16.2B: Prokaryotic versus Eukaryotic Gene Expression

Prokaryotes regulate gene expression by controlling the amount of transcription, whereas eukaryotic control is much more complex.

Learning Objectives

• Compare and contrast prokaryotic and eukaryotic gene expression

Key Points

• Prokaryotic gene expression is primarily controlled at the level of transcription.
• Eukaryotic gene expression is controlled at the levels of epigenetics, transcription, post-transcription, translation, and post-translation.
• Prokaryotic gene expression (both transcription and translation) occurs within the cytoplasm of a cell due to the lack of a defined nucleus; thus, the DNA is freely located within the cytoplasm.
• Eukaryotic gene expression occurs in both the nucleus (transcription) and cytoplasm (translation).

Key Terms

• **epigenetics**: the study of heritable changes caused by the activation and deactivation of genes without any change in DNA sequence
• **nucleosome**: any of the subunits that repeat in chromatin; a coil of DNA surrounding a histone core
Prokaryotic versus Eukaryotic Gene Expression

To understand how gene expression is regulated, we must first understand how a gene codes for a functional protein in a cell. The process occurs in both prokaryotic and eukaryotic cells, just in slightly different manners.

Prokaryotic organisms are single-celled organisms that lack a defined nucleus; therefore, their DNA floats freely within the cell cytoplasm. To synthesize a protein, the processes of transcription (DNA to RNA) and translation (RNA to protein) occur almost simultaneously. When the resulting protein is no longer needed, transcription stops. Thus, the regulation of transcription is the primary method to control what type of protein and how much of each protein is expressed in a prokaryotic cell. All of the subsequent steps occur automatically. When more protein is required, more transcription occurs. Therefore, in prokaryotic cells, the control of gene expression is mostly at the transcriptional level.

Eukaryotic cells, in contrast, have intracellular organelles that add to their complexity. In eukaryotic cells, the DNA is contained inside the cell’s nucleus where it is transcribed into RNA. The newly-synthesized RNA is then transported out of the nucleus into the cytoplasm where ribosomes translate the RNA into protein. The processes of transcription and translation are physically separated by the nuclear membrane; transcription occurs only within the nucleus, and translation occurs only outside the nucleus within the cytoplasm. The regulation of gene expression can occur at all stages of the process. Regulation may occur when the DNA is uncoiled and loosened from nucleosomes to bind transcription factors (epigenetics), when the RNA is transcribed (transcriptional level), when the RNA is processed and exported to the cytoplasm after it is transcribed (post-transcriptional level), when the RNA is translated into protein (translational level), or after the protein has been made (post-translational level).

**Prokaryotic vs Eukaryotic Gene Expression**: Prokaryotic transcription and translation occur simultaneously in the cytoplasm, and regulation occurs at the transcriptional level. Eukaryotic gene expression is regulated during transcription and RNA processing, which take place in the nucleus, and during protein translation, which takes place in the cytoplasm. Further regulation may occur through post-translational modifications of proteins.

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