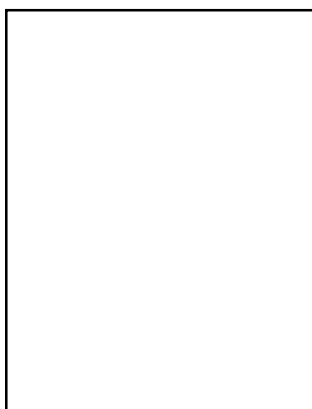


Food and agricultural biotechnology for the 21st century

Daniel D. Jones

Research on plant and animal biotechnology is proceeding at breathtaking speed, with many new discoveries and inventions almost daily. New frontiers in food and agricultural biotechnology are being crossed. This promises to transform the production of agricultural commodities in significant ways in the new century. This article attempts to discuss some related concerns and issues and provides insight into some case experiences of new biotechnological applications in agricultural and food production.



Dr. Daniel D. Jones

National Programme Leader Biotechnology

*Cooperative State Research
Education and Extension Service*

*US Department of Agriculture
Waterfront Centre, Room 3002,
800 9th Street S.W.*

Washington, DC, 20026, USA

Tel: +1(202) 401-6854

Fax: +1(202) 401-1602

E-mail: ddjones@reeusda.gov

Introduction

The discovery and applications of new techniques of molecular biology in food and agriculture are proceeding at a breathtaking pace. From the discovery of restriction enzymes for cutting and pasting sequences of deoxyribonucleic acid (DNA) in 1970, through the first transfer of foreign genes into tobacco in 1983, to the commercialization of transgenic corn and soybeans in 1995, developments in food and agriculture are creating new products and raising new issues for scientists, businessmen, regulators, and consumers.

Current research on plant and animal genomes promises to change the production of agricultural commodities in significant ways. Changes in the manufacture and marketing of food and fibre products are occurring so rapidly that many consumers do not have time to react to them in a rational way.

The purpose of this article is to review some of the pending concerns and issues in food and agricultural biotechnology, to survey alternative ways of addressing them, and to describe some examples and case studies of the new biological technologies as applied to agricultural and food production. For the purposes of this article, I shall define "biotechnology" broadly to mean the use of living organisms or parts of living organisms to produce a useful product. I shall use the term "genetic modification" or "genetic engineering" in a more limited sense to mean the use of recombinant DNA to accomplish intended genetic changes. Recombinant DNA is defined by the US National Institutes of Health Guidelines as either (i) molecules that are constructed outside living cells by joining natural or synthetic DNA segments to DNA molecules that can replicate in a living cell, or (ii) molecules that result from the replication of those described in (i) above.¹

Benefits and risks

Food and agricultural biotechnology, in common with most technologies, presents both the promise of benefits and the potential for risks. Potential benefits of agricultural biotechnology include the possibility of higher crop yields, reductions in fertilizer and pesticide use, tolerance of adverse climates, greater use of marginal lands, fewer adverse environmental impacts, identification and elimination of diseases in food animals, and better food quality and nutrition, including restoration of micronutrient deficiencies. A recent example of the micro-nutrient benefit is a newly developed strain of "Golden Rice" that contains higher levels of β -carotene, a precursor of Vitamin A. This genetically engineered rice could help to prevent blindness and other health disorders resulting from Vitamin A deficiencies around the world.

Potential risks to agriculture and the environment include adverse effects on non-target organisms, development of pest resistance, and unintended transfer of genes, including gene transfer to wild relatives of crops, transfer of genes coding for toxic gene products, and transfer of antibiotic resistance via antibiotic marker genes. In the USA, known risks to agriculture and the environment are often addressed through the development of public documents on potential environmental impact and sometimes accompanied by specific regulatory requirements and mitigation measures. For example, the US Environmental Protection Agency (EPA) requires that farmers who plant genetically modified plants that produce their own biopesticide also set aside a percentage of land planted with unprotected plants to decrease biological selection pressure and slow the development of pest resistance to the biopesticide.²

Environmental risks of a less certain nature are frequently the subjects of discovery and risk-related research. For example, the US Department of Agriculture (USDA) supports a National Research initiative which funds discovery research in the areas of natural resources and environment; nutrition, food quality, and health; plant systems; animal systems; markets, trade, and policy; and new products and processes.³ In addition, USDA supports a biotechnology risk as-

essment research programme which funds research on the introduction into the environment of genetically modified organisms (GMOs) and the large-scale deployment of GMOs.⁴

Finally, in fiscal year 2000, USDA supported an Initiative for Future Agriculture and Food Systems designed to address critical emerging agricultural issues related to future food production, environmental quality and natural resource management, and farm income.⁵ This programme also included specific funds for research into the effects of agricultural biotechnology on human, animal, and plant health and the social and economic aspects of agricultural biotechnology.

Potential risks of genetic changes to food include the possible reduction of nutrient content, the possible increase in toxicant content, and the possible transfer of genes for allergy-causing substances into new foods. In the USA, the Food and Drug Administration (FDA) conducts a consultative process with companies proposing to market genetically modified foods based on specific regulatory recognition of the possibility of these unintended, adverse effects in genetically modified food.⁶ A number of genetically modified foods have been the subject of these consultations and have been successfully marketed with no known adverse effects to date.⁷

Safety of GM foods

In general, traditional foods and genetically modified (GM) foods look and taste the same. GM foods contain one or a few genes out of thousands of genes in a plant or animal that are different from those in traditional foods. These genes yield traits that may be beneficial to the grower, food processor, consumer, and the environment. Yet, because the genetic expression of a single gene can have profound effects on a plant or animal, those with responsibility for evaluating the safety of GM foods have sought approaches that are satisfactory from the standpoints of science, public policy and acceptability to consumers. In recent years, two contrasting approaches to evaluating the safety of GM foods have been developed. They are respectively called the method of substantial equivalence and the precautionary principle.

Substantial equivalence

The essence of the substantial equivalence approach to evaluating the safety of a new food product is to compare the new product to a familiar or traditional product. If it can be demonstrated that the new product will not affect human health or the environment differently from its traditional counterpart, then the new product is considered "substantially equivalent" to the existing product. Historically, the substantial equivalence approach was originally developed in the context of medical device evaluation in the USA⁸ and was later adapted to the evaluation of new foods. The selection of which specific characteristics to include in the comparison, and exactly how to compare them can be important topics of discussion and perhaps generate disagreement. Even so, the substantial equivalence approach has been generally accepted by several national authorities, the Organization for Economic Cooperation and Development⁹, and other international organizations.

Differing interpretations of the purpose and basis of the substantial equivalence approach have resulted in an ongoing debate about its adequacy. Critics have attacked the motivation and procedures of the substantial equivalence approach as inherently suspect.^{10,11} Proponents have just as fervently defended it.^{8,12,13} A possible future dilemma is whether reliance on the substantial equivalence approach for purposes of safety determination will undermine marketing goals of product differentiation and identity preservation. In other words, can a food manufacturer have both substantial equivalence and a product that is sufficiently distinctive from others to market it successfully? Further experience with the application of substantial equivalence in the food industry should help to illuminate some of these questions.

The precautionary principle

Another approach to the safety evaluation of GM foods is the precautionary principle.

Historically, it originated in Germany in the 1970s in the context of environmental and sustainability issues.¹⁴ The precautionary principle can be stated in non-technical language as follows: "When a product or 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.¹⁵ Other versions of the precautionary principle are summarized in Reference 27. The precautionary principle has received official recognition as a basis for environmental law in the Treaty on European Union¹⁶ and as a tool of sustainable development in the United Nations Conference on Environment and Development.¹⁷

The precautionary principle has stimulated a great deal of discussion and debate. Critics argue that the precautionary principle challenges scientific reliance on experiment, theory falsification, verification, consistency, and predictability.¹⁸ Proponents argue that the precautionary principle represents an attempt to take science seriously, not to discard or revise it.¹⁴ Others charge that decisions based on the precautionary principle are veiled forms of trade protectionism. Recent examples include bans on US and Canadian beef because of the use of growth hormones and delays in the approval of GM crops in European markets.¹⁶ It will probably take some time for the scientific and legal arguments engendered by the precautionary principle to be resolved.

Labelling of GM foods

Another burning question is whether GM foods should be labelled. The current situation in the USA is that GM and non-GM foods may be labelled voluntarily as long as the label is accurate and not misleading. There is currently no requirement in the USA to label GM foods unless a known allergen is present or the composition or nutritional content has been substantially changed. There is discussion in the USA about the possibility of labelling GM foods on the basis of the consumer's right to know how a food was prepared, but a definitive resolution has not yet been reached.

A labelling issue also arises when companies wish to label their products as not being GM. For example, it would be inaccurate to label milk as not containing bovine growth hormone because milk contains certain levels of naturally-occurring bovine growth hormone. On the other hand, it may be

accurate for a label to indicate that milk is from cows who have not been administered bovine growth hormone.

Labelling of GM foods raises a number of issues and implications:

- *The percentage of GM ingredients in a food that would trigger special labelling.* Preliminary national efforts in this area have come up with different percentages ranging from a proposed one per cent tolerance in the European Union¹⁹ to a 5 per cent tolerance in Japan.²⁰
- *Whether liability issues about the presence or absence of GM ingredients require segregation of GM and non-GM commodities.* Commodity segregation would most likely increase the cost of food distribution significantly.
- *Whether liability issues require strict identity preservation and chain-of-custody records for commodities and ingredients.* Identity preservation presents its own set of costs in terms of finance and record-keeping. The European Community estimates that identity preservation ranges between 6 and 17 per cent of the farmgate price for different crops.²¹
- *Whether commodities and food products need to be tested for genetic changes.* DNA test kits are already available for specific DNA sequences associated with particular genetic events.
- *Whether new DNA test methods need to be developed and validated and whether those who perform DNA tests need to be accredited or certified.* USDA has begun to set aside funds and other resources for validating DNA test methods.

These and other questions will complicate discussions of food labelling for the foreseeable future.

A number of proposals for GM food labelling have been published, and only a sampling can be presented here. For consumers who wish to avoid GM food products, organic foods are an option. The US draft National Organic Standards rules prohibit the use of genetic engineering in organic food production.²² If this prohibition is included in the final standards, then purchasing organic food products would be one way to avoid GM food.²³ Another recent publication discusses GM organisms in the context of the global trading system and

proposes a system of voluntary labelling of GM food products.²⁴

Case studies

USDA supports research that facilitates progress and breakthroughs in food and agricultural biotechnology. USDA administers a number of special grants in biotechnology that are non-competitive, authorized by Congress, and approved by the President. Some of these projects illustrate the broad range of applications of biotechnology and genetic engineering to food and agricultural production.

The first case involves corn rootworm, a serious pest of corn in the USA. Researchers from Purdue University, along with an industrial collaborator, isolated a group of genes from soybeans and other legumes. These genes interfere with digestion of proteins by rootworm larvae and prevent their growth. The research team transferred one of the genes from soybean into corn and arranged it so the gene is expressed only in corn roots. The rootworms which feed on the roots of the inhibitor-containing plants fail to grow and thereby do little damage to the corn. The Purdue team identified a whole series of inhibitor genes with different modes of action. These inhibitors are available for use in case the corn rootworm develops resistance to the original inhibitor now in the field. Thus, a whole arsenal of resistance genes, not just one, has been developed from this one research project.

A second example is improvement of the lysine content and nutritional value of corn. Most varieties of corn do not provide enough of the essential amino acid lysine to meet the dietary needs of animals such as swine and poultry. As a result, feed for these animals must be supplemented with lysine at an annual cost of about US\$70 million. Researchers at the University of Minnesota are working to improve the ability of the corn plant to produce increased quantities of lysine contained in each kernel. Geneticists have isolated the genes that control the production of lysine in corn. The use of advanced genetic techniques is allowing researchers to manipulate the genetics of the corn plant so that lysine can be produced in useful quantities in each corn kernel. The overall goal of this research is to produce high-lysine elite lines of corn plants that will facilitate the

development of new corn varieties that produce consistently high lysine levels.

A final example that does not involve recombinant DNA, but does involve biotechnology in addressing critical agricultural problems, is the conversion of agricultural and livestock wastes to more useful products. Research supported by a USDA special grant and carried out by the Iowa Biotechnology Byproducts Consortium has resulted in significant advances in the development of technologies for the conversion of agricultural byproducts, including organic wastes, to methane. An Anaerobic Sequencing Batch Reactor (ASBR) uses a microbial process to break down plant and animal wastes to produce methane. The ASBR is being used to treat wastewater from plants processing pork, beef, and oats. Another important application of the ASBR is the conversion of swine wastes to methane, which virtually eliminates the obnoxious odours common to confinement-swine feeding facilities. It is the general belief that this new system is a breakthrough in swine waste management that will virtually eliminate current problems with waste and air pollution arising from swine production facilities.

A second development by the Iowa Consortium is the Temperature Phased Anaerobic Treatment Process (TPATP) which improves upon conventional technology to achieve higher conversion rates of sewage and other waste streams. This system operates with two reactors in series, operating at two different temperatures. TPATP systems are less than one-half the size of conventional systems currently in use and could result in major savings in reactor capital costs.

This system has also been shown to destroy disease-causing microorganisms in waste streams. This is particularly important when streams contain wastes from human sources, and is of great importance to cities that must meet the new federal standards for disposal of sewage sludge. The temperature-phased process offers the opportunity to greatly reduce the cost of sludge disposal and to increase the effectiveness of water treatment in urban settings. These and other examples of the application of biotechnology to food and agricultural production are described in Reference 25.

DNA testing

If consumers and food producers continue to have sufficient concern about the GMO content of food products, it may become necessary to test commodities and food products for the presence of specific genetic changes. These tests may be necessary in order to document product identity preservation and to address potential legal liability issues. A number of DNA test kits are available today, but the proliferation of biotechnology applications in agriculture and food production may require the development of a wider variety of DNA tests in the future. This raises the question of the validation of test methods and the accreditation of testing laboratories.

On 4 May 2000, the USDA announced that it would help standardize the identification of biotechnology-derived grains by accrediting laboratories and evaluating tests used to detect the presence of genetically modified grains. USDA's Grain Inspection Packers and Stockyards Administration (GIPSA) will, upon request, review laboratories testing grains for the presence of biotechnology-derived grains and will accredit those laboratories that meet performance standards. In addition, GIPSA will evaluate test kits against the manufacturer's performance specifications for determining the presence of biotechnology-derived grains in bulk grain to ensure that these tests are accurate and reliable. Testing laboratories in the USA and manufacturers of commercially available test kits marketed and sold in the USA will be invited to participate. In the words of the US Secretary of Agriculture, "We want to provide consumers, farmers, and industry with more information about biotechnology-derived foods and we want to ensure that information is accurate and reliable."²⁶

Trade in GMOs

Issues such as the safety and labelling of GMOs have surfaced in recent discussions on international trade. The Cartagena Protocol on Biosafety adopted earlier this year in Montreal achieved compromises on some of these issues, but did not necessarily solve all of them. For example, the protocol will assist the development of biosafety regulatory frameworks in developing countries. Also, some developed countries achieved their goal of securing an

agreement that does not mandate segregation of GMO and non-GMO commodities, although commodity segregation could occur for other reasons. Weaknesses in the agreement include the absence of a dispute-settling mechanism and vagueness on liability and compensation issues.

The protocol opened for signature in May 2000 and it will enter into effect after 50 countries have ratified it. For a balanced and comprehensive discussion of the Cartagena Protocol and its impact on international trade in GMOs, see Reference 27.

The long term

Over the past several years, agricultural biotechnology has evolved from essentially a laboratory curiosity to a force to be reckoned with in the global environment, human society at large, and international trade. Millions of acres of crop land are planted with transgenic crops, which now constitute a significant portion of the total agricultural output in a number of countries. The societal effects of a phenomenon of this magnitude could be unpredictable if we do not have a forward-looking plan for managing it. In July 1999, the US Secretary of Agriculture outlined a series of five principles for managing the social and economic development of agricultural biotechnology in the 21st century.²⁸ These principles were designed specifically for the US situation, but others in the international community may wish to consider them as possible guidelines for developing policy on food and agricultural biotechnology as well. The five principles enunciated by the Secretary are:

- An arm's length regulatory process;
- Consumer acceptance;
- Fairness to farmers;
- Corporate citizenship; and
- Free and open trade.

Regulatory process

Government officials responsible for regulating public health, safety, and the environment must maintain an objective, dispassionate distance from the companies developing and promoting products of biotechnology. USDA is taking several steps to assure an objective regulatory process. These include a request for an independent scientific re-

view of USDA's biotechnology approval process, and the establishment of regional centres around the country to evaluate biotechnology products over a long period of time and to provide information on an ongoing basis to growers, consumers, researchers and regulators.

Consumer acceptance

Consumer acceptance of biotechnology products depends critically on a rigorous and open regulatory process. Only in this way will consumers be able to develop confidence that the safety of these new products is being evaluated objectively.

Other factors that could affect consumer acceptance are informative labelling as a basis of purchasing decisions, responsible media coverage of biotechnology issues, private sector outreach, and public education that deals even-handedly with both the risks and the benefits of agricultural biotechnology. With success in these areas, farmers, consumers, and others may eventually come to realize the economic, environmental, and health benefits of biotechnology products.

Fairness to farmers

Biotechnology, in the Secretary's view, should result in greater, not fewer, options for farmers. The technology should provide real and meaningful results for farmers, regardless of the size of the farming operation. Production contracting, consolidation, market concentration, vertical integration and proprietary research can each create obvious pitfalls for farmers. Overzealous pursuit of corporate intellectual property rights can pit farmers against their neighbours and have a destabilizing effect on farm communities. The Secretary believes that farmers are as entitled to meaningful choices about using or not using advances in biotechnology as consumers and companies are.

Corporate citizenship

The Secretary believes that biotechnology companies must understand and respect the roles of farmers, consumers, and regulators in addition to pursuing profits. To succeed in the long term, industry needs to act with sensitivity and foresight, not only in promoting its products, but also in countering anti-bio-

technology activists' views that feeding the world is simply a cover for corporate profit-making. The basic principles of good corporate citizenship and sensitivity awareness are key components of successful long-term business practice.

Free and open trade

With significant amounts of US corn and soybeans being produced from genetically modified seeds and other commodities moving in the same direction, the Secretary is concerned that some countries are erecting what amount to non-scientific trade barriers to GM commodities and food products.

Failure to work out GMO disagreements in a sensible way could significantly damage international trade and have an adverse effect on both agricultural and non-agricultural issues in the long run. Bilateral and multilateral agreements on trade in GMO foods and commodities are the preferred way of addressing these issues. Enforcement actions under international trade treaties are a next resort, but they may also have undesirable negative results on trade relations and public support.

Conclusion

Genetic engineering and biotechnology will undoubtedly have a profound effect on agricultural and food production in coming years. There is enough potential synergism in the application of biotechnology and GM to food and agricultural production to ensure that farmers, consumers, and companies have meaningful choices and a chance to realize true benefits.

At the same time, as with most new technologies, there is a remote but real possibility of unintended effects of GM in food and agricultural production on health and the environment if the technology is not managed properly. These unintended effects have the potential to be perceived as negative for the future of the technology if they are not offset by benefits elsewhere in the social system. With adequate patience and foresight, we should be able to develop adequate public policies to monitor, control and minimize potential risks of biotechnology and any possible adverse impacts on public health, the environment, and society at large.

References

1. US National Institutes of Health, *Guidelines for Research Involving Recombinant DNA Molecules, Section I-B. Definition of Recombinant DNA Molecules*, available at <http://www4.od.nih.gov/oba/sect1.htm>, accessed 6 September 2000.
2. Matten, S.R., "EPA regulation of resistance management for Bt plant-pesticides and conventional pesticides" in *Resistant Pest Management*, 10 (2), Winter 1998, 3-9.
3. U.S. Department of Agriculture, National Research Initiative Competitive Grants Programme, 2000. Programme description, available at: <http://www.reeusda.gov/nri/programs/progdesc/nripd.htm>, accessed 6 September 2000.
4. U.S. Department of Agriculture, "Biotechnology Risk Assessment Research Grants Programme". Description, available at: <http://www.reeusda.gov/crgam/biotechrisk/biotech.htm>, accessed 6 September 2000.
5. U.S. Department of Agriculture, "Initiative for Future Agriculture and Food Systems", available at: <http://www.reeusda.gov/ifafs/>, accessed 6 September 2000.
6. U.S. Food and Drug Administration, Guidance on Consultation Procedures, "Foods Derived from New Plant Varieties", October 1997, available at: <http://vm.cfsan.fda.gov/~lrd/consulpr.html>, accessed 6 September 2000.
7. U.S. Food and Drug Administration, "Foods Derived from New Plant Varieties Derived through Recombinant DNA Technology", Final Consultations under FDA's 1992 Policy, May 2000, available at: <http://vm.cfsan.fda.gov/~lrd/biocon.html>, accessed 7 September 2000.
8. Miller, H., "Substantial equivalence: Its uses and abuses", *Nature Biotechnology*, 17 November 1999, 1042-3.
9. Anon., Report of the OECD Workshop on the Toxicological and Nutritional Testing of Novel Foods, SG/

- conomic Cooperation and Development (OECD), Paris, 1998.
10. Millstone, E., E. Brunner, and S. Mayer, "Beyond 'substantial equivalence'", *Nature*, 7 October 1999, available at: <http://www.plant.uoguelph.ca/safefood/gmo/se-response.htm#millstone>, accessed 7 September 2000.
 11. Fagan, J., "The Failings of the Principle of Substantial Equivalence in Regulating Transgenic Foods", available at: <http://www.purefood.org/subequiv.html>, accessed 7 September 2000.
 12. AgBios, Inc., "Substantial equivalence and its application in GM food safety assessment", available at: <http://www.plant.uoguelph.ca/safefood/gmo/se-response.htm#agbios>, accessed 7 September 2000.
 13. Taylor, S. and S. Hefle, "Reponse to 'Beyond Substantial Equivalence'", available at: <http://www.plant.uoguelph.ca/safefood/gmo/se-response.htm#taylor>, accessed 7 September 2000.
 14. van Dommelen, A., *Hazard Identification of Agricultural Biotechnology: Finding Relevant Questions*, International Books, Utrecht, 1999.
 15. Raffensperger, C., "Info Re: Precautionary Principle", FLORA Community Web, 28 Jan 1998, available at: www.flora.org/flora.mai-not/2166, accessed 7 September 2000.
 16. Foster, K.R., P. Vecchia, and M.H. Repacholi, "Science and the Precautionary Principle", *Science*, 288, 979, 2000.
 17. United Nations Conference on Environment and Development, "Environmentally Sound Management of Biotechnology", *Agenda 21: Programme of Action for Sustainable Development*, Rio de Janeiro, 1992.
 18. O'Riordan, T., and A. Jordan, "The Precautionary Principle in Contemporary Environmental Politics", *Environmental Values*, 4, 191, 1995.
 19. Hodgson, J. "EC Says 1% Is Acceptable GMO 'Contamination'", *Nature Biotechnology*, 17 December 1999, p. 1155.
 20. Anon., "Japan Announces Tolerance", *AgBiotech Reporter*, 17(3), March 2000, p. 20.
 21. European Community, *Economic Impacts of Genetically Modified Crops on the Agri-Food Sector*, 2000, available at <http://europa.eu.int/comm/dg06/publi/gmo/summary.htm>, accessed 7 September 2000.
 22. U.S. Department of Agriculture, "National Organic Programme; Proposed Rule", *Federal Register*, 65(49), p. 13511-13560, 13 March 2000.
 23. Apel, A., "Labelling the Industry Can Live With", *AgBiotech Reporter*, 17(5), May 2000, p. 26.
 24. Schulz, E., *The Opportunities and Hazards of Agricultural Biotechnology*, Economic Strategy Institute, Washington, DC, 2000.
 25. Anon., *Putting Research to Work for America*, Michigan Biotechnology Institute International, East Lansing, Michigan, U.S.A., 1998.
 26. US Department of Agriculture, *USDA to Validate Tests for Biotech Grains, Accredited Labs*, press release available at <http://www.usda.gov/news/releases/2000/05/0147>, accessed 7 September 2000.
 27. Gupta, A., "Governing Trade in Genetically Modified Organisms: The Cartagena Protocol on Biosafety", *Environment*, 42(4), May 2000, 23-33.
 28. Secretary of Agriculture Dan Glickman, *New Crops, New Century, New Challenges: How Will Scientists, Farmers, and Consumers Learn to Love Biotechnology and What Happens If They Don't?*, Remarks to the National Press Club, Washington, DC, 13 July 1999, available at <http://www.usda.gov/news/releases/1999/07/0285>, accessed 7 September 2000.

Acknowledgments

The author gratefully acknowledges Deborah Windish of MBI International for narrative input on the case studies and Ramkishan Rao and Jamshyd Rasekh of USDA for helpful comments on the draft manuscript. □

Note: The views expressed are the author's and do not necessarily represent the policies or interpretations of the US Department of Agriculture or the US Government.

JEMU suppliers database on website

There is a significant advance in the accessibility of information on UK sources of environmental solutions, with the launch of the JEMU (Joint Environmental Markets Unit) database on the World Wide Web www.dti.gov.uk/jemu.

The new database will offer free access to information on over 5,000 UK environmental companies and organizations and will also enable direct access to the individual company/organization website where provided. The web version will be complemented by a new issue of the database on CDROM, which will be available shortly from JEMU/TPI.

Users may choose a standard or advance search, using either the company name or a combination of key words and environmental sector. To search the database, click 'UK supplier database' on the JEMU homepage. Sectors to choose from include, air pollution control, energy management, contaminated land, marine pollution, noise and vibration control, recovery and recycling, renewable energy, waste management, and water and wastewater treatment.

A more detailed search can be carried out by specifying a sub-sector, so, for air pollution control, users have a choice of sub-sectors in dust and fume control, SO₂ and HCl control, NO₂ control and VOC and odour control.

Contact: The Technology Partnership Initiative (TPI), 151 Buckingham Place Road, London, SW1W 9SS.
Tel: (+44-20) 7215 1037 Fax: (+44-20) 7215 1089, E-mail: jemu-tpi@end.dti.gov.uk, <http://www.dti.gov.uk/jemu>

Source: TPI News, July 2000