BIOTECHNOLOGY: PRESENT AND FUTURE

Dr. T. Perera, Project Leader, Molecular Entomology, IFS

BIOTECHNOLOGY

Biotechnology is simply the use of **microorganisms**, and plant and animal cells, to produce materials such as food, medicine, and chemicals that are useful to mankind.

The products of biotechnology are all around us. The yogurt, beer, wine, and cheese in your refrigerator are products of biotechnology. The pickles, bread, and vinegar in your kitchen cupboard are too! Even your compost bin is a biotechnology factory - a mechanism for harnessing the natural chemical processes of living organisms for your own use.

Some products of biotechnology have been around for a long time. Yeasts were first used to brew beer and make wine as long ago as 6000 BC. Leavened bread, which is made using yeast, and cheese, made using bacteria, have been around for hundreds of years.

All those centuries ago people discovered, quite by accident, how to make use of biological processes that occur all the time within living cells. They did not understand the processes, but they could see the results. They discovered, for example, that certain microorganisms like **bacteria** and **moulds** would produce vinegar, beer or wine when grown in large vats. This process was called **fermentation**. Through trial and error, they learned to control these processes and make large quantities of a limited range of products.

Scientists now understand what many of these biological processes are and how they occur. This has allowed them to develop new techniques to alter or copy some of these natural processes and therefore make a much wider variety of products. Some, like cheese, are the same as the products made using traditional biotechnology, but the new methods are quicker, cheaper, and more reliable. Others, such as some new pharmaceuticals, could not be made at all using the older methods.

GENETIC ENGINEERING

A primary aim of modern biotechnology is to make a living cell perform a specific and useful task in a predictable and controllable way. The task could be to ferment sugar to make alcohol, or produce a substance that makes flowers red, or a chemical that will help fight a bacterial infection. Whether a living cell will perform these tasks is determined by its genetic make-up - by the instructions contained in a collection of chemical messages we call **genes**. These genes are

passed on from one generation to the next, so that offspring inherit a range of individual traits from their parents.

Scientists now understand the chemical coding system underlying these genes, which is based on a substance called **Deoxyribonucleic Acid (DNA)**. A gene is actually a segment of DNA and its message is encoded in the molecule's chemical structure.

Once scientists understood the DNA code, they began looking for ways to change the instructions in the genes - to introduce new instructions that would cause the cell to produce needed chemicals, or carry out useful processes, or give an organism desirable characteristics. The result was modern genetic engineering - the science of manipulating and transferring chemical instructions from one cell to another.

TRANSGENIC ANIMALS AND PLANTS

Transgenic plants and animals result from genetic engineering experiments in which genetic material is moved from one organism to another, so that the latter will exhibit a desired characteristic. Scientists, farmers and business corporations hope that transgenic techniques will allow more precise and cost-effective animal and plant breeding programs. They also hope to use these new methods to produce animals and plants with desirable characteristics that are not available using current breeding technology.

In traditional breeding programs, only closely-related species can be crossbred, but transgenic techniques allow genetic material to be transferred between completely unrelated organisms, so that breeders can incorporate characteristics that are not normally available to them. The modified organisms exhibit properties that would be impossible to obtain by conventional breeding techniques.

DNA DETECTIVE : GENE PROBES & FINGERPRINTS

Modern techniques in biotechnology mean that scientists can now detect individual genes in plants and animals, allowing faster and more accurate agricultural breeding programs and improved medical diagnosis of inherited diseases.

Scientists can also construct "genetic fingerprints" to help identify individuals. These techniques are already being used for a range of forensic purposes including identifying bodies, tracing offenders, providing evidence in paternity disputes *etc.*

HUMAN HEALTH

Ever since the antibiotic 'penicillin' was discovered, biotechnology has played a key role in the treatment of human illness.

Some antibiotics, like penicillin, are produced naturally by microorganisms. These can be produced in commercial quantities using traditional fermentation techniques. However, many of the antibiotics we require are not produced in exactly the form we need. Once scientists had to wait for natural mutations accidentally to produce the ideal version, or use chemical synthesis techniques to modify the natural product. Now, using genetic engineering, scientists can sometimes alter existing microorganisms to produce large quantities of antibiotics with the desired chemical structures.

A range of other pharmaceutical products are now produced by genetically engineered microorganisms. These include:

- **Tissue Plasminogen Activator (TPA)**, used to dissolve blood clots and so reduce the risk of a heart attack or stroke

- **Human insulin**, used to treat human diabetes (instead of having to rely on animal insulin, which can cause adverse reactions in some patients, diabetics can now obtain the correct form of insulin in quantities never before available)

- **Human growth hormone**, used to treat some forms of dwarfism, but with the potential to treat wounds, burns, fractures, and other conditions that heal slowly

Biotechnology can also help in the detection and diagnosis of viral diseases and inherited disorders.

- **Monoclonal antibodies** are molecules that are used for precise diagnosis of bacterial and viral infections. Each type of monoclonal antibody attaches to a specific type of invading bacterium or virus, and this antibody-invader combination can be easily detected

- **Gene probes**, which chemically label particular parts of the DNA in the cell's chromosomes, are also a valuable diagnostic tool. Already they are being used to test foetuses as early as four weeks for a range of genetic diseases including Down's Syndrome. They can also be used to determine an individual's susceptibility to autoimmune diseases such as insulin-dependent diabetes, some forms of arthritis and anemia, and chronic diseases of the liver, kidney, and nervous system.

Biotechnology is also providing new methods of producing vaccines to combat disease. Genetic engineering has already been used to develop a vaccine against Hepatitis B, for example.

PLANT & ANIMAL AGRICULTURE

Genetic engineering of plants is still relatively new, and the technologies are less developed than for genetic engineering of microorganisms. However, scientists have already been able to adjust the nutritional content of plants, and to produce disease-resistant and herbicide-resistant crops. Biotechnologists also hope to produce plants that can withstand drought, extreme heat, cold, or salty soils, enabling farmers to utilize land that is currently useless.

Micropropagation techniques - where plants are grown from single cells or from small plant pieces - are now used in many plant breeding nurseries to allow rapid multiplication of identical plants and to produce virus-free stocks.

Animal farmers and consumers will also benefit from biotechnology. Feed crops with improved nutritional value are being developed to increase farming efficiency. Genetically engineered animal vaccines for diseases such as footrot, and the use of animal growth hormone (produced in large quantities by genetically engineered microbes) should result in greater yield and better quality animal products.

FOOD PRODUCTION

Bread, cheese, wine, beer, yogurt, and vinegar are common products of biotechnology which are now produced using updated methods.

Microorganisms themselves can be eaten; 'Vegemite', which is an extract of yeast, is a popular example.

Vitamins B2 (riboflavin) and B12 (cobalbumin) are essential for good health, and are used both in medicine and as food additives. The bacterium that produces B12 and the mould that produces B2 have both been selectively bred so they manufacture many thousands of times more vitamin than they would naturally. Supply is further increased by the manipulation of fermentation techniques.

WASTE MANAGEMENT

Human waste is already handled using biotechnology. Sewage processing plants, which are present in almost every city in the world, use microorganisms to consume a range of solid waste materials.

Biotechnology is also being applied to the problem of industrial pollution. Unaltered bacteria have already been used to break down oil and petrol pollution, and now genetically engineered bacteria have been developed which feed on oil slicks. Scientists are working on ways of using microorganisms to break down other forms of pollution, such as pesticides, herbicides, and hazardous chemical waste.

FUELS

It is well known that microorganisms produce alcohol from sugar; brewers have been using this knowledge for centuries. This knowledge is also providing us with a renewable source of fuel that is less polluting than petrol. In Brazil, many cars are powered by fuel alcohol derived from sugar cane, instead of petrol. Other research is investigating the use of microorganisms to produce methane gas from waste materials, and hydrogen gas from water.

SUMMARY

These are only a few of the present uses and future possibilities of biotechnology. Genetic engineering undoubtedly is the technique of modern biotechnology. With its great potential for relieving problems of human disease, hunger and pollution, it is probably the most significant development in biology since Mendel's observations on plant genetics or the discovery of antibiotics.

As with all new developments, there are many who think this technology is dangerous. For some it is unethical or immoral to tamper with the genetic material. They believe this will lead to a loss of our own "genetic privacy", and that no one has the right to own either organisms or genes. Others question the environmental consequences of these developments, that it will lead to the development of more potent pests, create new health problems because of allergens and toxins, and reduce biodiversity. Yet others question the socioeconomic consequences of biotechnology, for example the promotion of "corporate" farming, and the effects on less developed countries.

These moral and social issues are of great importance, and they will have to be addressed, because there is no doubt that this science is here to stay.