7.5B: The Promoter and the Transcription Machinery

LEARNING OBJECTIVES

- Describe the role of promoters in RNA transcription

Genes are organized to make the control of gene expression easier. The promoter region is immediately upstream of the coding sequence. This region can be short (only a few nucleotides in length) or quite long (hundreds of nucleotides long). The longer the promoter, the more available space for proteins to bind. This also adds more control to the transcription process. The length of the promoter is gene-specific and can differ dramatically between genes. Consequently, the level of control of gene expression can also differ quite dramatically between genes. The purpose of the promoter is to bind transcription factors that control the initiation of transcription.
Figure: **Promoters**: A generalized promoter of a gene transcribed by RNA polymerase II is shown. Transcription factors recognize the promoter. RNA polymerase II then binds and forms the transcription initiation complex.

Within the promoter region, just upstream of the transcriptional start site, resides the TATA box. This box is simply a repeat of thymine and adenine dinucleotides (literally, TATA repeats). RNA polymerase binds to the transcription initiation complex, allowing transcription to occur. To initiate transcription, a transcription factor (TFIID) is the first to bind to the TATA box. Binding of TFIID recruits other transcription factors, including TFII B, TFII E, TFII F, and TFII H to the TATA box. Once this transcription initiation complex is assembled, RNA polymerase can bind to its upstream sequence. When bound along with the transcription factors, RNA polymerase is phosphorylated. This releases part of the protein from the DNA to activate the transcription initiation complex and places RNA polymerase in the correct orientation to begin transcription; DNA-bending protein brings the enhancer, which can be quite a distance from the gene, in contact with transcription factors and mediator proteins.

In addition to the general transcription factors, other transcription factors can bind to the promoter to regulate gene transcription. These transcription factors bind to the promoters of a specific set of genes. They are not general transcription factors that bind to every promoter complex, but are recruited to a specific sequence on the promoter of a specific gene. There are hundreds of transcription factors in a cell that each bind specifically to a particular DNA sequence motif. When transcription factors bind to the promoter just upstream of the encoded gene, they are referred to as cis-acting elements because they are on the same chromosome, just next to the gene. The region that a particular transcription factor binds to is called the transcription factor binding site. Transcription factors respond to environmental stimuli that cause the proteins to find their binding sites and initiate transcription of the gene that is needed.
Key Points

- The purpose of the promoter is to bind transcription factors that control the initiation of transcription.
- The promoter region can be short or quite long; the longer the promoter is, the more available space for proteins to bind.
- To initiate transcription, a transcription factor (TFIID) binds to the TATA box, which causes other transcription factors to subsequently bind to the TATA box.
- Once the transcription initiation complex is assembled, RNA polymerase can bind to its upstream sequence and is then phosphorylated.
- Phosphorylation of RNA polymerase releases part of the protein from the DNA to activate the transcription initiation complex and places RNA polymerase in the correct orientation to begin transcription.
- Transcription factors respond to environmental stimuli that cause the proteins to find their binding sites and initiate transcription of the gene that is needed.

Key Terms

- **TATA box**: a DNA sequence (cis-regulatory element) found in the promoter region of genes in archaea and eukaryotes
- **transcription factor**: a protein that binds to specific DNA sequences, thereby controlling the flow (or transcription) of genetic information from DNA to mRNA
- **promoter**: the section of DNA that controls the initiation of RNA transcription

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