Microbial communities can be highly structured (e.g., biofilms), and cell-to-cell communication is important in the physical structure of the biofilm. Cell-to-cell communication is also important in microbial phenomena such as bioluminescence, exoenzyme synthesis, and virulence factor production. Basically, these phenomena depend on local cell concentration. How do bacteria count? They produce a chemical known as *quorum sensing molecule*, whose accumulation is related to cell concentration. When the quorum sensing molecule reaches a critical concentration, it activates a response in all of the cells present. A typical quorum sensing molecule is an acylated homoserine lactone. The mechanism of quorum sensing depends on an intracellular receptor protein, while chemotaxis depends on surface receptor proteins.

With higher cells, the timing of events in cellular differentiation and development is associated with surface receptors. With higher organisms, these receptors are highly evolved. Some receptors respond to steroids (*steroid hormone receptors*). Steroids do not act by themselves in cells, but rather the hormone–receptor complex interacts with specific gene loci to activate the transcription of a target gene.

A host of other animal receptors respond to a variety of small proteins that act as *hormones* or *growth factors*. These growth factors are normally required for the cell to initiate DNA synthesis and replication. Such factors are a critical component in the large-scale use of animal tissue cultures. Other cell surface receptors are important in the attachment of cells to surfaces. Cell adhesion can lead to changes in cell morphology, which are often critical to animal cell growth and normal physiological function. The exact mechanism by which receptors work is only now starting to emerge. One possibility for growth factors that stimulate cell division is that binding of the growth factor to the receptor causes an alteration in the structure of the receptor. This altered structure possesses catalytic activity (e.g., tyrosine kinase activity), which begins a cascade of reactions leading to cellular division. Surface receptors are continuously internalized, complexes degraded, and receptors recycled to supplement newly formed receptors. Thus, the ability of cells to respond to changes in environmental signals is continuously renewed. Such receptors will be important in our later discussions on animal cell culture.

4.8. SUMMARY

In this chapter you have learned some of the elementary concepts of how cells control their composition in response to an ever-changing environment. The essence of an organism resides in the chromosome as a linear sequence of nucleotides that form a language (*genetic code*) to describe the production of cellular components. The cell controls the storage and transmission of such information, using macromolecular templates. DNA is responsible for its own *replication* and is also a template for *transcription* of information into RNA species that serve both as machinery and template to *translate* genetic information into proteins. Proteins often must undergo posttranslational processing to perform their intended functions.

The cell controls both the amount and activity of proteins it produces. Many proteins are made on *regulated genes* (e.g., *repressible* or *inducible*), although other genes are *constitutive*. With regulated genes, small effector molecules alter the binding of regulatory proteins to specific sequences of nucleotides in the *operator* or *promoter* regions. Such regulatory proteins can block transcription or in other cases enhance it. A group of con-