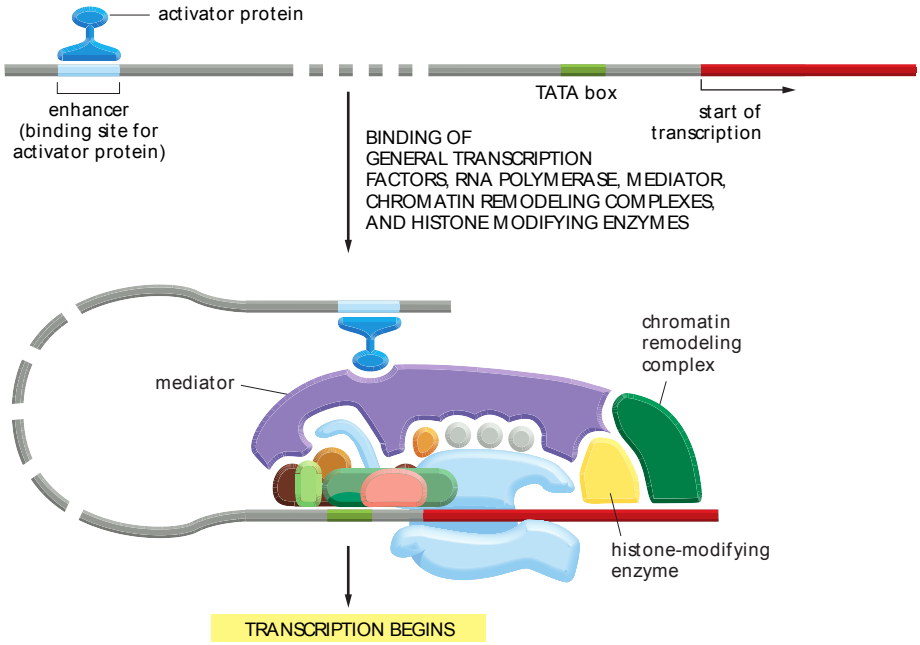

Figure 6–19 Transcription initiation by RNA polymerase II in a eucaryotic cell. Transcription initiation in vivo requires the presence of transcriptional activator proteins. As described in Chapter 7, these proteins bind to specific short sequences in DNA. Although only one is shown here, a typical eucaryotic gene has many activator proteins, which together determine its rate and pattern of transcription. Sometimes acting from a distance of several thousand nucleotide pairs (indicated by the dashed DNA molecule), these gene regulatory proteins help RNA polymerase, the general transcription factors, and the mediator all to assemble at the promoter. In addition, activators attract ATP-dependent chromatin remodeling complexes and histone acetylases.

As discussed in Chapter 4, the "default" state of chromatin is probably the 30-nm filament (see Figure 4–22), and this is likely to be a form of DNA upon which transcription is initiated. For simplicity, it is not shown in the figure.

chromatin structures. As a result, transcription initiation in a eucaryotic cell is more complex and requires even more proteins than it does on purified DNA. First, gene regulatory proteins known as transcriptional activators must bind to specific sequences in DNA and help to attract RNA polymerase II to the start point of transcription (Figure 6–19). We discuss the role of activators in Chapter 7, because they are one of the main ways in which cells regulate expression of their genes. Here we simply note that their presence on DNA is required for transcription initiation in a eucaryotic cell. Second, eucaryotic transcription initiation in vivo requires the presence of a protein complex known as Mediator, which allows the activator proteins to communicate properly with the polymerase II and with the general transcription factors. Finally, transcription initiation in a eucaryotic cell typically requires the local recruitment of chromatin-modifying enzymes, including chromatin remodeling complexes and histone-modifying enzymes. As discussed in Chapter 4, both types of enzymes can allow greater access to the DNA present in chromatin, and by doing so, they facilitate the assembly of the transcription initiation machinery onto DNA. We will revisit the role of these enzymes in transcription initiation in Chapter 7.

As illustrated in Figure 6–19, many proteins (well over 100 individual subunits) must assemble at the start point of transcription to initiate transcription in a eucaryotic cell. The order of assembly of these proteins does not seem to follow a prescribed pathway; rather, the order differs from gene to gene. Indeed, some of these different protein complexes may interact with each other away from the DNA and be brought to DNA as preformed subassemblies. To begin transcribing, RNA polymerase II must be released from this large complex of proteins, and, in addition to the steps described in Figure 6–16, this often requires the in situ proteolysis of the activator protein. We return to some of these issues in Chapter 7, where we discuss how eucaryotic cells can regulate the process of transcription initiation.

Transcription Elongation Produces Superhelical Tension in DNA

Once it has initiated transcription, RNA polymerase does not proceed smoothly along a DNA molecule; rather, it moves jerkily, pausing at some sequences and rapidly transcribing through others. Elongating RNA polymerases, both bacterial and eucaryotic, are associated with a series of elongation factors, proteins that decrease the likelihood that RNA polymerase will dissociate before it reaches the end of a gene. These factors typically associate with RNA polymerase