lactase is translated. The repressor protein is removed, and RNA polymerase can bind to the promotor, allowing the organism to make more lactase to metabolize the lactose (Figure 10.34).

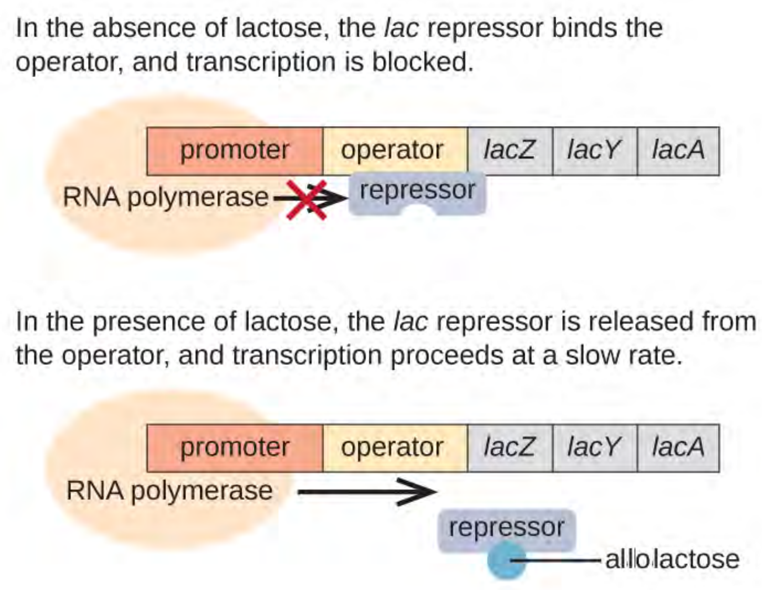

Figure 10.34 The three structural genes that are needed to degrade lactose in *E. coli* are located next to each other in the *lac* operon. RNA polymerase can bind to the promoter if a repressor is not present. (credit: Modified by Elizabeth O'Grady original work of Parker et al. / Microbiology OpenStax)

CONCEPTS IN ACTION – Learn more about operons in this video.

Eukaryotic Gene Expression

Eukaryotic cells, in contrast, have organelles and are therefore more complex. Recall that in eukaryotic cells, the DNA is contained inside the cell's nucleus where it is transcribed into mRNA. The newly synthesized mRNA is then transported out of the nucleus into the cytoplasm, where ribosomes translate the mRNA 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 in the cytoplasm. The regulation of gene expression can occur before or during both transcription and translation.

Recall, that DNA in the nucleus is condensed by wrapping around histone proteins. When several histone proteins are wrapped together it forms bead like structures called a nucleosome. Nucleosomes can control how accessible the DNA is to transcription proteins, a type of regulation referred to as epigenetic control. For example, if a gene is to be transcribed, the histone proteins and DNA in the chromosomal region encoding that gene are modified in a way that opens the promoter region to allow RNA polymerase and other transcription proteins to bind and initiate transcription. If a gene is to remain turned off, or silenced, the histone proteins and DNA have different modifications that signal a closed chromosomal configuration. In this closed configuration, the RNA polymerase and transcription factors do not have access to the DNA and transcription cannot occur (Figure 10.35).

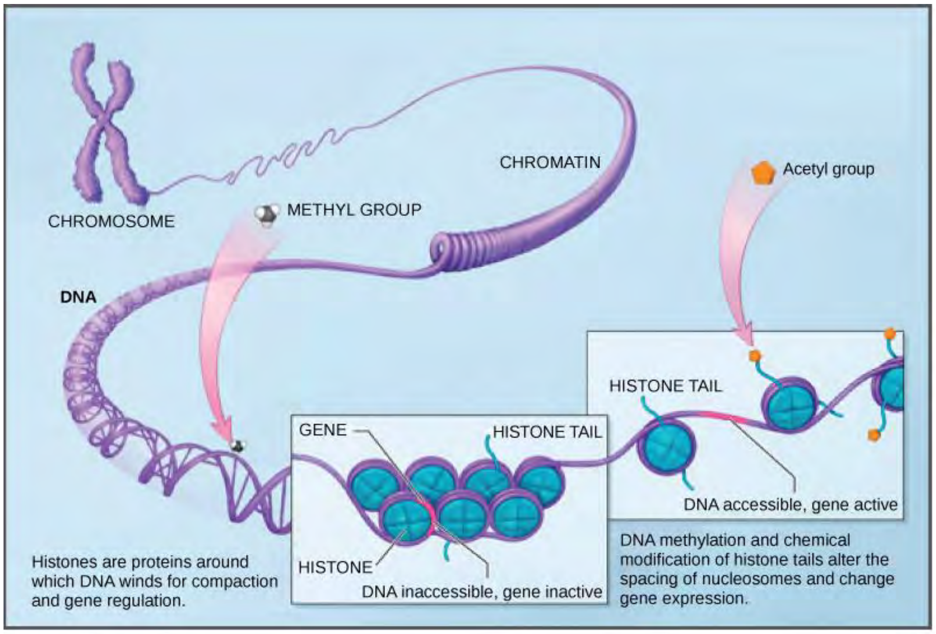

Figure 10.35 Histone proteins and DNA nucleotides can be modified chemically. Modifications affect nucleosome spacing and gene expression. (credit: Modified by Elizabeth O'Grady original work of NIH / Biology 2E OpenStax)

Gene expression can also be controlled when the mRNA is transcribed (transcriptional regulation) or when the mRNA is processed and exported to the cytoplasm after it is transcribed (post-transcriptional regulation). Recall from section 10.3 that mRNA transcripts undergo alternative RNA splicing. Alternative RNA splicing is a mechanism that allows different protein products to be produced from one gene when different combinations of introns, and sometimes exons, are removed from the transcript (Figure 10.28). Alternative splicing can be haphazard, but more often it is controlled and acts as a mechanism of post-transcriptional gene regulation. The frequency of different splicing alternatives is controlled by the cell as a way to control the production of different proteins.

CONCEPTS IN ACTION – Learn more about alternate splicing at this site.

Gene expression can also be controlled as the mRNA is translated into protein (translational regulation) or after the protein has been made (post-translational regulation). Like transcription, translation is controlled by proteins that bind and initiate the process (Figure 10.36). For example, an initiation protein must bind to the small sub-unit of the ribosome to allow translation (Figure 10.36). If that protein is phosphorylated, translation will be blocked, and the protein cannot be made. This is an example of translational gene regulation. Chemical modifications such as phosphorylation can occur in response to external stimuli such as stress, the lack of nutrients, heat, or ultraviolet light exposure.

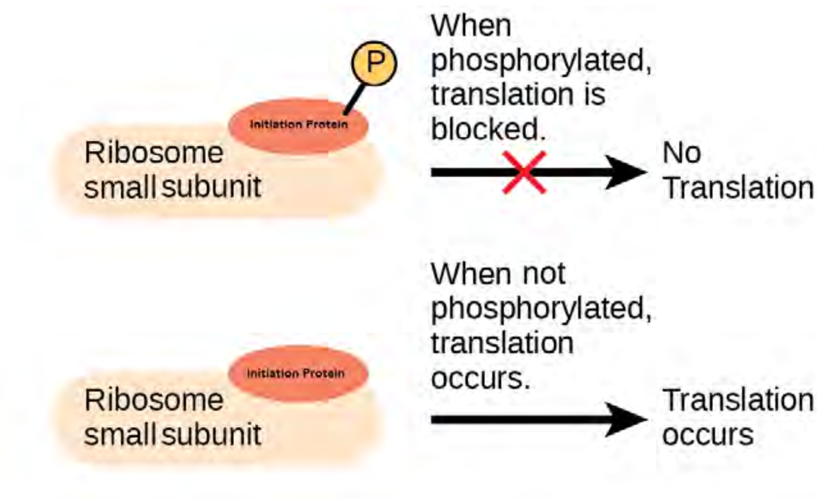

Figure 10.36 Gene expression can be controlled by chemical modifications of proteins needed to initiate translation. (credit: Modified by Elizabeth O'Grady original work of Clark et al. / Biology 2E OpenStax)