Designer Genes

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A decade ago, few people had even heard of biotechnology or its potential benefits. Today, 2,000 Americans a week use a drug based on gene splicing that stops heart attacks while they are happening. This drug alone is expected to earn hundreds of millions of dollars for Genentech, the San Francisco company that developed it.

Similarly, Genentech has used gene-splicing techniques to develop human insulin, interferon, and human growth tissue to combat diabetes, cancer, and dwarfism, respectively. By all accounts, Genentech's accomplishments are merely a drop in the bucket. Theoretically, every living thing can be altered or affected by this technology, a technology that is less than 40 years old.

Granted, biotechnologists are still working their way up the life scale, moving from the genes of microbes to those of higher organisms. And, the farther they go, the more concerned some people become about the ethics of tinkering with life. While this is an important issue not to be taken lightly, scientists focus on mechanics not morals.

Currently, 8,000 to 10,000 university, hospital, and industrial scientists worldwide are said to be engaged in gene splicing experiments. There is, for example, a push to create laboratory animals that can serve as models for disease and other medically related conditions. And, there are visions of an agricultural revolution limited only by one's imagination. In Canada, alone, there are more than 200 biotechnology firms. Fewer than 80 existed 20 years ago.

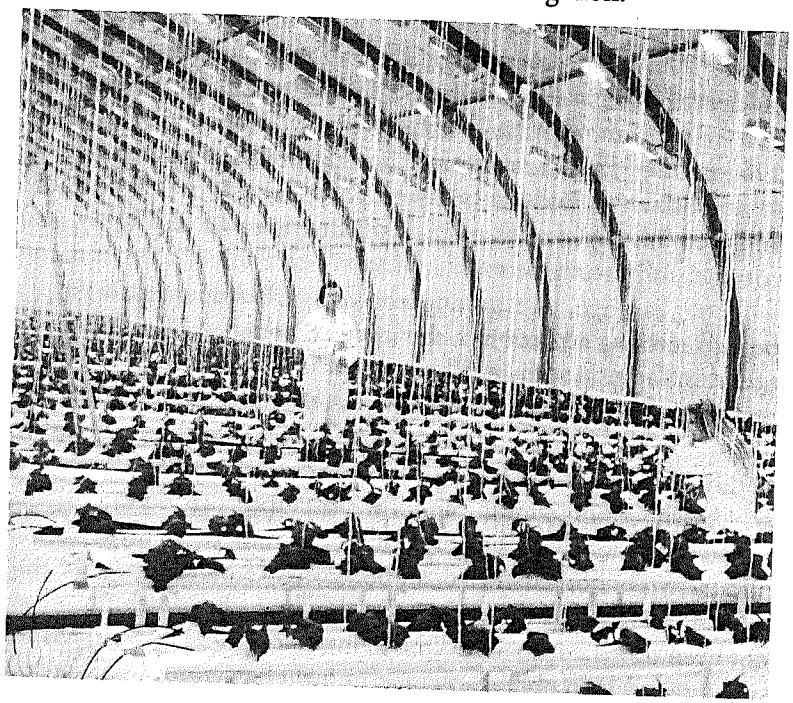
While it is readily acknowledged that gene transfer is not a very efficient or well-understood process, here is a sampling of some recent accomplishments.

In April 1988, the United States Patent Office granted the

first patent ever for an animal. In this case, it was a mouse with genes customized to suit the needs of cancer researchers. The recipients of the patent altered a certain gene in the mouse to enable it to develop breast cancer in a relatively short time. This allows researchers to test various cancer treatments more accurately and efficiently than before. Exclusive rights to produce the mouse have been granted to DuPont, the huge, multinational chemical company.

Waiting for patent approval are at least 40 applications involving genetically altered animals. Included are a mouse that carries the genes of the AIDS virus, and a proposed use of growth hormone to make pigs grow more quickly and develop less fat.

Already, pest-resistant tomatoes, potatoes, and tobacco have been produced. And, research is under way in a number of countries, including Canada, to put the bacterial gene that produces natural insecticides into commercially important plants. Genes for cold tolerance, salt or heavy metal resistance, and disease protection are also under investigation.



Last August [1989], permission was granted to release a genetically engineered virus in a cabbage patch in northern New York State. The virus, which naturally kills a certain type of caterpillar, had been genetically altered so that it would not linger in the natural environment or remain on cabbages after they reached market. The virus promises to be the first of a number of bioengineered organisms that may eventually replace chemical spraying of crops. Already, the United States Environmental Protection Agency has approved the testing of a virus that attacks the spruce budworm and the boll weevil.

Of interest to Canadian farmers and home gardeners alike, is an experiment under way near San Francisco. After two years of testing, it appears that genetically altered bacteria have been used successfully to prevent certain crops from being damaged by frost. Some bacteria present on tomatoes, citrus fruits, pears, avocados, potatoes, and other vegetables produce a protein that causes ice crystals to form and plants to freeze when the air temperature drops nearly to zero. By examining the DNA molecules of the bacteria, scientists found the gene responsible for producing the protein. They removed it and reinserted the altered DNA, and produced billions of bacteria unable to produce the ice-making protein. When these bacteria were sprayed on plants normally affected by low night-time temperatures, freezing was prevented. However, plants in the same field which had not been sprayed became frost-bitten and died. It's expected that ice-inhibiting bacteria will be commercially available soon.

Four years ago, a technique known as DNA Fingerprinting began receiving attention in the media. Police were finding it useful in forensic science. The concept is simple enough. Every person is unique, and that uniqueness is derived from particular genetic codes embedded in DNA. Any human tissue, blood, or bodily fluid left at the scene of a crime can be analyzed for DNA. The results should pinpoint the culprit precisely.

Advocates of DNA Fingerprinting claim there is only a one-in-two billion chance it can be wrong. However, they are meeting resistance from court officials who feel the technique has not been tested adequately. DNA Fingerprinting, however, has been used to help obtain several criminal convictions in Canada.

The same theory is behind studies of extinct animals and birds, and long-dead humans. Scientists have shown they can retrieve DNA from dried or preserved flesh and both analyze and replicate it. Suddenly, the collections of stuffed animals in every museum are being regarded as storehouses of genetic information. In studies carried out in various parts of the world, new evidence is surfacing to show previously unknown connections between types of animals and between certain birds. And, more information about the origins of ancient peoples is being revealed.

DNA Fingerprinting is also being used in wildlife management. Studies are under way to determine whether rare, wild birds have unique DNA characteristics that make them different from members of the same species that have been bred in captivity. If so, it could provide enforcement officers with a method for nabbing illegal exporters of rare and protected birds.

Similarly, Fisheries Canada scientists are looking into the possibility of using DNA Fingerprinting to snare fishermen who catch protected species.

Over the protests of animal rights activists, researchers are continuing to find ways to get living human cells to grow and reproduce in mice. Last December [1989], researchers at the Hospital for Sick Children in Toronto successfully transplanted human bone marrow into mice. This allows a range of human blood cells and immune system cells to be studied in a way not possible before. Scientists are excited by this development because it is a major step forward in providing a method for curing diseases caused by defective genes.

Meanwhile, gene experts in the U.S. reported recently they have found a gene present in every type of cancer which manufactures a protein that prevents cancer-fighting drugs from entering a cancerous cell. The discovery is important because it may lead to new cancer treatment methods.

In Great Britain, a team of scientists have found an "obesity gene." They say it increases the body's ability to convert food into fat and deliver it efficiently to fat tissue.

At the same time, medical researchers at the U.S. National Institute of Health were granted approval to start a pivotal experiment in the evolution of genetic engineering. For the

first time, genes will be transplanted into humans. Doctors were given permission to inject cells containing a gene from a common bacterium into cancer patients to help measure the effectiveness of an anti-tumour treatment. Of equal importance, the transplantation techniques being developed in these experiments could some day be used to cure several genetic disorders.

At a cancer research conference in Toronto last September [1989], a team of British scientists announced another breakthrough. They have found several of the genetic defects that play a key role in the development of lung, breast, and colon cancer. They claim this discovery one day will help doctors identify patients who are susceptible to certain types of cancers. And, those people could be warned to avoid certain harmful activities, such as smoking.

The discovery might make it possible for scientists to stop cancer by replacing the missing or damaged genes. Currently 16,000 Canadians a year are diagnosed as having lung cancer, and in most cases, the disease is detected too late to be stopped.

Not to be overshadowed by these developments is the accomplishment of a Canadian biochemist. Several years ago, while at McGill University in Montreal, Dr. Kelvin Ogilvie developed a method of making ribonucleic acid (RNA)—a molecule regarded as of equal importance to DNA in genetic engineering circles.

Until Ogilvie discovered how to make RNA in the laboratory, experimenters had to remove it from living organisms before they could use it in their studies. Now, it can be produced in 15 hours in a device invented by Ogilvie, which he calls the "gene machine." This opens the door to mass production of both RNA and DNA, and is being hailed as a major step in finding treatments for diseases caused by a class of viruses called retroviruses.

Other benefits may come from the ability to make DNA and RNA. It's probably only a matter of time before these substances can be custom-made in the laboratory without having to extract them from fruit flies or mice and then tinker with them. This development is both exciting and frightening at the same time, as the critics of genetic engineering are quick to point out.

If the current rate of progress continues—and there is no reason to think it will not—40% of the $4 billion Canadian pharmaceutical market in 1995 may consist of drugs derived from biotechnology. This figure is expected to rise to 70% by the year 2000. As one pharmaceutical industry spokesperson stated, "biotechnology will have as great an impact on the 21st century as the microchip did a few years ago." In fact, the Science Council of Canada estimates that products based on biotechnology will be earning $180 billion worldwide by 1996.

In the near future, a promising new use for farm animals may be found. It has been theorized that a gene capable of producing a rare and expensive biological substance could be attached to the DNA sequence that is turned on during milk production. As experiments with sheep have already shown, the result is milk containing the biological substance. Thus, someone needing this substance can simply take it in a glass of milk.

Japanese experimenters have shown that silk worms can be programmed to produce human insulin, and work is going on to see if eggs can be used for the same purpose. If biological products can be produced in large quantities in this manner, it's quite conceivable that some day pharmaceutical companies will own large herds of animals.

Another idea receiving serious consideration is the production of plants having made-to-order protein or oil content. Even custom tailored flavour is a possibility. Or, how about a nice juicy slice of "meat" derived from all-new creatures specially engineered to be low in fat, high in protein, yet taste great. These developments are certainly possible, but, for now, attention is focussed on medical science.

However, genetic engineering is not the solution for all diseases. So far, the technology does not make it possible to insert the correct gene into any kind of cell. While success has been achieved with relatively simple organisms, it is still not possible to select a gene that will form complex creatures, such as humans, and modify a particular characteristic. This, of course is what critics fear, but the ability to actually carry it out has yet to be demonstrated.

Activities

1. With a partner, list the different marketable products and services mentioned in the essay and discuss whether they seem to support the Science Council of Canada's estimate of the economic potential of biotechnology.
2. In a group of three, brainstorm several legal or moral questions which biotechnology raises. Be prepared to explain with examples one issue that the questions raise.
3. With a partner, role play a scene in which an inventor comes to the patent office to register a genetically-altered plant or animal. Present your role play to another partnership.
4. In a group of four, discuss a few of the following questions and write a journal entry or present a report about your discussion to the class.
   - If a biotechnology research company were to find a way of shutting off the aging gene in the human body, should they have the right to market the technology only to those who could pay their price? Would such a product be socially useful?
   - Do scientists have the right to enter cemeteries to exhume long-dead bodies and conduct genetic research testing on people who may or may not want their genetic secrets revealed?
   - Should a private company have the right to own, breed, and sell genetically-altered plants and animals for profit?
   - How can society protect itself from an error which might create a monster like Frankenstein's while an individual or company engages in biotechnological research?