relating cellular physiology to the genome. Such an understanding will provide important guidance to development of future bioprocesses.

8.6. SUMMARY

A cell's *genotype* represents the cell's genetic potential, whereas its *phenotype* represents the expression of a culture's potential. The genotype of a cell can be altered by *mutations*. Examples of mutations are *point mutations*, *deletions*, and *additions*. Additions are usually the result of *insertion sequences* that "jump" from one position to another.

Mutations may be *selectable* or *unselectable*. The rate of mutation can be enhanced by the addition of chemicals called *mutagens* or by radiation. *Auxotrophs* are of particular use in genetic analysis and as a basis for some bioprocesses. Another useful class of mutants is *conditional* mutants.

Gene transfer from one cell to another augments genetic information in ways that are not possible through mutation only. *Genetic recombination* of different DNA molecules occurs within most cells. Thus, genetic information transferred from another organism may become a permanent part of the recipient cell. The three primary modes of gene transfer in bacteria are *transformation*, *transduction*, and *conjugation*. Self-replicating, autonomous, extrachromosomal pieces of DNA called *plasmids* play important roles in transformation. *Episomes*, which are closely related to plasmids, are the key elements in conjugation. Bacteriophages are critical to *generalized transduction,* while *temperate phages* are key to *specialized* transduction. Internal gene transfer can occur due to the presence of *transposons,* which probably also play a role in the assembly of new plasmids.

We can use gene transfer in conjunction with *restriction enzymes* and *ligases* to genetically engineer cells. In-vitro procedures to recombine isolated donor DNA genes with *vector* DNA (for example, plasmids, temperate phages, or modified viruses) are called *recombinant DNA techniques*. Once the vector with the DNA donor insert has been constructed, it can be moved to a recipient cell through any natural or artificial method of gene transfer. Although transformation is the most common technique in bacteria, a large variety of artificial methods have been developed (e.g., *biolistic process, electroportation,* modification of infective agents, and *protoplast fusion*) to insert foreign DNA into a host cell.

Genomics is the set of experimental and computational tools which allows the genetic blueprints of a whole organism to be read. *Functional genomics* is the process of relating genetic blueprints to the behavior and structure of an organism.

SUGGESTIONS FOR FURTHER READING

Many of the references cited at the end of Chapter 4 have selections dealing with mutation and selection, gene transfer, and genetic engineering.

The following book explores these same topics, but more from the perspective of the industrial microbiologist: