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Office of Consumer Affairs

CONSUMER QUARTERLY

JULY 1996 • VOLUME 1, NUMBER 3

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Biotechnology: What Is It All About?

Biotechnology — or some aspects of it — has been the focus of heated debate among industry, governments, consumer and environmental groups, the research community and professional groups. Media reports of biotechnology breakthroughs in health or agriculture are intermingled with those focusing on concerns about biotechnology itself. However, research shows that, while Canadians have heard of biotechnology, their understanding of what it is all about is limited.

What is biotechnology?

Biotechnology is the use of living organisms, or parts or products thereof, to produce goods and services. It is widely applied in the health, agriculture, fisheries, forestry, mining and environment industries to develop products with special characteristics and to deal with specific problems.

Biotechnology is not new. Everyone is familiar with the use of yeast — a living organism — to make beer, bread and wine. Breeding techniques designed to produce better tasting, more nutritious

fruits and vegetables, special varieties of flowers, or animals that produce leaner meat are other well-known applications of biotechnology.

Less well known is the fact that some antibiotics, as well as genetic testing for diseases, are applications of biotechnology.

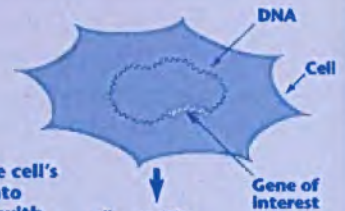
What is new?

Genetic engineering, or recombinant DNA (deoxyribonucleic acid) techniques, is new. The first genetic engineering experiments were successfully performed in 1973. The results of this research first emerged in the marketplace in the 1980s, but are now appearing in increasing numbers.

Recombinant DNA techniques involve transferring specific genetic information from one organism to another. Typically, this means isolating a gene, or the part of a living cell that contains the hereditary information for a particular trait or characteristic, "cutting it out" and transferring it to another organism. The recipient organism then exhibits the transferred characteristic (see illustration, right).

How are New Gene Combinations Made?

1. Isolate chromosomal DNA with the gene of interest to be introduced into a different cell.



2. Cut the cell's DNA into pieces with enzymes; one of these pieces has the gene of interest.



3. Combine gene of interest with a special type of DNA used for cloning to introduce the new gene into a different cell.



4. Introduce the new gene of interest into a new cell with existing DNA.



Source: *Do You Know About Biotechnology?*, Industry Canada, 1996, work in progress



Scientists are now able, through genetic engineering, to develop crop varieties to reduce farmers' reliance on external pesticides; they implant the same characteristics as occur naturally in some organisms into the plants. For example, a potato plant resistant to the Colorado Potato Beetle, a common pest, was developed by transferring into the plant a gene from *Bacillus thuringiensis* (Bt). Bt produces a protein that disrupts the digestive system of the beetle, and is already used as a pesticide. The genetically modified potato plant now eliminates farmers' need to use Bt separately. Bt has been thoroughly tested and approved as safe for human consumption.

Through genetic engineering, all the results of traditional breeding methods can be achieved faster and with greater precision. More importantly, genetic engineering can be applied across all living species: micro-organisms, plants, animals and humans. Thus, the scope for developing organisms or products with specific characteristics is virtually limitless. However, most genetic engineering research and applications have so far focused on micro-organisms, plants and, to some extent, animals.

It is this new area of biotechnology, genetic engineering, that has caused all the controversy. As well, the terms can be confusing: some writers use the word biotechnology when referring to genetic engineering applications only, while others use it to imply both traditional and new uses of living organisms.

What is all the fuss about?

In the past few years, governments, the private sector and consumer groups have conducted surveys and focus groups to gauge public awareness, views and concerns about biotechnology. Not surprisingly, the use of DNA technologies has evoked a wide range of responses.

Some people are concerned that genetically engineered products may be more harmful to individuals and the environment than products produced using traditional techniques. They argue for strict regulation to eliminate risks and slow down the pace of change.

Others see genetic engineering offering the possibility of many exciting scientific breakthroughs that will improve the quality of life. These people contend that Canadian society cannot afford to forego the potential benefits genetic engineering will bring, and that concerns about risk can be adequately addressed by regulation.

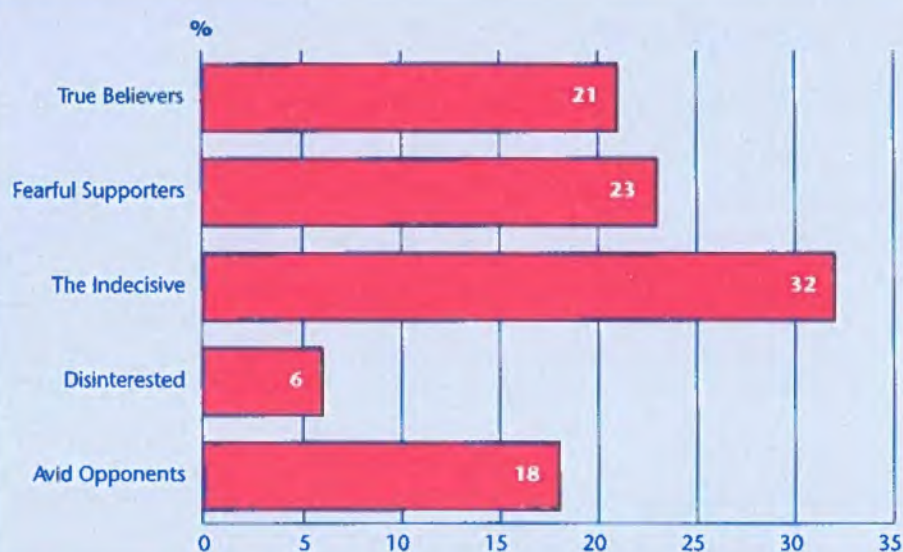
Still others have raised ethical concerns about altering the genetic make-up of living organisms. Where does one draw the line? Many Canadians do not yet know what to make of genetic engineering. Even

among those who see the potential benefits, many have said they want genetically engineered products identified in some way, so everyone can make their own choices.

A 1994 survey (Figure 1) showed that about 60 percent of Canadians were uncertain or undecided about genetic engineering, while the rest were almost equally divided between 'true believers' and 'avid opponents.' These mixed results appeared to reflect a lack of knowledge about the risks and benefits of the new technologies and the need for people to understand them better in order to reconcile them with their value systems.

Recent focus group research supports these findings — cautious optimism coupled with concerns about possible long-term adverse effects. Human safety remains a top priority, followed by concerns about the environment. Some participants were concerned that they did not know enough about the risks involved and the regulatory safeguards that are in place to manage these risks. Some people, for example, had in mind past mishaps with other technologies such as

Figure 1
Profile of Public Attitudes to the New Biotechnology



Source: Optima survey results as analyzed by Ekos Research Associates Inc.

thalidomide and silicone breast implants. Others were aware that some government controls were in place, but were unclear about the processes involved.

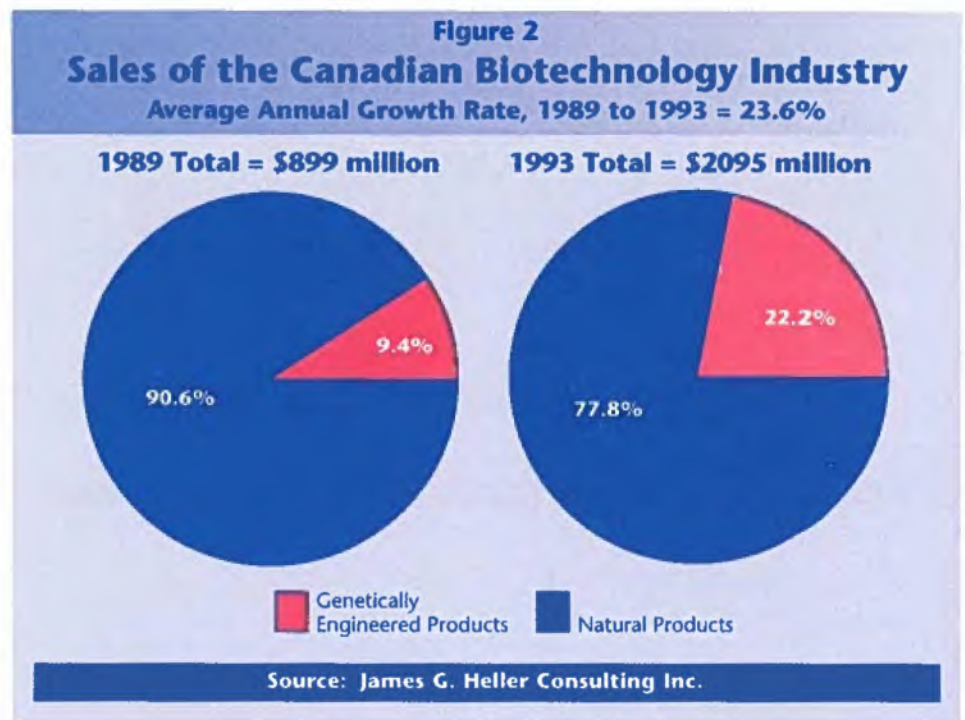
Research results suggest consumers' risk tolerance regarding applications of genetic engineering varies according to their perception of the nature and level of the benefits. For example, they seem prepared to accept higher risks in the case of medical applications, likely because these are perceived as significantly enhancing the quality of life, and indeed, in some cases, as crucial to survival.

The need for credible information about genetic engineering, including the pros and cons in easy-to-understand language, was a clear message from the focus groups. The ability to exercise choice, and having the information to do so, was also cited as important. There was, however, little recognition of both the costs and practical constraints to labelling or identifying genetically engineered foods that would need to be considered.

Who to believe remains a problem. There was no consensus in the focus groups on a single credible source of information. Some questioned the credibility of profit-oriented organizations. Governments and universities were considered the most likely sources of information, but even here, some people were sceptical about government and about the ability of universities to be objective when their research is funded by industry. While non-governmental organizations were viewed as potentially credible, some public interest groups were seen as being too extreme or one-sided. Partnering among stakeholders (e.g. industry, consumer groups and governments) was seen as one way to provide full and balanced information.

What is at stake?

While media coverage has generally focused on a few specific uses of biotechnology, the potential applications of DNA-based technologies are far-reaching. They transcend the issue of whether a particular pest-resistant potato or a drug to increase milk production in cows is neces-



sary or even desirable; the marketplace will ultimately dictate the outcome for any given product. The significance of DNA-based technologies is their enabling effect — the scope of benefits made possible by applying a new scientific technique across a range of products and industries.

For example, in health care, one can look to new therapies and cures for previously untreatable diseases; new, better, safer and less expensive vaccines and drugs; and faster and more reliable diagnoses. Genetic engineering has already made it possible to use bacteria to produce human insulin so patients can avoid the allergic reactions associated with the original animal insulin formulations.

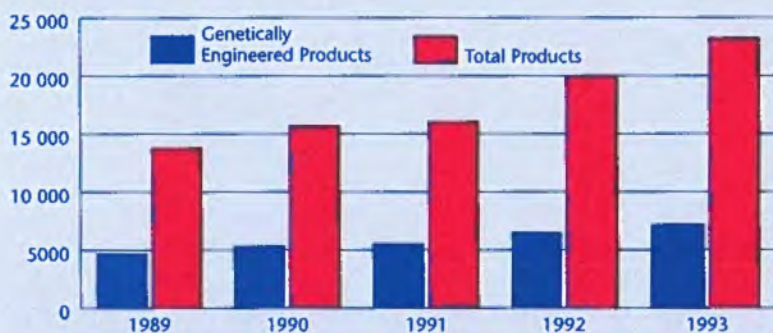
In the agri-food sector, new crop varieties are helping farmers reduce their reliance on pesticides that leave chemical residues in foods and have an impact on the environment. Genetic engineering techniques can be used to remove allergens from food, overcome difficult growing conditions, produce better quality foods and increase yields. For example, scientists have produced herbicide-tolerant Canola varieties that will permit more environmentally sound weed control. Other examples include food products with specific characteristics, such as tomatoes that have a longer shelf life and more flavour.

In the natural resource and environment sectors, potential benefits include managing pests such as the spruce budworm and the gypsy moth, producing trees that grow faster, cleaning up contaminated environments by using micro-organisms that feed on toxic chemicals and break them down into non-toxic substances (bioremediation), and using enzymes to reduce the need for chlorine bleaching in the pulp and paper industry and to produce renewable fuels, such as ethanol.

Clearly, the burgeoning biotechnology applications hold the promise of significant economic benefits: high quality jobs, income growth and increased international competitiveness for several key sectors such as health, agriculture and mining. Biotechnology is expected to increase competitiveness and growth in a range of sectors that account for 30% of Canadian GDP.

Figure 2 shows that the Canadian biotechnology industry, while still small, has grown rapidly in recent years, despite the generally slow pace of overall economic growth. Sales of biotechnology products more than doubled from \$900 million in 1989 to \$2 billion in 1993. Health products accounted for the lion's share of these sales, followed by agri-food products. The sales-share of genetically engineered products has also

Figure 3
Total Employment in Biotechnology Industries



Source: James G. Heller Consulting Inc.

been increasing during this period from 9 percent in 1989 to 22 percent in 1993.

Employment in the Canadian biotechnology industry grew rapidly from 14 000 people in 1989 to 23 000 in 1993. About 6000 are directly employed in developing genetically engineered products (Figure 3). By some estimates, Canadian sales of biotechnology products could reach \$5 billion by the year 2000. For these gains to be realized, however, consumers must be willing, active and informed participants in the marketplace.

Managing the risks

Biotechnology products have been regulated in Canada for health and safety for decades. With this experience, the federal government has in place practical processes for regulating the new biotechnology products and ensuring that such products undergo thorough safety and environmental assessments. This approach seeks, as a primary goal, to protect human and animal health and the environment, while avoiding to the extent possible impediments to economic development. It uses science-based risk assessments and takes into account the characteristics of the product and the potential risks of the product through its whole life cycle. The Canadian risk assessment process to determine health, safety and efficacy is generally acknowledged to be among the best in the world.

Regulation of biotechnology products for health and safety is the responsibility of a

number of departments within the federal government: Health Canada, Agriculture and Agri-Food Canada, Fisheries and Oceans Canada and Environment Canada. They work closely together to ensure that products are properly assessed before being introduced into the Canadian market.

Making it happen

At the heart of the biotechnology debate is the question of consumer confidence and comfort with the new DNA-based technologies. All new technologies tend to engender uncertainties at their outset. And it is precisely because these new technologies are so far-reaching that science alone is not sufficient to secure consumer acceptance of genetically engineered products in the marketplace. Consumers want to be assured that the risks associated with the new DNA-based technologies are being adequately addressed. Science, therefore, must work hand in hand with efforts to inform the public about the risks and

Clarification

The Bank of Nova Scotia has asked us to note that the accounts listed in the table entitled "Examples of Monthly Chequing Account Charges" (*Consumer Quarterly*, April) were specifically intended for users of basic services. As a result, the figures in the Average Use column of the table are unrealistically high. We believe that this is a fair comment since an average user would not choose the basic account option.

benefits of new technologies and products, the processes for testing such products before they are released into the marketplace, as well as the regulatory safeguards that are in place to minimize and manage those risks. Greater transparency of the processes involved could do much to increase consumer acceptance.

Consumers need more information about the new genetically engineered products from a source, and in a form, that they find credible. They want straight talk and sound information on which to base their own decisions. They want to have choice in the products they buy, both at a broad level and with respect to individual purchases.

Confronting biotechnology and the new DNA-based technologies is very challenging for consumers. Complex new products and services that embody unfamiliar technologies can quickly result in knowledge gaps. The challenge of the new biotechnologies is, in part, one of public awareness and consumer education. The bigger challenge, though, is finding practical answers to seemingly intractable questions. This will only happen if scientists, producers and consumers work together to find acceptable solutions.

Suggestions and requests

For information about the *Consumer Quarterly*, contact Bernard A. Keating, Senior Economist (Internet: keating.bernard@ic.gc.ca; Tel.: (613) 952-8883).

To learn more about the background biotechnology studies and about future research initiatives, contact Marc Legault, Marketplace Analyst (Internet: legault.marc@ic.gc.ca; Tel.: (613) 941-0631).

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