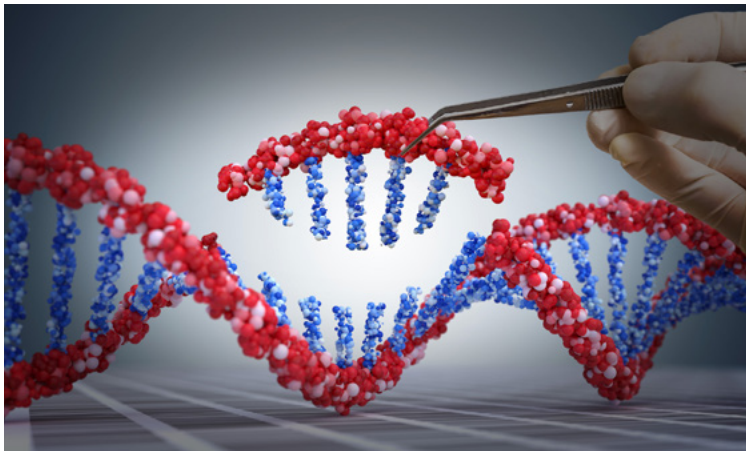
Chapter 7

Genetic Technologies



Summary of Terms

- **Genome** The total genetic content of an organism.
- **Genetic engineering** The process of changing the traits of organisms by directly manipulating their DNA.
- **Genetically modified organism** An organism whose DNA has been changed through genetic engineering.

Detailed Chapter Summary

The entire human genome, which consists of 3.2 billion nucleotide pairs, was sequenced during the Human Genome Project. More than 99% of nucleotide sequences are identical in all humans. The human genome contains a total of about 19,000 protein-producing genes. However, these genes represent only 2% of the genome. The rest of the genome consists of other sequences, including a lot of repeat sequences with no clear function. Single-nucleotide polymorphisms, or SNPs, describe locations in the genome that vary among humans. There are millions of SNPs in the genome, and some of these are expected to be important to human diseases.

There are many inherited genetic diseases that affect humans. Pedigrees, which are charts showing the members of a family affected by a genetic disease, can help determine a couple's risk of having a child with genetic disease. Creating a pedigree is an important first step in assessing risk. If a disease requires two recessive alleles in order to affect a person, then it becomes important to know whether one or both parents are carriers. Carriers of a disease are heterozygotes who possess one disease allele and one normal allele, meaning that they are not affected by the disease but can pass it on. Genetic testing can also determine whether a fetus is affected. Chorionic villus sampling and amniocentesis are two techniques used to collect fetal cells for testing during pregnancy. Down syndrome is a genetic disease correlated with age of the mother. It is caused by trisomy 21.

Cancer occurs when mutations in the genes that control cell division allow cells to divide out of control and spread through the body. Mutations in many important genes are usually required for cancer to develop. Many environmental factors increase the risk for developing cancer including smoking, diet, radiation, ultraviolet light, chemicals, and infection by certain bacteria and viruses. Certain inherited mutations can also make cancer more likely to develop.

Genetic engineering describes the process of changing the traits of organisms by directly manipulating their DNA. A genetically modified organism is one whose DNA has been changed through genetic engineering. Many genetically modified bacteria, plants, and animals have been developed. Some of these produce useful compounds, such as human insulin, whereas others have useful traits, such as disease resistance or rapid growth.

Cloning describes the creation of an organism that is genetically identical to one that already exists. Many animals have been cloned, but human cloning has so far never been performed and would be ethically problematic.

A number of scientists are working on using genetic engineering to address human diseases carried by mosquitoes. One group is working on genetically engineered mosquitoes whose offspring die. Another group is developing mosquitoes that spread infertility. Still others are working to make the mosquitoes themselves resistant to diseases such as malaria, so that they will not pass these diseases to humans.

CRISPR-Cas9 is a powerful tool for genome editing. This tool allows scientists to add, remove, or change DNA at specific locations in the genome. Scientists hope to use this tool to treat certain genetic diseases, including cancer.

Despite the promise of many DNA technologies, there are also some concerns. One worry is that deadly bacteria or viruses could be released. Another is that genetically modified crops could be unsafe for human consumption or could harm natural environments. DNA from genetically engineered plants could also contaminate natural populations. The technology can also be seen as a distraction from the development of more sustainable agricultural practices. Because DNA technologies are generally very expensive, there is also worry that only the wealthy and privileged will have access to important technologies. Finally, there are numerous ethical questions regarding the responsible use of DNA technologies that still need to be answered.