REVIEW

Worlds Apart? The Reception of Genetically Modified Foods in Europe and the U.S.

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Recent controversies about genetically modified foods in the United Kingdom and several other European countries highlight the apparent differences that exist in public opinion on this subject across the Atlantic. Why are people in the United States seemingly untroubled by a technology that causes Europeans so many difficulties? The results of survey research on public perceptions of biotechnology in Europe and the United States during 1996–1997, together with an analysis of press coverage and policy formation from 1984 to 1996, can help to answer this question.

An international study of biotechnology in the public sphere (*1*) sheds some light on why genetically modified (GM) foods are so much more controversial in Europe than in the United States. Here, we compare public perceptions of five applications of modern biotechnology and look for explanations for the differences between Europe and the United States in terms of media coverage, trust in the regulatory process, and scientific literacy.

In October 1996 a representative sample survey (about 1000 respondents per country) was conducted in all 15 member states of the European Union, together with Norway and Switzerland (henceforth "Europe"). The key questions were also used in a U.S. survey in late 1997 (*2*). These surveys were conducted 2 to 3 years ago and over a period of roughly a year; hence, our data provide a historical snapshot of public perceptions in 1996–1997. Of course, with the rapid advance of food biotechnologies and other developments in the life sciences (such as the cloning of Dolly the sheep), we would not expect to find the same opinions and attitudes in 1999. But the use of similar questions in the surveys makes it possible to look at comparative structural differences in the pattern of public perceptions that may hold clues to understanding the situation in 1999.

Respondents were asked whether they thought each of five biotechnologies—genetic testing, GM medicines, GM crops, GM food, and xenotransplantation (GM animals for use in human transplantation)—was useful, risky, morally acceptable, and to be encouraged (*2*). Figure 1 shows the mean levels of support (encouragement), on a scale from +2 to –2, for all the applications.

People in Europe and the United States showed varied levels of support across the different applications. GM medicines and genetic testing received the most support, GM crops and GM foods received intermediate support, and xenotransplantation received the least support. There was not always strong support for biotechnology in the United States; for example, the average U.S. respondent was opposed to xenotransplantation. Moreover, U.S. respondents were not always more supportive than European respondents; for example, Europeans were more supportive of genetic testing, whereas people in the United States were significantly more supportive of GM crops and GM foods than were people in Europe.

When the surveys were conducted, biotechnology was a relatively unfamiliar topic. On the questions about the five applications, 19% of the U.S. respondents and 27% of the European respondents did not give a complete set of responses. With this level of unfamiliarity, we can assume that some people responded to the questions with "nonattitudes" (*3*). Such responses would be likely to be volatile if, for example, the issue became more controversial. To this extent we must be cautious in our interpretations of and extrapolations from the survey results. In the absence of a filter question allowing us to exclude those people with "no opinion" (*4*), the following analysis uses only those who gave a full set of responses, on the assumption that they were more likely to have better formed opinions. Judgments of use, risk, moral acceptability, and encouragement were each collapsed into a dichotomy (useful/not useful, and so forth) so as to model patterns of response (henceforth "logics") over the four dimensions of attitude. This produces 16 possible combinatorial logics (Table 1), but empirically only three were widely used.

Logics 1 and 2 are similar in being supportive, but they display different perceptions of risk. For the "supporter," risk is not an issue. The "risk-tolerant supporter" sees but then discounts the risk. Opponents take a position exactly opposite to that of supporters.

Table 2 shows the distribution of these three prevalent logics for each application. For GM medicines and genetic testing, supporters constituted the single largest category. Levels of risk-tolerant support were also relatively high, and levels of opposition were relatively low. Greater opposition to genetic testing in the United States ($P < 0.05$) than in Europe may indicate a sensitivity about genetic privacy in the context of work, credit, or insurance. In contrast, for xenotransplantation, supporters and risk-tolerant supporters totaled only 36% in Europe and 42% in the United States, with about 33% in opposition.

Turning to GM crops and GM foods, we see a contrast between Europe and the United States. Both GM crops and GM foods were better supported in the United States than in Europe (for both contrasts, $P < 0.05$). For both applications, there were fewer supporters and more opponents in both the United States and Europe. The contrast is greatest in the case of GM foods, to which 30% of Europeans were opposed.

A fourth possible logic—"moral opponents" (in the context of Table 1, answers =

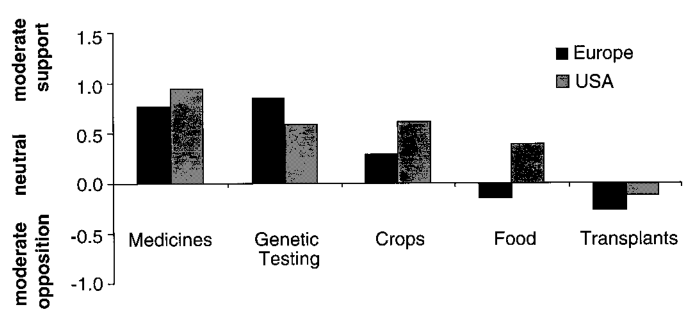

Fig. 1. Mean support for five applications of biotechnology. The United States and Europe differ significantly for each application (F values from one-way analyses of variance for each application were all significant at $P < 0.05$).

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yes, no, no, no)—counts for no more than 3% on any application (*2*). That there were so few people adopting the converse of the logic of risk-tolerant support suggests that respondents with concerns about gene technology tended to think principally in terms of moral acceptability rather than risk—a significant difference from the way in which experts normally judge the acceptability of new technologies.

Three factors may help to explain the relatively greater European resistance to agricultural and food biotechnology when the surveys were conducted. First, consider the influence of the press. One popular view suggests that the content (either positive or negative) of press coverage shapes public perceptions in the corresponding direction. Another hypothesis suggests that in technological controversies it is the sheer quantity of press coverage that is decisive: The greater the coverage, the more negative the public perceptions (*5*).

To compare U.S. and European press coverage, we analyzed a longitudinal sample of articles drawn from elite national newspapers in 12 European countries and the United States. We do not assume that these newspapers are widely read, but rather that they inform politicians and other journalists and, over time, reflect the tone of the national debate. Because there is no trans-European press, Fig. 2 shows the average of the 12 European national newspapers compared with *The Washington Post*. (Because we are exploring post hoc explanations, strict comparability of measures is not essential.)

Between 1984 and 1991 there is a broadly similar trajectory in Europe and the United States. Thereafter, however, the European trajectory rises more steeply than that in the United States. The comparison is consistent with the hypothesis concerning the importance of the quantity of media coverage. The relatively greater increase in coverage in Europe goes together with greater public concern.

On the basis of coding categories designed to facilitate systematic comparison of media coverage (*1*), Table 3 shows the content of coverage in Europe and the United States. From 1984 to 1990, there are relatively few differences between the European and U.S. press. "Progress" and "economic prospect" are the dominant frames in both cases, and the important themes are "health," "basic research," and "economics." From 1991 to 1996, differences between Europe and the United States become evident. *The Washington Post* moves from "progress" to "economic prospect," whereas in Europe "progress" remains dominant. The emerging frames in the United States are "public accountability" and "nature/nurture," versus "ethics" in Europe. In the United States, we see fewer "benefit" stories and more "risk and benefit" stories. There is no evidence of increasing "risk" stories in Europe.

These results do not confirm the view that public perceptions reflect the content of press coverage. On the contrary, although the trend in European press coverage was more positive than that in the United States, by 1996 public opinion in Europe was more negative. Instead, our evidence supports the hypothesis that increasing amounts of press coverage of technological controversies are associated with negative public perceptions.

In an increasingly complex world, trust functions as a substitute for knowledge (*6*). For this reason, a second factor that may contribute to public opinion on food biotechnology is trust in regulatory procedures. Europe and the United States have rather different histories of biotechnology regulation (*7*). In the United States, a relatively short public debate settled most of the key regulatory issues by the end of the 1980s. Because U.S. regulators did not see biotechnology as posing special risks, regulation was contained within existing laws addressing known physical risks of new products. In Europe, by contrast, a relatively protracted public debate has yet to achieve a viable transnational consensus. European regulators have

Table 1. Three common logics. For both the United States and Europe, the three patterns of response, or logics, shown are overwhelmingly the most frequently used. For data on all 16 possible logics, see (*2*).

Logic	Useful	Risky	Morally acceptable	Encouraged
1: Supporters	Yes	No	Yes	Yes
2: Risk-tolerant supporters	Yes	Yes	Yes	Yes
3: Opponents	No	Yes	No	No

Table 2. The logic of judgments for five applications of biotechnology. Loglinear modeling on each application, with opponents as the reference category, shows that the probability of being a supporter or risk-tolerant supporter differs significantly ($P < 0.05$) for the United States and Europe, with the exception of xenotransplantation and medicines, where there is no significant difference in the probability of risk-tolerant support. T values of $> \pm 1.96$ indicate significance at < 0.05.

Application	Logic	Europe		United States		T
		Proportion of respondents with a complete set of responses, N = 12,178 (%)	Proportion of the total sample, N = 16,500 (%)	Proportion of respondents with a complete set of responses, N = 863 (%)	Proportion of the total sample, N = 1067 (%)	
Medicines	Supporters	41	30	54	44	4.76
	Risk-tolerant supporters	37	27	29	23	1.52
	Opponents	8	6	5	4	
Genetic testing	Supporters	50	37	51	41	−6.08
	Risk-tolerant supporters	33	24	21	17	−9.38
	Opponents	7	5	14	11	
Crops	Supporters	35	26	51	41	8.17
	Risk-tolerant supporters	26	19	22	18	3.07
	Opponents	18	13	10	8	
Food	Supporters	22	16	37	30	11.89
	Risk-tolerant supporters	21	15	24	19	8.13
	Opponents	30	22	13	11	
Xenotransplantation	Supporters	16	12	23	19	2.86
	Risk-tolerant supporters	20	15	19	15	−1.47
	Opponents	33	24	35	28	

dealt with biotechnology as a novel process requiring novel regulatory provisions, and a complex series of national and European initiatives have embraced a wider range of both known and unknown risks (including risks to the environment).

The surveys in Europe and the United States asked questions concerning trust in regulation (*2*). The European respondents were asked to select from a list of national and international institutions the one best placed to regulate biotechnology. The results show highest confidence in international organizations such as the United Nations and the World Health Organization (34.5%), followed by scientific committees (21.6%) and national public bodies (12%). The Europeans were next asked, "Which of the following sources of information do you have most confidence in to tell you the truth about genetically modified crops grown in fields?" Here the vote of confidence went to environmental, consumer, and farming organizations (23%, 16%, and 16%, respectively), whereas national public bodies (4%) and industry (1%) commanded little support.

The U.S. respondents were asked, "If the USDA/FDA (separate questions) made a public statement about the safety of biotechnology, would you have a lot, some, or no trust in the statement about biotechnology?" The USDA carried the support of 90% of respondents, the FDA 84%. Thus, trust in the regulatory authorities is higher in the United States than in Europe. This may help to explain why the public concerns are greater in Europe than in the United States.

A third factor is the role of knowledge in public perceptions. A common belief is that scientific literacy generates support for science and technology. Two types of knowledge of biology and genetics were tested by seven items in the surveys. Four true/false "textbook" items tested general knowledge: "The cloning of living things produces an exactly identical offspring," "Yeast for brewing beer contains living organisms," "It is possible to find out in the first few months of pregnancy whether a child will have Down's syndrome," and "It is possible to transfer animal genes into plants." Three true/false items tested images of food biotechnology: "Ordinary tomatoes do not contain genes while genetically modified tomatoes do," "By eating a genetically modified fruit a person's genes could become modified," and "Genetically modified animals are always bigger than ordinary ones." For the textbook items, an incorrect answer was presumed to reflect a lack of scientific knowledge. For the image items, an incorrect answer was presumed to reflect both a lack of scientific knowledge and an image of threatening possibilities of food adulteration, infection, and monstrosities.

The textbook and image items formed two scales: the number of correct responses (0 to 4) for the textbook items and the number of threatening images (0 to 3) for the image items. The correlation between these two scales is low, implying that they are measuring different constructs (Europe, $r = 0.053$; United States, $r = 0.037$).

On textbook knowledge, the mean score for Europe was 2.76, significantly higher than the U.S. mean score of 2.43 ($T = -10.87$, $P < 0.0005$). In only 4 of the 17 European countries were scores lower than in the United States. Thus, textbook knowledge does not explain the more positive attitudes of people in the United States. Indeed, statistically controlling for level of knowledge, the more positive opinions in the United States remain.

By contrast, the mean score for threatening images of food biotechnology in the United States was 0.24, significantly lower than the European mean score of 0.88 ($T = -36.24$, $P < 0.0005$). The lowest score for threatening images in any European country is more than twice as great as the U.S. score. If more Europeans think that GM foods are the only foods containing genes, that eating GM foods may result in genetic infection, and that GM animals are always bigger, it is hardly surprising that they approach modern food biotechnology with greater suspicion.

Greater prevalence of menacing food images may be related to the recent food safety scares in Europe, most notably that surrounding bovine spongiform encephalopathy (BSE). These have sensitized large sections of the European public to potential dangers inherent in industrial farming practices and the lack of effective regulatory oversight. Also, Europeans tend to view farmland as an important environmental resource.

In conclusion, no single explanation accounts for the greater resistance to food biotechnology in Europe. Various factors are implicated and interrelated. Different histories of media coverage and regulation go together with different patterns of public perceptions, and these in turn reflect deeper cultural sensitivities, not only toward food and novel food technologies but also toward ag-

Fig. 2. Quantity of coverage in opinion leader press.

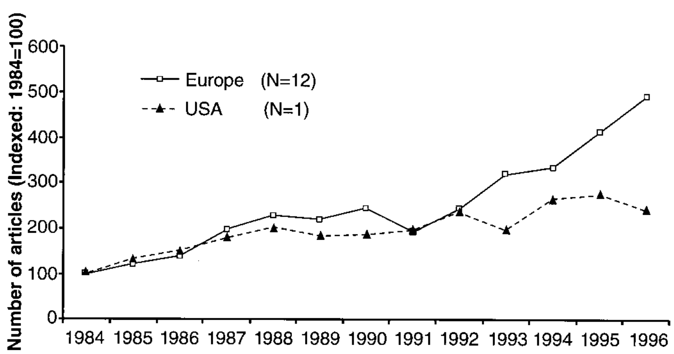

Table 3. Content of press coverage in the United States (one newspaper) and Europe (12 newspapers). Frames are perspectives in which biotechnology is discussed. Themes are specific topics within the area of biotechnology. For 1984–1990, Europe, $N = 1769$; United States, $N = 117$. For 1991–1996, Europe, $N = 2861$; United States, $N = 89$.

Period	Frame	U.S. (%)	Europe (%)	Theme	U.S. (%)	Europe (%)	Risk/benefit	U.S. (%)	Europe (%)
1984–1990	Progress	50	49	Health	29	24	Benefit	39	43
	Economic prospect	17	18	Basic research	14	12	Risk and benefit	34	30
	Nature/nurture	10	1	Economic	13	10	Risk	6	12
	Ethical	8	12	Regulation	11	9	Neither	21	15
	Public accountability	8	13	Safety and risk	11	7			
1991–1996	Progress	30	50	Health	37	30	Benefit	27	38
	Economic prospect	29	15	Economic	12	9	Risk and benefit	44	24
	Nature/nurture	15	4	Regulation	12	10	Risk	9	10
	Public accountability	15	10	Safety and risk	11	7	Neither	20	30
	Ethical	6	16	Basic research	8	10			

riculture and the environment. This raises the following question: How should science, industry, and governments respond?

References and Notes

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8. The authors of this paper are the coordinators of a Concerted Action of the European Commission (B104-CT95-0043), with British funding from the Leverhulme Trust. The U.S. survey was coordinated by J. Miller, an associate member of the project.

VIEWPOINT

Biotechnology and Food Security in the 21st Century

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Biotechnology can contribute to future food security if it benefits sustainable small-farm agriculture in developing countries. Presently, agrobiotechnology research cites ethical, safety, and intellectual property rights issues. Protection of intellectual property rights encourages private sector investment in agrobiotechnology, but in developing countries the needs of smallholder farmers and environmental conservation are unlikely to attract private funds. Public investment will be needed, and new and imaginative public-private collaboration can make the gene revolution beneficial to developing countries. This is crucial for the well-being of today's hungry people and future generations.

The human family has achieved outstanding progress in the 20th century. Developing countries have covered as much ground over the past 35 years in challenging poverty, hunger, disease, and ignorance as the industrialized nations covered in more than a century. The developing countries have doubled school enrollments, halved infant mortality and adult illiteracy, reduced malnutrition by a third, and extended life expectancy at birth by 20 years (*1*).

One of the greatest achievements since the Second World War has been the phenomenal increase of research-based agricultural productivity that has fed millions and served as the basis of economic transformation in many poor countries, especially on the Indian subcontinent (*2*). This "Green Revolution" has avoided dire predictions of death and famine in Asia (*3*). Food production has instead outpaced population growth, mainly because of substantially higher yields and increased irrigated land area. Food availability per capita grew and prices fell.

However, much remains to be done despite these gains. Poverty continues to limit access to food, leaving hundreds of millions of people undernourished in developing countries (*4*). Increased population, income growth, and urbanization will drive sustained growth in food demand, with a doubling of food needs in developing countries possible over the next four decades (*5*). Will the world continue to provide the supplies to meet this demand?

A priori, biotechnology—one of many tools of agricultural research and development—could contribute to food security by helping to promote sustainable agriculture centered on smallholder farmers in developing countries. Yet, biotechnology is now a lightning rod for visceral debate, with opposing factions making strong claims of promise and peril (*6*).

The World on the Eve of the New Century

Today the world is marked by aggregate affluence, but also by economic uncertainties, poverty, hunger, and violent conflict. Averages mask or divert attention from inequalities within and among societies. The natural resources on which future progress depends are imperiled (*7*). Population growth adds about 86 million persons a year, mostly in the poorest countries (*8*). Poverty and environmental degradation go hand in hand, for it is the poor who suffer the consequences of desertification and live the misery of unsanitary conditions. Tackling these problems is closely related to the policies that will be followed in transforming agriculture in developing countries (*9*).

Despite some problems, the Green Revolution has been a great success. There are, however, questions about whether a new, "doubly green revolution"—environmentally sustainable as well as yield-increasing—could help food needs over the next two decades. This revolution will need the political will to remove policy distortions that discriminate against poor people, investments in rural health and education, as well as rural roads, credit institutions, and high-quality research, within which biotechnology will have an increasing role (*2*, *9*).

Feeding the World in the 21st Century

Nobel laureate Norman Borlaug estimates that to meet projected food demands by 2025, average cereal yield must increase by 80% over the 1990 average (*10*). Making this formidable task even more difficult is that, to ensure that food production is coupled with both poverty reduction and environmental conservation, it will be essential that this increase occur in the complex smallholder farming systems of the poorest countries (*11*).

That requires policies and actions to promote agriculture and rural development, an enabling regulatory framework, fair trade, flexible and responsive institutions, increased investments in health and education, especially for women, and access to credit, roads, marketing, and extension. Research is a necessary but not sufficient condition for sustainable agricultural development, just as food production is a necessary but not sufficient condition for food security (*9*). The transformation will require access to and ability to apply technological advances, since future growth in food production will have to come largely from agricultural intensification on existing land. Most land suited to agriculture is already in use. More efficient use of water, energy, and labor is also essential (*12*).

A Double Shift in the Agricultural Research Paradigm

Two shifts in the research paradigm are necessary. The first involves integration of crop-specific research, which has been so successful in the past, into a broader vision that

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