INTRODUCTION

- Biotechnology, in its most general meaning, is the use of biologic processes to create a product for human use and benefit.
- Today, when people use the term biotechnology, we usually think they mean the application of modern methods of manipulation of DNA (deoxyribonucleic acid), the genetic information of an organism, to make a product.
- In fact, biotechnology is ancient, providing the basis for making a wide range of products, including bread, cheese, beer, and wine.
INTRODUCTION

- These early forms of biotechnology relied on fermentation, the breakdown by microorganisms of organic molecules, particularly sugars, into simpler compounds, often CO2 (carbon dioxide).
- In practice, fermentation involves holding the material under conditions that allow the microorganisms to increase in number, and to change the original material through chemical reactions inside the cells.
- The starting material in fermentation can be bread dough, made of flour, water, and yeast, or grape juice plus yeast.

BREAD

- To make bread, after the dough is kneaded to make the gluten (flour protein) stringy, the dough is kept at a warm temperature to allow the yeast cells to multiply in number.
- The yeast cells need energy to grow, so they break down sugars in the flour to CO2, creating pockets of gas.
- This gas makes the dough rise. When the bread is baked, the gluten dries out and the bread is filled with many small holes.
**WINE**

- Wine makers grow yeast submerged in liquid grape pressings.
- This deprives the yeast of oxygen so that it produces ethanol as a waste product when it metabolizes sugar.
- A slightly more complicated process is used to make beer, but the principle also involves growing yeast cells without oxygen so that they produce ethanol as they make energy.

**CHEESE**

- Cheese is also made through biotechnology.
- Rennin, a protein found in the stomachs of young cows, is added to milk to make cheese. (Today, rennin is usually made with modern biotechnology methods.)
- The rennin breaks down casein, the major protein of milk, into small pieces.
- Then, cheese makers add bacteria to milk to convert (ferment) the lactose sugar in the milk to acid, which causes the casein fragments to curdle, making them form semi-solid lumps.
- The flavor of cheese becomes more intense as it ages, and the flavors concentrate.
- Adding certain molds during the aging process turns cheese blue in color.
MENDELIAN GENETICS

- Modern biotechnology, defined as the movement and modification of genes at will, was built on discoveries in genetics and biochemistry originally made in the first half of the 20th century.
- Scientists learned that inherited characteristics or traits, such as hair or eye color, are passed from parents to offspring in units of inheritance called genes.
- Gregor Mendel figured this out in the late 19th century by carefully conducting breeding experiments with peas.

MENDELIAN GENETICS

- 1) genes are carried on chromosomes, structures in the cell's nucleus;
- 2) genetic information resides in the chemicals that make up the chromosomes; and
- 3) traits are generally based directly or indirectly on the proteins produced in cells.
PROTEIN

- **Proteins (also called polypeptides) are composed of one or more linear chains of amino acids.**
- There are 20 different amino acids that share a common structure, with side chain groups that vary in size, shape, charge, chemical reactivity, and solubility in water.
- Proteins can be small (made up of just a few amino acids) or very large (composed of thousands of amino acids).
- The biochemical properties, three-dimensional shape, and function of each protein primarily result from the sequence of the amino acids that make up the particular protein.

WHAT IS A GENE?

- DNA molecules are chains of four bases: adenosine (A), cytosine (C), guanine (G), and thymine (T).
- Each of these bases is slightly different from the others in its chemical makeup.
- Figuring out the structure of DNA provided the clues to how DNA worked to transmit genetic information (Figure 1.1).
Genes are composed of the sequence of As, Ts, Cs, and Gs that the cell decodes to make up a protein.

The code for each of the 20 amino acids is a particular triplet of bases.

When a cell manufactures a protein, intermediate copies of the gene sequence are made, in the form of messenger ribonucleic acid (mRNA), and these copies move to the ribosomes, the protein-manufacturing structures of the cell.

In the ribosome, the code is read from the triplets of RNA bases that specify the amino acids.
FROM GENE TO PROTEIN

- RNA is composed of four bases that are slightly different chemically from the bases of DNA.
- The sugar portions of the DNA bases have one less oxygen atom than the RNA bases do.
- Amino acids are shuttled to the ribosome and lined up by another type of RNA called transfer RNA (tRNA).
- For each amino acid, a specific tRNA, carrying the base sequence that complements the triplet code for that amino acid, lines up the amino acid by base pair formation with the mRNA on the ribosome.

HOW TO ENGINEER A GENE?

- The essential task of modern biotechnology is to change an organism’s genetic material (DNA) to allow for the production of a useful protein.
- The gene for the protein must first be isolated and engineered so that it will drive production of the protein.
- To isolate a gene, scientists use surgical DNA “scissors” called restriction endonucleases (RE), proteins made by bacteria that cut DNA, based on specific rules.
THE POLYMERASE CHAIN REACTION

- To prepare a gene for engineering, the scientist generally needs many millions of identical copies of the gene.
- Originally, the only way to get these copies was to start with a large number of cells or a large piece of tissue, to use chemicals to extract and purify the DNA, and then to treat the DNA with an RE to clip the desired gene.
- In the mid-1980s, American chemist Kary Mullis developed a method that could make many copies of a stretch of DNA, even when the scientist knew only the sequence of bases at either end of the strand.
- This technique, called the polymerase chain reaction (PCR),
Once the gene has been isolated, the next step is to join it to a molecular "on-switch," a sequence of DNA that will allow the cell to use the gene to make the desired protein. The on-switch, called a promoter, is matched to the type of cell that will be used for production.
Figure 4.1 Shown here are industrial biotechnology reactors used to grow cells for production of biotechnology products. Temperature, pH, and other conditions are carefully monitored and controlled. Industrial biotechnology reactors can hold thousands of liters and stand two stories high.