Where change is the only constant. A diverse range of applications over the next decade will change the nature of the debate about biotechnology. Europe's response will be critical.

a commentary by Donal Nugent (Council for Agricultural Science and Technology)

For the Spanish conquistadores who encountered the flourishing civilizations of Mexico in the 16th century, the diet of these new peoples was a source of some wonder. Corn (maize), in particular, they noted was held in the highest regard. Ironically for a crop that had its own god, this food is almost entirely the product of human ingenuity. From humble weedy relatives, centuries of selective breeding have created these powerful stalks crowned with golden cobs. The modification of genes has been a human endeavor since the birth of civilization but, as the ancient Mexicans knew, nature likes to take its time. Today, even at its most advanced, conventional agronomy needs between 10 to 12 years to generate a new crop variety. This is because plants need to be back-crossed, that is bred with distant relatives, to ensure unwanted genes are eliminated while retaining the desired trait. Biotechnology, as a process that facilitates the transfer of individual genes, bypasses this process and allows for the direct incorporation of traits. This is the source of both its promise and its controversy.

To date, the most commercially successful genetically modified varieties of crops have had genes added that make them either disease resistant or herbicide tolerant. There is a good reason for this. The need to commercialize crops that bring significant financial returns is a matter of business expediency, given the enormous costs and rigorous regulatory procedures involved. On-going research in universities and industry around the world points to an array of novel applications for biotechnology which will certainly impact further the food we eat but which will also bring even more dramatic developments in diverse applications from biofuels, plastics and pharmaceuticals.

Jurassic Park – Not Yet Open For Business

While the best-known biotech engineered crops are soy and corn, disease resistant or herbicide tolerant varieties of most major fruits and vegetables have also been developed. For a variety of reasons, mostly to do with consumer acceptance, the majority has yet to be commercialized. One notable exception, however, points to the future potential of the technology. The dream of resuscitating extinct species may still be the stuff of Spielberg, but a more practical success can be claimed with the resuscitation of the ailing Papaya industry in Hawaii. Papaya Ringspot Virus had put the industry into a serious long-term decline until disease resistant varieties, developed using biotechnology, were introduced in the late 90s. Europe obviously places a high value on its food security and should crops (or animals) succumb to diseases, which cannot be conventionally managed, biotech solutions could find themselves high on the agenda. At the height of the BSE crisis in Britain, American soy was imported on a large scale. The usually skeptical British raised few questions about the use of a biotech-derived crop when the alternative (feeding the animals to themselves through meat and bone meal) had proved such a disastrous course.

Whatever about the return of the dinosaur, the dream of feeding the world is one thankfully not the preserve of mad scientists. Born in Hirschberg, Germany in 1933 and gaining his doctorate at the Max-Planck-Institute in Cologne, Dr Ingo Potrykus has played a major role in developing and applying genetic engineering technology to crop plants and diseases in the Third World. Potrykus made the cover of Time magazine in 2000 with the development of GM 'golden rice', a variety rich in beta-carotene from which the body produces vitamin A (conventional rice has no vitamin A). The Time headline ran 'This rice could save a million kids a year.' The biotech element of the rice incorporates daffodil genes, which provide the

golden colour and helps fortify it with beta-carotene. Commercialisation of this rice is still a few years down the line and should provide an interesting case study in consumer response to a biotech product with a significant health benefit over its conventional counterparts.

The International Food Information Council has identified a number of biotech-enhanced products at research level, which may soon find their way to the supermarket shelf. These include: cooking oils with higher stearate levels; small, single serve, seedless melons; tomatoes with increased lycopene; higher starch potatoes (which absorb less fat); and strawberries containing ellagic acid (a natural cancer-fighting agent). Developments in biotech derived foodstuffs are not limited to plants. The US Food and Drug Administration (FDA) is currently considering a license for the first transgenic animal into the food chain, a salmon that grows at four times the rate of conventionally farmed salmon. The marketing of this food will certainly bring the debate about biotechnology to a new level. Opponents will argue that such fish will represent a real danger of transgenic gene flow into the environment and the FDA is certain to consider security and containment issues as the most important in deciding if a license should be granted. Supporters will point to more efficient energy consumption and less waste production from these animals as compared to their conventionally farmed counterparts. They will also argue from experience that farmed fish simply do not prosper in the wild.

The Third Wave

Biotechnology has been used to derive medicines such as insulin from plants and animals since the 1980s. Advanced medical applications, such as the potential for transplanting rejection-free animal organs into people, have received widespread attention and will continue to register as fascinating confluences of science and ethics.
Less well know is the so-called ‘third wave’ application (medicine and agriculture being the first two), namely industrial biotechnology. Dr Barry Marrs, executive director of the Fraunhofer USA Center for Molecular Biotechnology believes that the application of biotechnology to manufacture industrial chemicals is fast approaching a reality while the production of biodegradable plastics and fibers from corn is already feasible. Industrial biocatalysis could change the nature of many aspects of the industry, he says: “The drivers are very powerful. We are finding better catalysts and improving them through directional evolution.” Dr Marrs believes that molecular farming, where complex chemicals are grown as components of GM crops, could transform chemical manufacturing into a greener, cleaner enterprise and reduce costs to a fraction of current levels. The technology may be groundbreaking but applications are not necessarily so: One biochemical he had developed is processed into a plastic with short-term cohesion properties, which finds perfect use in kitchen paper. After use, the plastics break down into the same biodegradable compounds as milk. (Dr Marrs spoke on May 7, 2003, at the EPA 2003 Science Forum: Partnering to Protect Human Health and the Environment, May 5-7, 2003, Washington DC in a session entitled Emerging Technologies)

Animal Crackers

Science has long recognized spider silk to be among the strongest fibers on earth but harvesting it for industrial uses was impractical (spiders being averse to domestication). A major project at the University of Wyoming has involved inserting spider silk genes into goat DNA resulting in transgenic animals that produce the spider silk proteins in their milk. The proteins can then be processed into a material that, under the trade name Biosteel, will find applications in medical equipment in the near future.

More conventional applications of biotechnology in animals could lead to enhanced productivity, less pollution and greater disease control. The birth of Dolly the sheep raised many long-term ethical questions, but the practical application of the technology in animal breeding is fast approaching feasibility. According to the FDA, cloned animals of high genetic merit could become available for breeding in the U.S. within three years.

Handling biowaste has become one of the big environmental issues in modern intensive farming. In the University of Guelph, Ontario, Canada, the Enviropig is living proof of one

biotech-derived solution. The pig has been engineered to produce less phosphorus in its waste and therefore introduce less potential pollution in the environment. It will require several years more testing before the Enviropig is considered for introduction to the market.

Researchers investigating biotech applications in poultry are examining the possibility of enhancing resistance to pathogens through genetically engineered vaccines, a procedure that would have application in all food animals.

The study of microbial DNA is also allowing for a better understanding of how pathogens develop and interact with their hosts, a knowledge base will almost certainly contribute to the development of future disease treatments.

Taking Stock

Biotechnology is providing European science, and the industries that depend on it, with a challenge. On the one hand, EU consumers continue to reject the use of biotechnology in food and demonstrate grave misgivings about the presence of biotech crops in their environment. On the other, European science is recognizing that biotechnology will become an important tool in the development of an increasingly diverse array of foods, medicines and chemicals. Some interesting anomalies point to the complexities inherent in the debate. In spite of consumer misgivings about genetic engineering, biotech-derived enzymes have found widespread use in the production of cheeses and beers in the EU. The EU does not require them to be identified on labeling because they are part of a process rather than actual ingredients. Golden rice, which may ultimately provide huge help benefits (by preventing blindness) in developing countries, was developed in Europe with EU funds part financing it.

Repeated scientific studies in all EU member states have come out in favor of biotechnology as safe and environmentally friendly science but receive little coverage in the media. In April this year, the British government established a citizens' jury to examine all the aspects of the debate. By a narrow majority it came out in favor of the use of the science. On the other hand, the formal complaint by the U.S. government about the 'de facto' EU moratorium on biotechnology will do little to warm European consumers to the prospect of biotech foods.

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The Council for Agricultural Science and Technology *(CAST, http://www.cast-science.org) assembles, interprets and communicates science-based information regionally, nationally and internationally on food, fiber, agricultural, natural resource and related societal and environmental issues to its stakeholders - legislators, regulators, policy makers, the media, the private sector and the public.*

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