNOLOGY: A SCENARIO ANALYSIS

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by
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10 pages

The emergence of biotechnology in crop and livestock applications has been an issue of great controversy. Proponents argue that the potential benefits are dramatic while opponents have raised many concerns about the technology's risks. The Starlink debacle is a prime example of the undesirable outcomes which the debate has created. Given the controversy, what is the future of biotechnology for food uses? This paper is designed to address this question with a focus on the feasible range of alternative futures (scenarios) that could emerge. As a major variable in this analysis, the integrity of the scientific and business communities plays a critically important role.

The paper begins with a description of three key uncertainties–food security, environmental/health impacts, and consumer reaction–that will define the future for biotechnology's use in food applications. Based on these uncertainties, four alternative future scenarios for biotechnology are presented. The role of messenger integrity is then introduced. The integrity of various possible messengers (scientists, businesses, government, and non-profits) is examined. The concept of integrity is then used to address a series of current biotechnology issues. Throughout the paper, comparisons and contrasts between the developed and developing world are made.

Fundamental Uncertainties about Biotechnology's Future

The controversy over biotechnology is driven by a number of key uncertainties. The first uncertainty is whether the growing population of the world can be fed without the emergence of a new "green revolution." Biotechnology has been argued to be this needed new technology. Some population growth projections would clearly argue that this new revolution is needed. Even so, biotechnology may or may not be the needed new technology. However, the slowing of world population growth rates, the emergence of expanding commodity supplies from developing countries, and the current glut of food commodities worldwide would be counter arguments against this need. Thus it is uncertain whether biotechnology is needed to assure food security.

The second uncertainty is whether biotechnology results in net environmental and health benefits or costs. On the benefits side, biotechnology reduces reliance on agri-chemicals in the food chain and holds open the promise of new beneficial health attributes being engineered into food, e.g., golden rice. On the cost side are the concerns over superweeds, superbugs, loss of beneficial insects or plants, terminator technology, allergic reactions, loss of nutrition, and other unintended environmental and health

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consequences of a new technology. The argument has been advanced by some that these costs have been overestimated and that "good science" can prove this. Again, it is unclear whether biotechnology will bring about net gains to the environment or human health.

The third uncertainty relevant to the future of biotechnology is the public/consumer reaction to the technology. Irrespective of how the first two uncertainties are resolved (and in reality they will almost assuredly not be resolved perfectly in one direction or the other), the reaction of the public will have a major impact. This has already proven to be true. There will likely be perceived differences across the public about the costs and benefits related to either food security or environmental/health impacts. As a result, one part of this uncertainty is whether individuals in a market setting will be allowed to respond individually or instead governments will respond en masse on behalf of the public in the form of broad regulation. Another part of this uncertainty is whether the consumers of the developed versus developing worlds may respond differently in how benefits and costs are assessed and traded off. Biotechnology may or may not win in the court of public opinion and thus substantial business risk arises for agribusiness firms.

By their very nature, these three uncertainties can not be resolved in the short-run. Only the emerging actual changes in population, biotechnology impacts on environment and health, and public/consumer reaction can resolve the uncertainties. Unfortunately, decision makers both private and public must make decisions today about whether to continue, expand, or abandon investments in the technology. Without such decisions, the technology may not be available if needed and may not be appropriately managed to mitigate adverse impacts if they emerge.

Four Scenarios for Biotechnology's Future

Based on the techniques of scenario analysis (Schonemaker), four possible futures could emerge based on these uncertainties:

Scenario 1: Biotechnology is banned, either formally or informally. The most direct road to this scenario is that the food security needs do not emerge, but the adverse environmental/health impacts do. The public reaction will be clear and negative in this case, either individually or en masse. A less direct road to this scenario could also emerge. The perceived adverse impacts of biotechnology come to be viewed by the public as a set of risks that are not seen as outweighed by any level of potential benefits. Biotechnology may thus be banned formally by government or informally by consumer choice in the marketplace. The U.S. nuclear experience provides evidence of this less direct path. Although no formal ban exists, public reaction has in effect lead to no new nuclear power facilities being built in the last 20 years.

Scenario 2: Biotechnology becomes fully accepted in the marketplace. Consumer-oriented biotechnology products become available, and biotechnology follows the pattern of other past agri-food innovations. Again, there are both direct and indirect paths to this scenario. The direct path is that the food security needs do emerge, and biotechnology proves to be safe in meeting these needs. The public reaction will be clear and positive in this case, either individually or en masse. The indirect path is that the food security need emerges, safety protocols (public and/or private) are developed to allay public concerns, and biotechnology emerges in the court of public opinion as the safest of available alternatives. Either path would result in biotechnology ultimately

becoming fully accepted even though the indirect path would have a longer period of controversy before consensus emerged.

Scenario 3: The food system adopts a "three labels" approach to biotechnology. Given the nature of the food security and environmental/health uncertainties, a solution that may evolve and has been adopted by some already, e.g., Japan, is to label all food by its method of production–conventional, biotechnology, and organic. Individual consumers thus choose in the marketplace based on their individual weighing of the risks and benefits. The public reaction is thus allowed to be resolved on an individual basis rather than en masse.

Scenario 4: Biotechnology is used only in non-food applications. Consumers are unwilling to have biotechnology used in food, but would allow commercial or industrial applications, e.g., pharmaceuticals, replacement of industrial chemicals with biologically based alternatives. Based on the recent StarLink experience and other needs to allay public concerns, a system of careful control of biotechnology crops and livestock emerges. Such agricultural products are produced in environmentally-controlled, manufacturing-like facilities. Strict system segregation from food uses is maintained to the public's satisfaction.

The scenario analysis suggests that the third uncertainty–consumer reaction–is critical to determine the future scenarios. The first two uncertainties will only be resolved over an extended time while the third one can be and is already being played out in the near term.

Modeling the Role of Integrity

The resolution of the third uncertainty–public/consumer reaction–depends on the integrity of the information that the consumer has for decision making. In essence, the consumer is faced with a classic information problem akin to the market for lemons (Akerlof). The consumer is being asked to purchase a product whose attributes can not be known at the time of purchase, i.e., the true costs and benefits of biotechnology. The consumer must thus fear opportunism on the part of the seller, i.e., the life sciences industry, who is presumed to have superior private information. The seller has incentives to hide information if it is adverse to the buyer's interests and to share it if in concert with the buyer's interests. However, the buyer can not know a priori which is true of the information-sharing practices of the seller. The history of the tobacco industry is a case well established in the minds of the consumers as a perfect example of this information problem.

The problem for the consumer is further complicated by the fact that there are many potential "sellers" of information about biotechnology. Governments, environmental groups, and food industry firms outside the biotechnology industry also have interests in consumers' decisions about this issue. The consumer must gauge the integrity of each of these information sources. There is also one additional source of information critical to this situation–the profession of science. The so-called "good science" argument is an ultimate appeal to consumers that science provides a source of information that can be inherently trusted on matters such as biotechnology.

The critical question relevant to public/consumer reaction becomes: Who has the integrity to interpret the risks and benefits of biotechnology to the general public and the food consumer? Given the information problem posited, the integrity of the messenger will be a key driver of the acceptance or lack

of acceptance of biotechnology and thus of the future scenario that emerges. A messenger with high integrity would be expected to give information about biotechnology that is true, complete, and not based on opportunism. Low integrity would result in a message that is in whole or in part untrue, incomplete, or based on opportunism. There would also be perceived gradations of information quality and thus integrity in between these two extremes.

In this context, the public/consumer assessment of messenger integrity can be conceived of as arising from three interrelated factors: a messenger's underlying motives, a messenger's organizational form (or affiliation), and other signals of integrity based on real behavior consistent or inconsistent with integrity. First, underlying motives are critical to whether a particular messenger will likely behave opportunistically. The greater the likelihood that a given messenger's interests will diverge from the interests of consumers, the greater the perceived likelihood that the messenger will not behave with integrity. Second, within the information economics literature, signaling is an important means for an economic actor with private information to adopt behavior that properly interpreted reveals the relevant private information (Milgrom and Roberts). One particularly important signal of motives is the institutional form or affiliation of the messenger. Institutional form is a relatively permanent decision about why and how to operate. It is thus evidence of a credible (as opposed to transitory) commitment to a given set of motives. The profession of science, government, business, and non-profit organization are each potentially powerful signals about underlying motives. Finally, a whole array of real behaviors on the part of messengers can signal real integrity or its absence.

Starting with the first two factors, motives and institutional form, a matrix of possible messengers about biotechnology can be formed (Table 1). The assessments found in the cells are an expression of likely *a priori* consumer/public perceptions of the link between motive and form for the indicated messengers. For example, governments are presumed to behave out of public motives, e.g., contributing to knowledge, monitoring behavior, and promoting social good. They are not expected to behave out of a profit motive. The public would *a priori* assume high messenger integrity for government messengers. On the other hand, private business is expected to behave out of a profit motive, and thus public perceptions of a business messenger's integrity are *a priori* low on topics such as biotechnology because the risk of opportunism is perceived as high. Like government, non-profits are also accorded an *a priori* assumption of high integrity because they do not pursue profit by definition. Finally, the profession of science has historically been accorded the presumption of high integrity because of is members' loyalty to the scientific principles of objectivity and thoroughness of analysis.

Unfortunately, for the public and for consumers, the real integrity of a messenger may not reflect the presumptions recorded in most of the cells of Table 1. The profession of science provides an interesting case in point. Historically, the purest expression of this institution would have been the university scientist whose sole presumed motive would have been contribution to knowledge. Academic freedom has always been about maintaining the independence and objectivity of scientists to pursue knowledge without the complications of other motives. As

Table 1: Public/Consumer Presumptions of Messenger Motive and Form Linkages

Motive / *Form of Institution*	**Contribute to Knowledge**	**Enhance Revenue/Profit**	**Monitor Behavior/ Enforce Standards**	**Promote Social Good***
Government	Research funding agencies	----------	Regulatory agencies Judicial bodies	Executive Legislature
Private Business	----------	Management Agents/Reps	Third Party Certifiers	----------
Non-profit Organization	Foundations NGOs	----------	"Watchdog" groups	Foundations NGOs
Profession of Science (cell entries refer to a scientist's work setting)	University Government ---------- Non-profit	---------- ---------- Business ----------	---------- Government ---------- ----------	---------- Government ---------- Non-profit

*This motive covers a wide range of possibilities running from broad consideration of the "public good" to the more narrowly defined goals of poverty/hunger elevation or environmental stewardship.

discussion has emerged recently over such concerns as the "kept university" (Press and Washburn) and academic generation of patents in support of personal and university revenue generation, the university scientist's motives have come increasingly under scrutiny by the public. A university scientist's real behavior in pursuit of revenue and personal profit may thus move such a scientist into the profit motive column of Table 1 with an accompanying decline in public/consumer perception of messenger integrity. The presence of other types of scientists across this row of the matrix raises a particularly perplexing question: Is the scientist loyal to the profession or to the employer? Public perceptions (the ones most relevant to the third uncertainty) likely view the scientist aligning with the employer rather than with the profession, whether or not this is in fact the case. The integrity of a scientist as a messenger is thus judged through the screen of who the scientist works for, and university scientists are not necessarily seen as having pure knowledge-based motives.

The real behavior of other messengers can also compromise the public/consumer perceptions of integrity. Government administrations or legislatures can act out of narrow political motives as opposed to the social good. The extent to which non-profits engage heavily in public advocacy of narrowly focused causes may cause them to lose the public's presumption of integrity. Advocacy raises that concern that such groups may be engaged in revenue enhancing motives to sustain their ability to advocate. The presumption of a given messenger's integrity will also vary by region of the world. Various messengers have had very different histories depending upon region or even country. In some areas, private industry may be viewed as having more integrity than governmental leaders.

Signals of real integrity (the third factor in public/consumer assessments of integrity) are thus critically important. Consumers will heavily consider the real behavior or "track record" of any messenger in regard to exhibiting integrity. Although the examples sited previous have shown how real behavior undermines presumptions of integrity, signals of real integrity can either:

(1) reinforce the perceived integrity of the messenger, e.g., a scientist exhibits detached objectivity with testing a claim or new technology, or

(2) counteract perceived integrity either
   (a) positively, e.g., a life science company openly accepts a third party review, or
   (b) negatively, e.g., a university scientist does exclusive research for a private life science firm that promises patent royalties in return.

There are a whole host of real signals that will either enhance or detract from a messenger's real integrity in the eyes of the public. Table 2 provides a representative, not exhaustive, list of these signals. Any behavior that communicates mutual interest with the consumer will reinforce integrity while any behavior that communicates a conflict of interest will reinforce a lack of integrity. Those situations in which a messenger would be perceived to be under pressure to abandon integrity are particularly salient to the public's judgement about integrity. For example, a university scientist speaks out against a private firm's message when the firm is a major donor to the university. Or, a firm's own scientist whistle blows about weak or absent testing procedures. In either case, the scientist signals real alignment with the motive of knowledge-contribution and thus enhances his/her integrity as a messenger. Successful messengers, either for or against biotechnology, will need in the final analysis to exhibit real integrity.

Table 2: Signals Consistent and Inconsistent with Real Integrity

Signals Consistent with Real Integrity	Signals Inconsistent with Real Integrity
• reputation for objectivity	• reputation for narrow interests
• tolerance of open, honest debate	• avoidance/opposition to open debate
• acceptance of neutral review	• unwillingness to have neutral review
• reputation for promoting/protecting the "public good"	• reputation for aggressive pursuit of profit without regard to other motives
• avoiding crusading/attack mentality	• exhibiting crusading/attack mentality
• avoiding exaggerated promotional claims	• engaging in exaggerated promotional claims
• any other behavior that communicates mutual interest with the public	• any other behavior that communicates conflicting interest with the public

Applying the Concept of Messenger Integrity to the Evolving Issues of Biotechnology

The concept of messenger integrity can be applied in a number of ways to explain recent public reactions to biotechnology and to predict future reactions to strategies currently and potentially open to messengers. These applications will show that the future scenario that emerges for biotechnology will depend on the integrity of the messengers that emerge.

Consider first the likely differences in the scenarios that may emerge for North America versus Europe.[2] In North American, the probability that either Scenario 2 (full acceptance) or Scenario 3 (consumer choice through labeling) will emerge is high. The US has a long history of successful agri-food system monitors with high levels of both perceived and real integrity, e.g., USDA, FDA, EPA, and university scientists. The USDA, FDA, and EPA have given approvals to biotechnology. Canada, much more than Mexico, has a similar system of monitors to the US, and both Canada and Mexico closely follow the lead of the US on these types of issues.

The probability of biotechnology playing a major role in the future of the EU is much lower than in North America. Scenarios 1 (banning of biotechnology) or 4 (limited use to non-food applications) are far more likely to emerge. The EU's government monitors have lost perceived (if not real) integrity recently due to the way they handled the outbreaks of mad cow disease and foot-and-mouth disease. The highly promotional manner in which biotechnology was introduced in Europe by the life sciences companies also limited their perceived integrity. It appears that the European public perceives the NGOs as the integrity leaders concerning the science of biotechnology. The supporting evidence is that most EU NGOs are anti-biotechnology. In addition to raiding GMO fields and protesting, these organizations appear to have influenced policy which has limited the consumption and production of biotech products in the EU. Unless risks are reduced and products are put in the market channel that address consumer benefits (cure diseases, bio factories with positive environmental impacts, etc.), the prospect of biotechnology products being successful in the EU is low. The other option is that the governing bodies of the EU food system regain their influence through improved acts consistent with real integrity and decide that biotechnology is critical for the future.

As a second case, consider the differences of reaction across the developing world. The future of biotechnology is extremely complex in developing countries. The economies of many of these nations are dependent on the US, EU or Japan. Therefore, the integrity of local messengers may be mitigated or enhanced by the influence of the final market for the product. In sub-Saharan Africa where many nations have historic trading ties with the EU, the integrity leader in most of these countries is the government who would like to reduce their malnutrition rates and increase income from agricultural trade. Such leaders are torn between the potential benefits of biotechnology and the demands of products moving from home markets to the EU. The messages remain mixed as to what to do with the technology. NGOs are intricately involved in these nations and have some influence as well. However, the government can simply remove an NGO that counters its policy. Thus far, only South Africa and Kenya have ongoing trials of biotech products in sub-Saharan Africa. The integrity that arises from this process will likely be high for these governments given the consistency of trials with real integrity. Any of the four scenarios for biotechnology could thus emerge in sub-Saharan Africa given the mixed messages and mixed levels of messenger integrity that exist there.

Predicting the scenarios for the developing world is further complicated by the existence of a centrally-planned economy where government is the sole voice whether it has integrity or not on the biotechnology issue. China is a good example where the government has decided that biotechnology is the key to feeding their population. Consumer choice to avoid biotechnology products may not exist in this system. Scenarios 2 (full acceptance) is created by fiat, but may unravel to Scenarios 1 (banning the

[2]Hill and Battle provide a useful analysis of the EU-US GMO debate.

technology) or 4 (limiting to non-food uses) if subsequent events prove the liabilities rather than the benefits of the technology. In any event, the surprising result is that Chinese consumers are in effect facing the same situation as North American consumers currently, neither can predetermine the presence of biotechnology in their food and thus neither has real choice. North American consumers do have the ability to create Scenario 3 (private choice through labeling) while the Chinese consumers are not likely to have this choice.

A third sub-case for the developing world exists and has the highest probability in the poorest of the poor countries. In this system there are several key breakdowns in society that may lead to business representatives being the integrity leader. These key breakdowns include one or more of the following: dysfunctional governments, extremely high food security risk, a fragile environment, and/or abundant health risk. The perceived risks of biotechnology may be lower than the real risks from these breakdowns. A biotechnology company could provide great opportunities to farmers, traders and the rural community. An anecdotal example of this comes from South Africa which does not represent the poorest of the poor as a country, however, it is a nation best described as both first and third world. Monsanto created a pilot program (subsidized the cost of buying the seed) for resource poor farmers so that they would try Monsanto's BT Cotton (Brink). These farmers were reported to have increased their annual profits by $150 on average. Integrity becomes driven by real benefits in the face of very high risk. If this example is expanded to a truly destitute country, it is a possibility that a private business, e.g., Monsanto, could become the perceived and real messenger of integrity. Presently, most biotechnology firms do not see ample returns on their investment and thus bypass these nations.

Moving beyond differences in the scenarios by country, the concept of messenger integrity can give guidance to individual messengers interested to promoting one of the scenarios over others. In general, efforts by Monsanto and the other biotechnology companies to promote biotechnology are likely to have relatively little influence on which scenario emerges in the industrialized world because they lack perceived integrity (due to the narrowness of profit motives) and they often fail to signal real integrity (e.g., highly promotional advertizing on the benefits and risks of biotechnology). Receptiveness to neutral review by third parties and investment in systems that promote consumer choice would be more likely to promote their perceived and real integrity and thus their influence on which scenario emerges.

The integrity concepts described in this paper can be applied to two other issues of note. First, arguments have been advanced that the development of consumer benefits from biotechnology (as opposed to the agronomic benefits created to date) will in and of itself create consumer acceptance. In effect, this is an argument that messenger integrity will not be important because the consumer will forget the potential costs and risks in the face of enhanced benefits. Now that the public and food consumers are aware of the integrity issues related to biotechnology, it is not very likely that the emergence of new benefits will eliminate the controversy. The balance of benefits and costs may improve in favor of benefits, but consumers will remain skeptical. For the consumers of the industrialized world most especially, the new benefits may have to be extremely valuable to counterbalance the uneasiness over potential risks.

Second, the concept of messenger integrity shows the "good science" argument to be a weak (if not entire useless) one for the public generally or for food consumers specifically. The "good science" argument is not compelling because the presumed integrity of the scientist as messenger depends upon whom the scientist represents rather than on some presumed loyalty to the scientific method and its

objectivity. Even in the case of university scientists, mixed signals of real integrity (pursuit of royalties vs. knowledge) can negate the integrity historically presumed. A call to allow "good science" to prevail in the controversy over biotechnology is not in itself a signal of real integrity. It may have become just the opposite.

Summary and Conclusion

Three key uncertainties–the real need for biotechnology to assure food security, biotechnology's real balance of benefits and costs, and public/consumer acceptance of the technology–give rise to four scenarios for biotechnology's future. The technology may be formally or informally banned (Scenario 1), become fully accepted (Scenario 2), move to market through strict labeling (Scenario 3), or limited to non-food applications (Scenario 4). Because of the critical role that public/consumer acceptance will have, the integrity of messengers about biotechnology will have a pivotal influence on the scenario that finally emerges. Messenger integrity is itself a highly complex issues. Integrity hinges on messenger motives, institutional form, and a wide array of possible signals that enhance or detract from the public's assessment of integrity. Assessments of real integrity were shown to vary not just by institutional form but also by region of the world with the most complex set of possibilities arising in the developing nations.

Agribusiness messengers from the biotechnology industry have some special liabilities when it comes to perceived and real messenger integrity. For these messengers to influence the biotechnology scenario that emerges, they will have to rely more on sending signals consistent with real integrity (e.g., neutral review, promotion of open and complete debate) and less on signals inconsistent with real integrity (e.g., narrow promotional appeals).

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