Genetically modified foods have met virtually no consumer resistance in the United States, but in Europe they are provoking fears about safety and environmental damage

Agricultural Biotech Faces Backlash in Europe

LONDON—Guy Watson, Britain's largest grower of organic vegetables, may seem an unlikely warrior in a battle that is roiling Europe's food industry and sending tremors through the board rooms of U.S. biotechnology companies. But Watson's peaceful farm at bucolic Buckfastleigh in southwest England has been on the front lines of an increasingly bitter struggle. Land adjoining the farm is being used by the National Institute of Agricultural Botany, which has won approval for a trial of genetically modified maize, and Watson believes that these experimental plants may contaminate his own organic maize when they release pollen later this month. So he challenged the trial in Britain's High Court, seeking to get the test plants destroyed. "I'm disappointed and angry. This is not what consumers want, and things are moving too fast for the full environmental impact to be assessed," he says.

Watson's legal quest failed last month, when the court upheld the institute's right to grow the experimental crop. But the case received huge media attention, and his fight has become a cause célèbre that led to an emergency debate in Parliament last week. It is the latest battle in a continent-wide campaign by consumer, environmental, and conservation groups to prevent genetically modified crops being grown on European soil or being imported from outside. In the United Kingdom, a poll this year found 77% of people want genetically modified crops banned, while 61% do not want to eat genetically modified food—attitudes typical of those in many European countries. Austria and Luxembourg are locked in dispute with the European Union (EU) over a genetically modified variety of maize that the EU has approved but they have banned from being planted in their fields. And Norway has banned all products from crops containing antibiotic-resistance marker genes, which have been used in the development of several crop species. Critics fear the transplanted genes could be transferred to other species.

Even Britain's royal family has joined the debate: Prince Charles, who farms his estate in western England organically, wrote a high-profile newspaper article earlier this summer attacking the development of genetically modified crops. "I happen to believe that this kind of genetic modification takes mankind into realms that belong to God and to God alone," he said. Numerous crop trials have been destroyed by protesters, and one U.K. group trashed a display of genetically modified wheat by the Biotechnology and Biological Sciences Research Council (BBSRC) at a spring farming show this year.

ANDREW TESTA

Direct action. Protesters destroy test plot of genetically modified plants.

Supermarkets have responded quickly to such public concerns about genetically modified food. In the United Kingdom most of the major retailers have introduced plans to label products containing genetically modified ingredients even before a proposed EU regulation forces them to do so. And some are committed to reducing or eliminating such products (see sidebar).

U.S. and multinational biotechnology companies are increasingly alarmed and surprised at the level of resistance in Europe to what they see as safe and innocuous technology. They view the new techniques, which have been embraced by many farmers in the United States and elsewhere with little public concern, as a seamless extension of traditional plant breeding. The United States has already approved more than 30 genetically modified crops for commercial use, with many more under trial. From a standing start in 1996, 27% of U.S. plantings of soybean are now genetically modified to carry resistance to herbicides and the share is expected to grow rapidly. Some European consumers "are not accepting this product and the benefits of biotechnology as quickly, and that is creating trade problems," Hendrick Verfaille, president of the multinational biotech company Monsanto, told a recent conference of U.S. and Canadian seed traders in Toronto.

The EU has tried to bring order to the situation, but its directives, which guide national regulations, have come under fire from biotech companies as too opaque and ineffective and from critics for not taking wider public concerns into account. "Our biotechnology industry has expressed considerable frustration at the cumbersome and unpredictable procedures in the [EU] and at the length of time it takes for the EU to review and approve products for commercialization," says Tim Galvin of the U.S. Department of Agriculture's (USDA's) foreign service in Washington, D.C., who gave evidence to a British House of Lords inquiry on the introduction of genetically modified crops last month. "Unless Europe can sort out its review processes, we could see a trade war developing."

Grassroots movement

The reasons for Europe's apparent Luddism are many and complex. In some countries, there is a general abhorrence of any genetic manipulation because of Nazi abuses of genetics in the name of science. There is also a general distrust of the food industry and official regulators, following numerous scares from salmonella, through *Escherichia coli*, to bovine spongiform encephalopathy (BSE or mad cow disease). Opponents argue that, although consumers may be taking risks by eating genetically modified food, all the benefits go into the pockets of (often U.S.–owned) biotech companies. And there are genuine differences between farming practices in the United States and Europe,

where many farms are still small and family-run and wildlife is dependent on particular farming techniques that critics fear will be changed by the new crops.

Yet the vehemence of the opposition to trials of genetically modified crops is surprising in view of Europe's willingness to embrace biotechnology for medical and other uses. There has, for example, been little ethical concern about the introduction of genetically engineered insulin for treating diabetes, or a genetically engineered version of the enzyme chymosin for cheesemaking. Ironically, because chymosin is traditionally extracted from calves' stomachs, the innovation has made cheese more acceptable for many vegetarians. And genetically modified food is already on sale: in 1996 Britain approved the sale of a tomato paste produced from plants modified to delay fruit-ripening, which was voluntarily labeled as genetically modified. The product sold well when it was introduced, says a spokesperson for one of the retailers selling it.

There are also clear signs that Europeans do see the benefits of genetic manipulation. In Switzerland, a national referendum in June on a proposal to severely restrict all transgenic research on animals and plants was defeated by a 2-to-1 margin (*Science*, 12 June, p. 1685). But it is not a blind acceptance. "In medical genetics, the public may have an eventual gain in terms of better diagnosis and treatment. By contrast, in agriculture the only clear beneficiaries of genetically modified crops are agrochemical companies, who get to retain their market share, while the public, and the environment, is left with the potential risks to their health," says biologist Tom Wakeford of the University of East London.

BBSRC

Public input. Exhibit allows people to register views on genetically modified food.

The trigger for the current wave of opposition was the unannounced arrival in Europe last year of products derived from genetically modified soybeans imported from the United States. Because there is no requirement to differentiate between modified and conventional beans in the United States, European consumers found that, unknowingly, they were eating foods that may have contained soybeans with genes for herbicide resistance. "I think that recent history with multinational companies bringing food products into Europe shows how important that early voluntary decision to label was," says geneticist Don Grierson, who led the work to develop the genetically modified tomato used in the tomato paste sold in Britain. "People were outraged because they wanted to be treated—rightly—as individuals with minds of their own," he says.

Although regulatory bodies have determined that the modified soybeans present no health hazards, tampering with the food chain without public consultation touches an extremely raw nerve—especially in Britain, which is still blighted by the legacy of BSE. "BSE was a watershed for the food industry in this country. For the first time people realized that merely attempting to ensure a culinary end product was safe to eat was not a good enough approach. We had to look at the entire process by which food is produced," says a spokesperson for Britain's Soil Association, which licenses organic growers.

There has also been a huge increase in

Can Regulations Requiring Labeling of Genetically Modified Foods Work?

Public pressure to label food containing genetically modified ingredients, as well as impending labeling legislation from the European Union (EU), has sent retailers and food manufacturers scrambling to find ways to determine whether the products they sell contain such ingredients. But critics question whether a meaningful labeling system can be achieved.

The proposed EU regulation would require labeling of foods in which "foreign" DNA or protein resulting from genetic modification can be detected. But the U.S. Department of Agriculture (USDA), commenting on the EU proposals, points out that no standard tests or limits of detection have been outlined. As a result, it says, many products may end up being labeled "may contain" or "may be produced from" genetically modified crops, with little benefit to the public. "The U.S. encourages industry to disseminate information concerning genetically engineered foods," says Tim Galvin of the USDA, "but does not believe that labeling is the most practical way."

The problem this poses for food companies is highlighted by soybeans. More than a quarter of soybean plantings in the United States—a major supplier to Europe—are now genetically modified varieties, and soybean products, such as flour, oil, and lecithin are used in a wide variety of processed foods. Because, under U.S. regulations, genetically modified varieties are considered equivalent to the conventional product, no labeling is required, and the major processing companies have not attempted to segregate the two types.

SAINSBURY'S

Up front. Tomato paste, labeled voluntarily, initially sold well.

One U.K. retail chain, Iceland, claims that it can get around these problems. Earlier this year, it announced that it will not sell any product containing genetically modified ingredients at all. The ensuing publicity may be one reason the company's sales recently shot up by 14%, says technical manager Bill Wadsworth. "Our aim is a balance between the use of lab tests and an effective audit trail from our sources," he says. The tests will use the polymerase chain reaction and other methods to detect novel DNA and proteins. The company says it will first eliminate flour and oils from genetically modified soybeans, then products derived from other genetically modified plants, and finally, products from animals that have been raised on genetically modified feeds.

Other companies are also seeking sources of unmodified soybeans, and one major chain, Sainsbury's, promises that products containing genetically modified soy will be kept to a minimum. Sainsbury's, along with another chain, Safeway, introduced the first genetically modified food to Britain—tomato paste in 1996. The paste initially sold well, says a company spokesperson, but the current publicity surrounding genetically modified foods may hurt sales.

Not all biotechnology companies oppose labeling. Monsanto, in its current newspaper advertising campaign, supports the move in the hope that, if it is open about genetically modified foods, it will eventually be able to win over reluctant consumers. **–N.W.**

demand across Europe for organically produced products. Already this year 140 British farmers have applied for accreditation as organic producers—445 are currently licensed—and the number of European organic producers has risen by 24% to 62,000 since 1996. Some countries, such as Sweden and Austria, are now almost 9% organic in terms of land area compared with about 2% 5 years ago.

More systematic samplings of public opinion have provided little comfort for the biotech industry. A "citizen's panel" project, organized by the University of East London earlier this year, provided an opportunity for 12 members of the public with no specialist knowledge of biotechnology to give their verdict on the technical issues following questions to a range of expert witnesses. The panel concluded that genetically modified foods provide no benefit to the consumer and that the risks they pose, both to long-term human health and to the environment, are unknown. However, they were not against laboratory research continuing into possible future benefits.

France also recently held a high-profile public "consensus conference" on genetically modified crops. A polling organization identified 14 lay people who had no prior scientific knowledge; they were then given intensive briefings and posed questions to experts. After that intense exposure to the issue, the panel called for the prohibition of antibiotic marker genes in transgenic crops, separation and labeling of transgenic and unmodified products, and a legal liability on any unforeseen consequences of introducing a transgenic product into food or the environment.

Environmental backlash

Public fears about safety are not the only problem agricultural biotech companies face in trying to market genetically modified products in Europe. Critics have also raised concerns about the possible environmental effects of introducing crops that might change farming practices. They argue, for example, that planting herbicide-resistant varieties could lead to changes in the use of herbicides that, in turn, might damage critical habitats. "There is insufficient assessment of any wider environmental impact of the effects of management practices that may be changed in growing the crop," says population biologist Brian Johnson, adviser on genetically modified organisms to the conservation body English Nature.

Changing farming practices is a key issue, conservationists say, because the farming environment in Europe is different from that in the United States. "In the U.S., you have farming, or you have wildlife, with only 28% of the land cultivated," says Johnson. "In Europe, farming and wildlife are intimately interlinked with 80% of U.K. land cultivated. So the impact of genetically modified crops, and the new management plans for the use of pesticides for herbicide-resistant crops, may have a devastating impact on wildlife species, many of which have already been highly damaged by intensification," he says.

"Narrow strips of land around field margins left to grow weeds and other wild plants provide a vital habitat and food source for many creatures, and are highly vulnerable to changes in management practices," says a spokesperson for Britain's Royal Society for the Protection of Birds (RSPB), with more than 1 million members Europe's largest conservation charity. Any changes in pesticide use that could destroy these plants could have a serious impact on wildlife. "There's no requirement to look at the effects of a genetically modified crop on other organisms. It's a very flawed process," says Johnson. English Nature and the RSPB have called on the government to introduce a moratorium on commercial release until further work on the environmental impact of genetically modified crops can be better assessed.

Marginal concerns. Weedy field margins, which may be vulnerable to changes in herbicide use, provide habitat for many species.

P.W./ENGLISH NATURE

European researchers are also beginning to find evidence of a potential environmental impact of genetically modified crops themselves and the need to monitor their effects carefully. Some groups have found evidence that genes from genetically modified crops can be transferred to native species via pollen. Other work by researchers at the Swiss Federal Research Station for Agroecology in Zurich has shown that lacewings, a natural predator of aphids, may be harmed by eating aphids on maize modified to express an insecticidal protein from *Bacillus thuringiensis*. Studies led by Nick Birch at the Scottish Crop Research Institute in Dundee have also found a similar effect with genetically modified potatoes containing a novel lectin, which reduces aphid attack without killing them. Ladybirds that feed on these aphids suffered significant loss of viability of their eggs compared to ladybirds feeding on control aphids. "There is a problem with monitoring programs. They have been a little bit forgotten," says Marcel Bruch, a biotechnology adviser to the Luxembourg government. But Swiss drug and agrochemicals giant Novartis says that extensive studies on its modified maize show that it is as safe as conventional maize in terms of its impact on beneficial insects and other wildlife.

Regulatory disharmony

Biotechnology companies hoping for relief on the regulatory front are facing disappointment there, too. The EU's attempts to ensure that uniform approval procedures for genetically modified crops are adopted across Europe seem to have stalled. In 1992, the European Commission, the EU's executive in Brussels, approved a directive spelling out licensing procedures for trials of genetically modified crops in the field and their commercial release. Each national government was required to incorporate it into its own law. According to the directive, if a crop is licensed for commercial growing following trials in one or more member states, then all member states must include the crop in their national lists of varieties approved for sale and cultivation.

That aim was soon put to the test. In 1995, the French government approved the commercial release in France of a genetically modified maize developed by Novartis. That approval was endorsed by the Commission in 1996 so that growers across all 15 member states could adopt the new crop. Austria and Luxembourg, however, refused to adopt it. Meanwhile, in France, after the Socialist Party wrested power from the conservatives in the 1997 general election, it bowed to pressure from Green Party colleagues and the public and last November announced a moratorium on any further approval or commercial releases of genetically modified crops.

Critics also contend that national licensing systems are open to abuse because safety data submitted to regulatory bodies comes from industry, and industry is also responsible for following up any permitted release. "They need to tear up [the directive] and start again," says biologist Mark Williamson of the University of York, who also presented evidence to Britain's House of Lords inquiry.

The European Commission is now consulting with interested parties on major amendments to the directive regulations. At the same time, the EU has also introduced plans to enforce the labeling of products

containing genetically modified ingredients, starting later this year. But again, the plan has infuriated U.S. authorities. "The proposed [labeling] regulations have a questionable scientific basis and are ambiguous and impractical," says USDA's Galvin.

Biotech firms go public

Concern about public opinion has led the U.K. government to establish a new panel to develop public consultation on the future of the biosciences. Britain, which held the presidency of the EU for the first half of this year, championed the need to bolster biotechnology. The science minister, John Battle, told a special conference in Brussels in June that issues of public perception had to be addressed. "The debate about biotechnology is still to be won," he said. And Tom Wakeford, a member of the new consultation panel, says it will have to be careful to allow the public to distinguish between genetic engineering directed toward medical, as opposed to agricultural, applications. "There are fundamental differences in each case as to who are the risk takers and who are the beneficiaries," he says.

The biotechnology industry has also begun to take its case to the public. Monsanto has been running a newspaper advertising campaign in Britain and France, which now backs European calls for labeling of genetically modified products. In Britain, the BBSRC has launched a touring exhibit, In-gene-ious, to raise public awareness about biotechnology. Spokesperson Monica Winstanley says the stand has attracted a great deal of interest from farmers and the public wanting to know more about the technology. "We're trying to get to the bottom of what people are concerned about—concerns that are amenable to a realistic response." How the technology has been handled by the multinational companies is one perceived problem, she says. But some protesters have tried to block the message: At Britain's premier agricultural show last month pots of genetically modified wheat were attacked.

But in spite of current stiff resistance, even the European states that have taken the hardest line are keeping the door slightly ajar. "We don't, in principle, oppose the development of biotechnology," says Georg Rebernig, a member of the Austrian representation to the EU in Brussels. "Our concern is that there is greater transparency and harmonization on risk assessment," he says. "The biotechnology industry has huge potential, but it can't force products down people's throats. It's vital the industry does everything possible to regain the trust of the people."

Others also believe the industry can reverse its current fortunes in Europe. "Our view is that we need more time to do more research on the wider impacts of genetically modified crops. This first generation of crops can be seen as quick and dirty. We'd like to see more sophisticated gene modification of crops and their assessment to show that they don't damage the environment," says Johnson of English Nature. "We support the development of genetically modified crops that can bring environmental benefits."

–NIGEL WILLIAMS

RADIO ASTRONOMY

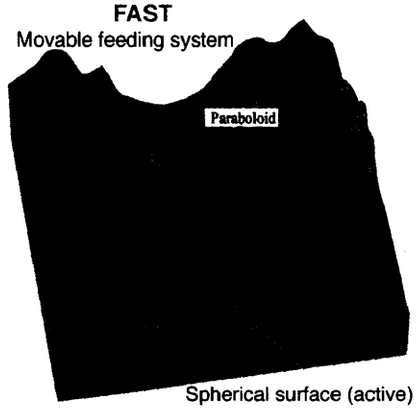
China Hopes to Move FAST on Largest Telescope

Chinese astronomers have the go-ahead to design a 500-meter dish that they hope will anchor a major international project

BEIJING—The terrain in southwest Guizhou Province—hundreds of round depressions, each surrounded by hills a few hundred meters high—already looks like a scene from another world. If astronomers get their wish, it will someday sprout a collection of instruments that would make it look even more like the backdrop to a science fiction movie.

China has embarked on a project to build the world's largest radio telescope, a spherical dish 500 meters in diameter, in this haunting landscape. The facility could make China a major player in the field. "Perhaps we can even achieve something that will bring a Nobel Prize to China," says project director Peng Bo of the Beijing Astronomical Observatory. But Chinese scientists are hoping for even more: They see the telescope as the forerunner of a billion-dollar, internationally funded radio array that would probe the very earliest stages of the universe.

Astronomers around the world are looking on with interest. Several years ago, an international team of astronomers began putting together plans for such an array, a cluster of instruments that, in combination, would form a collecting area 1 kilometer on a side. Operating at wavelengths of several centimeters to a meter and at frequencies up to 10 gigahertz, the array would be able to peer back in time, looking for traces of atomic hydrogen, the building block of the universe, which emits a very weak spectral line at a wavelength of 21 centimeters. It could also probe for heavier molecules, including carbon dioxide, that indicate star formation, as well as exotic objects such as pulsars and the physics of black holes.



Natural advantage. China's proposed radio telescope could be forerunner of a massive array that makes use of the unusual landscape.

YAN *ET AL.* / FAST PROJECT GROUP

But such collecting power doesn't come cheap. The reigning individual heavyweight of radio astronomy, a 305-meter dish in Arecibo, Puerto Rico, run by Cornell University for the National Science Foundation, would cost about $100 million to replicate. And the square-kilometer array—with a collecting area of 1 million square meters—would require roughly 25 such dishes. (Arecibo has an effective collecting area of 40,000 square meters.) "There is nothing in the square-kilometer array that can't be done, from a technical perspective, except that it would cost many billions of dollars," notes Britain's Peter Wilkinson of the University of Manchester observatory at Jodrell Bank. So finding ways to save money is critical.

Enter Guizhou. Its plentiful limestone formations, called karsts, provide naturally occurring bowls in which the large receiving dishes can be suspended. "The geology is similar to Arecibo, and they have the largest number of such depressions anywhere in the world," says Richard Strom of the Netherlands Foundation for Radio Astronomy, who has visited the site and has been active in planning the array. Having an existing hole in the ground reduces construction costs by as much as 90%, estimates Wilkinson. Still, the costs of scaling up are formidable. "It's a huge global undertaking that's unlikely to be decided before 2010," says Wilkinson.

Chinese officials have decided not to wait before taking the first step, however. This spring, the Ministry of Science and