

# Aspects of Biotechnology

## Understanding Biotechnology

### WHAT IS BIOTECHNOLOGY?

Biotechnology is the use of living organisms in production and manufacturing processes. The term *biotechnology* can cover a range of activities. You could think of using yeast to make bread dough rise as a form of biotechnology. In a general sense, biotechnology includes any manipulation of a living matter intended to improve the human condition or the environment. For example, farmers have been altering plants and animals for thousands of years



broccoli × cauliflower  
= broccoflower

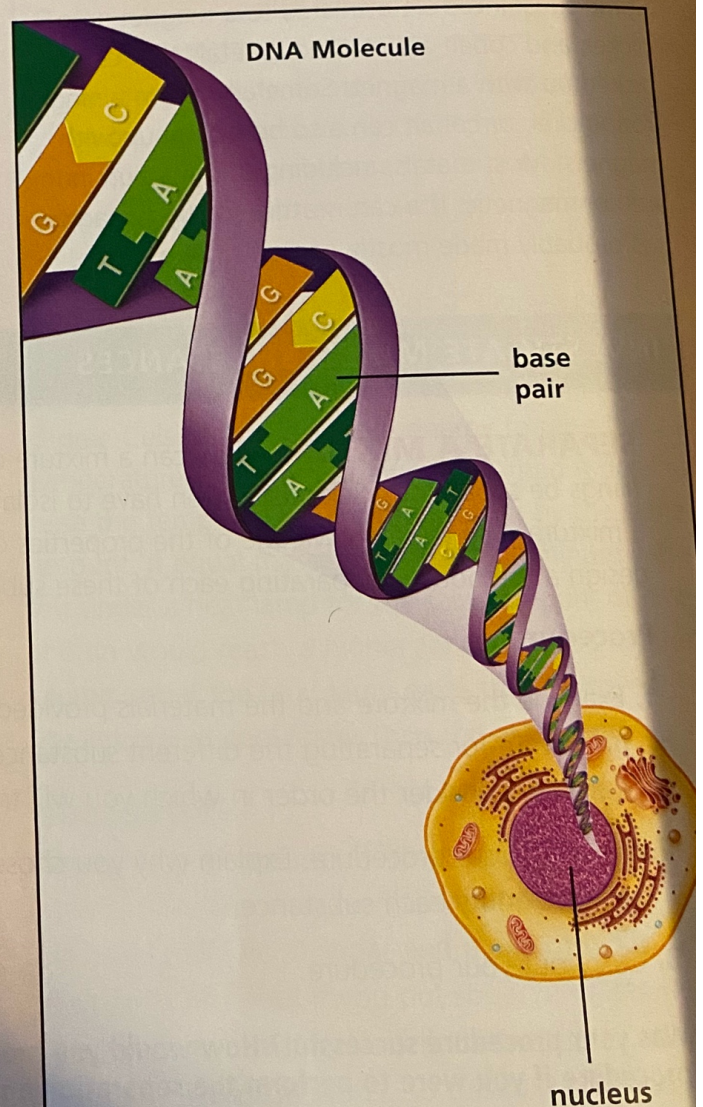
by cross breeding to get desired traits. The broccoflower, which is a cross between a cauliflower plant and a broccoli plant, is produced by conventional cross-breeding techniques.

However, most people today think of biotechnology as the direct manipulation of an organism's genes. Often, this process involves the insertion of a desired gene from one organism into another. With the latest scientific knowledge and technology, today's biotechnologists engineer and use organisms for a variety of industries, including agriculture, forestry, and medicine.

### WHAT DO WE KNOW ABOUT GENES?

In order to alter the genes of a living organism effectively, scientists must understand what genes that organism has and where each gene appears in the genetic sequence. Scientists identify all the genetic information of a species—its genome—by identifying the sequence of bases that make up its DNA. The Human Genome Project involves an international effort to sequence all the DNA found in human chromosomes. The scientists have worked out the initial sequence of approximately 6 billion bases. Now they are working to locate and identify the genes within that sequence. Scientists estimate there are 30,000 genes in human chromosomes.

Scientists have completed DNA sequencing on a number of organisms. These include yeast, roundworms, rice, mice, and fruit flies. Scientists are now finishing drafts of the genomes of chimpanzees and honeybees and some expect to start on the genome of dogs next. Once the genes within a particular genome are identified, scientists can compare the genes of one organism to another. The mouse, for example, has many genes similar in sequence and function as those found in the human genome.



Genes are segments of a DNA strand, such as the one shown here. The strands are tightly wound into structures called chromosomes, which are located in a cell's nucleus.

## Applying Biotechnology

### USES OF BIOTECHNOLOGY

Biotechnology has a wide range of potential applications. Imagine bacteria designed to eat pollutants, or bacteria that can extract minerals from poor-quality ores, or a tobacco plant that can produce a low-calorie sweetener. Biotechnologists are at work on these applications, as well as many others.

**Medicine** Some human medical disorders are caused by damaged or missing genes. In the future, it may be possible for scientists to treat such disorders by inserting properly functioning genes into the cells of their patients. Medical researchers can also use biotechnology to produce medicines and vaccines. By genetically altering and then culturing bacteria, researchers can get bacteria to produce insulin needed by diabetics. Bacteria can be genetically manipulated to produce new forms of antibiotics that will work against organisms that have become resistant to current antibiotics. Medicines could be tailored to specific diseases, reducing the risk of unwanted side effects.

**Forestry** North Carolina is investigating the uses of biotechnology in forestry. The Institute of Forest Biotechnology is looking at ways to preserve heritage trees that are threatened by pests or disease. For example, the Fraser fir, a tree that is economically important in North Carolina, is threatened by root rot caused by water mold. Because chemical methods of controlling the rot are difficult and expensive, scientists are looking for other methods to save the Fraser fir. Perhaps biotechnologists can find a way to incorporate a rot-resistant gene into the chromosomes of the Fraser Fir.

**Agriculture** Biotechnology has many implications for agriculture. Disease-resistant crops could improve crop yields. To increase food production, crops could be engineered to grow in environments that would usually not be able to support such crops. The development of pest-resistant crops could reduce the need for chemical pesticides. The use of pest-resistant crops would allow for farming methods that are potentially better for the environment.



These tomatoes have been genetically altered to grow in conditions that would not support natural varieties of tomatoes.

### RISKS AND BENEFITS OF BIOTECHNOLOGY

Biotechnology can provide many benefits. However, many people are concerned about the development of biotechnology. One issue involves the introduction of genetically altered species into the environment. It is difficult to predict the results of introducing any new species into the environment. Biotechnologists try to keep genetically altered organisms isolated from natural species. For example, scientists working on producing salmon that grow more quickly than natural salmon keep the genetically engineered salmon isolated in pens. However isolation is not always possible. For example, biotechnologists must consider the risk and effect of a potential crossing of genetically altered seed plants, such as corn, with natural species.

Another concern is how genetically altered foods might affect humans. If corn is genetically modified to produce a natural pesticide, could the plant be harmful to humans as well as the insects it is designed to repel? If a peanut gene is transferred to a corn plant, would people with severe peanut allergies have an allergic reaction to the genetically altered corn? Government health agencies have to decide on such safety concerns. At the very least, many people think that genetically altered foods should be clearly labeled.

## Careers in Biotechnology

### BIOINFORMATICS

Gene sequencing produces large quantities of scientific data. The data must be organized and stored in such a way that the information is accessible to scientists. People who work in bioinformatics study ways of efficiently storing and retrieving biological data. Bioinformatics involves the use of computers and database programs to make genetic data available to scientists. Because the quantity of data is so great, new techniques are being developed that reduce the time it takes to search through the databases to find particular pieces of genetic information.

### BIOLOGY AND COMPUTER SCIENCE

A biology student who is interested in developing a disease-resistant crop or a new medicine might become a lab technician or a research scientist. He or she would focus on cell biology and genetics to understand how cells function to produce certain effects.

A student of computer science might choose to enter the fields of bioinformatics and database programming. Biotechnologists work with large amounts of data composed of millions of base-pair sequences. The sequence that makes up a gene must be isolated and identified from larger noncoding sequences of DNA.

### CLINICAL RESEARCH

Once a product is conceived, it must be developed and tested. Clinical research scientists experiment with new concepts to see if producing a particular product will be possible under realistic conditions. A clinical researcher might, for example, experiment with genetically modified wheat to see under what conditions it will grow.

### LAW AND SAFETY

There are many regulations involving genetically modified foods. Biotechnology companies have departments that specialize in understanding the current restrictions and laws. Companies are also responsible for getting approval from the appropriate government agencies in order to distribute these products. Safety experts oversee the testing process to make sure the clinical researchers are taking all the appropriate safety precautions and following all the laws that regulate the biotechnology industry. Specialists are also needed to perform tests on new products to be sure that they are safe for people to use and to evaluate the impact the products might have on the environment.



Biotechnology is a growing industry in North Carolina—one that will provide many career opportunities in many fields of study.