Only a fraction of the genome in a cell is expressed at any given time. The shape and activity of that cell will be determined by which genes have been and continue to be expressed.

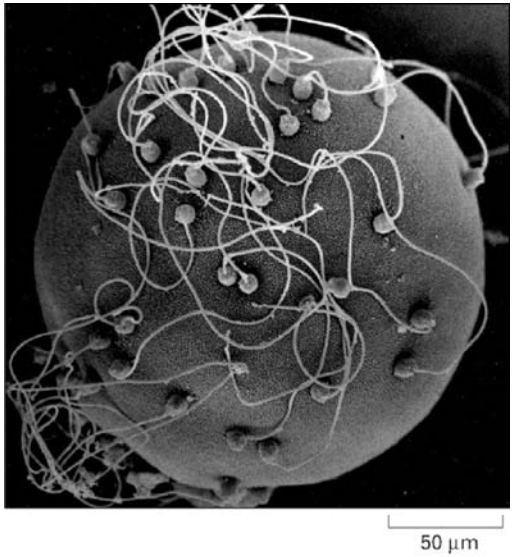
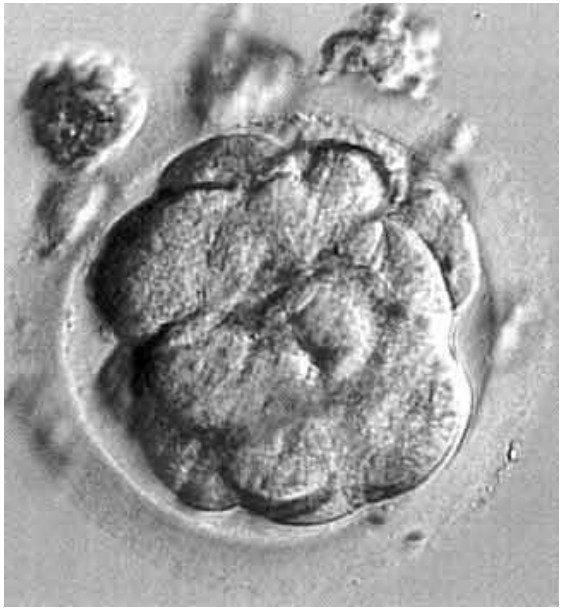
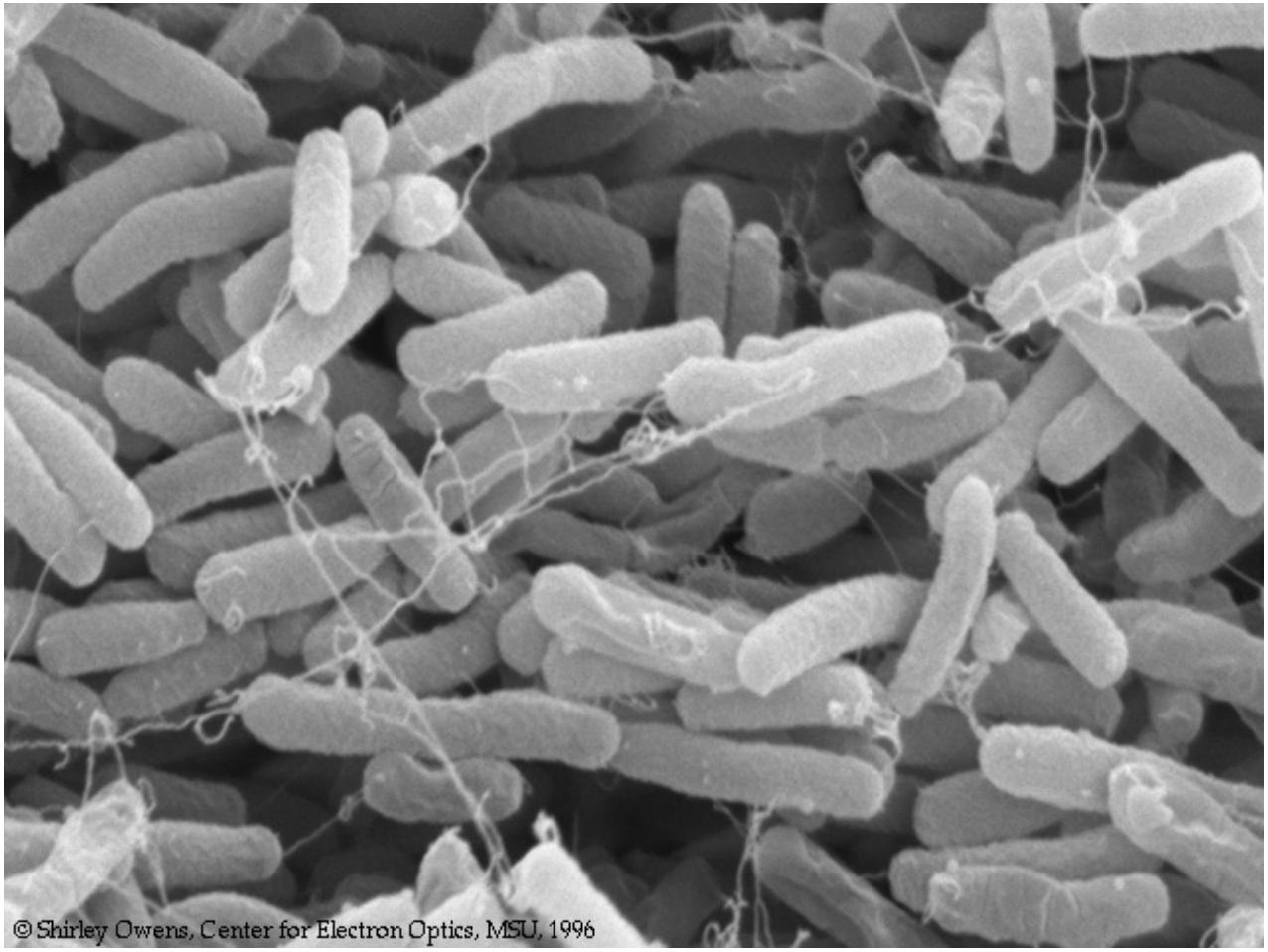


Figure 20–4. Molecular Biology of the Cell, 4th Edition.



Cells may alter their gene expression in response to environmental cues



Gene Regulatory Proteins

- Gene regulatory proteins, also known as Transcription Regulators or Transcription Factors are proteins that bind to DNA elements near promoters and affect the rate of transcription of specific genes.

Gene Regulatory Proteins form non-covalent bonds with DNA bases via the major groove

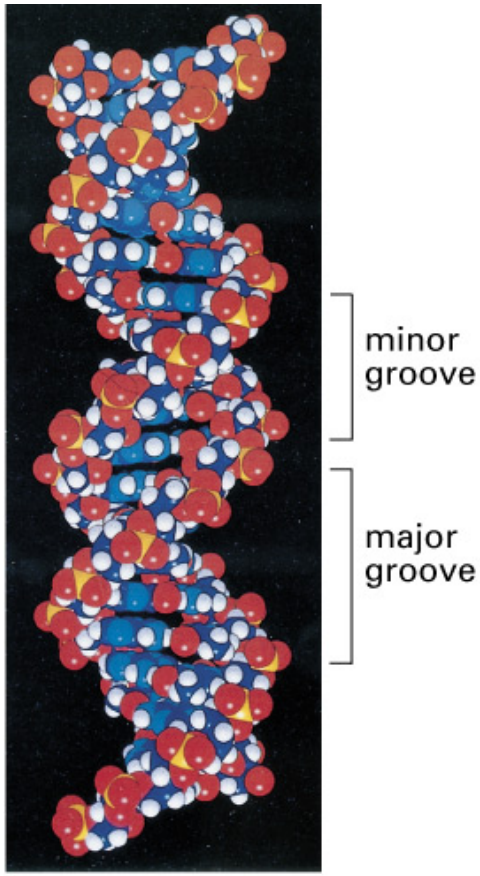


Figure 7–6. Molecular Biology of the Cell, 4th Edition.

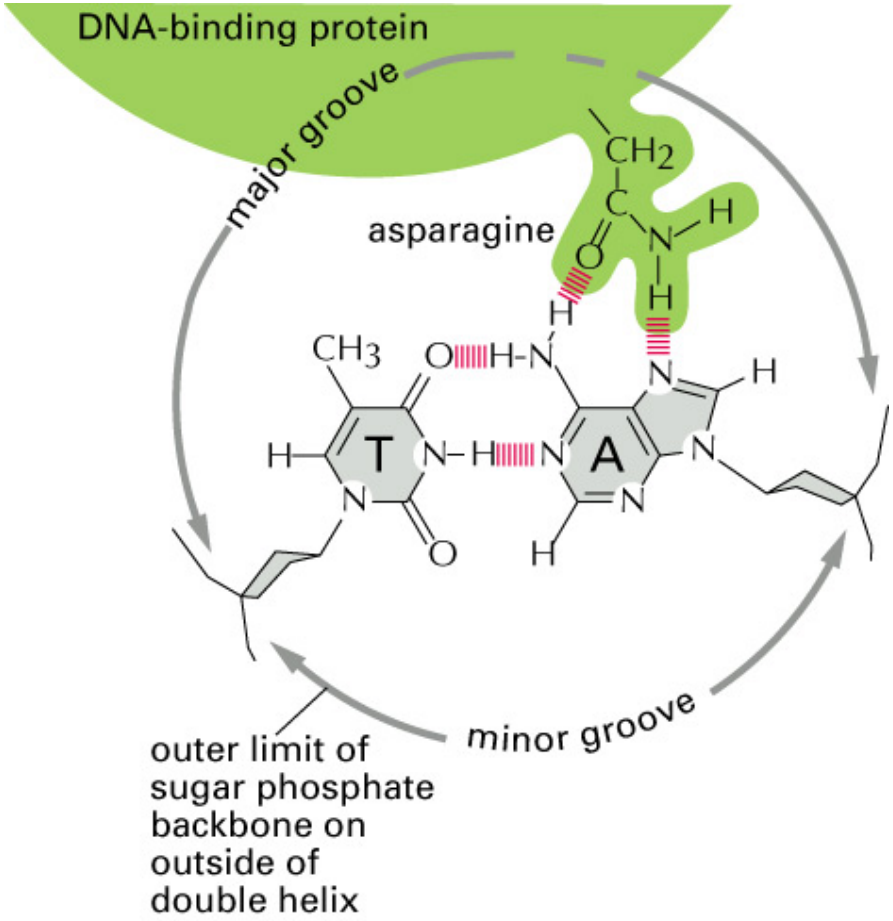


Figure 7–12. Molecular Biology of the Cell, 4th Edition.

Gene Regulatory Proteins contain structural motifs that can read specific DNA sequences. This diagram shows a Helix-Turn-Helix Motif

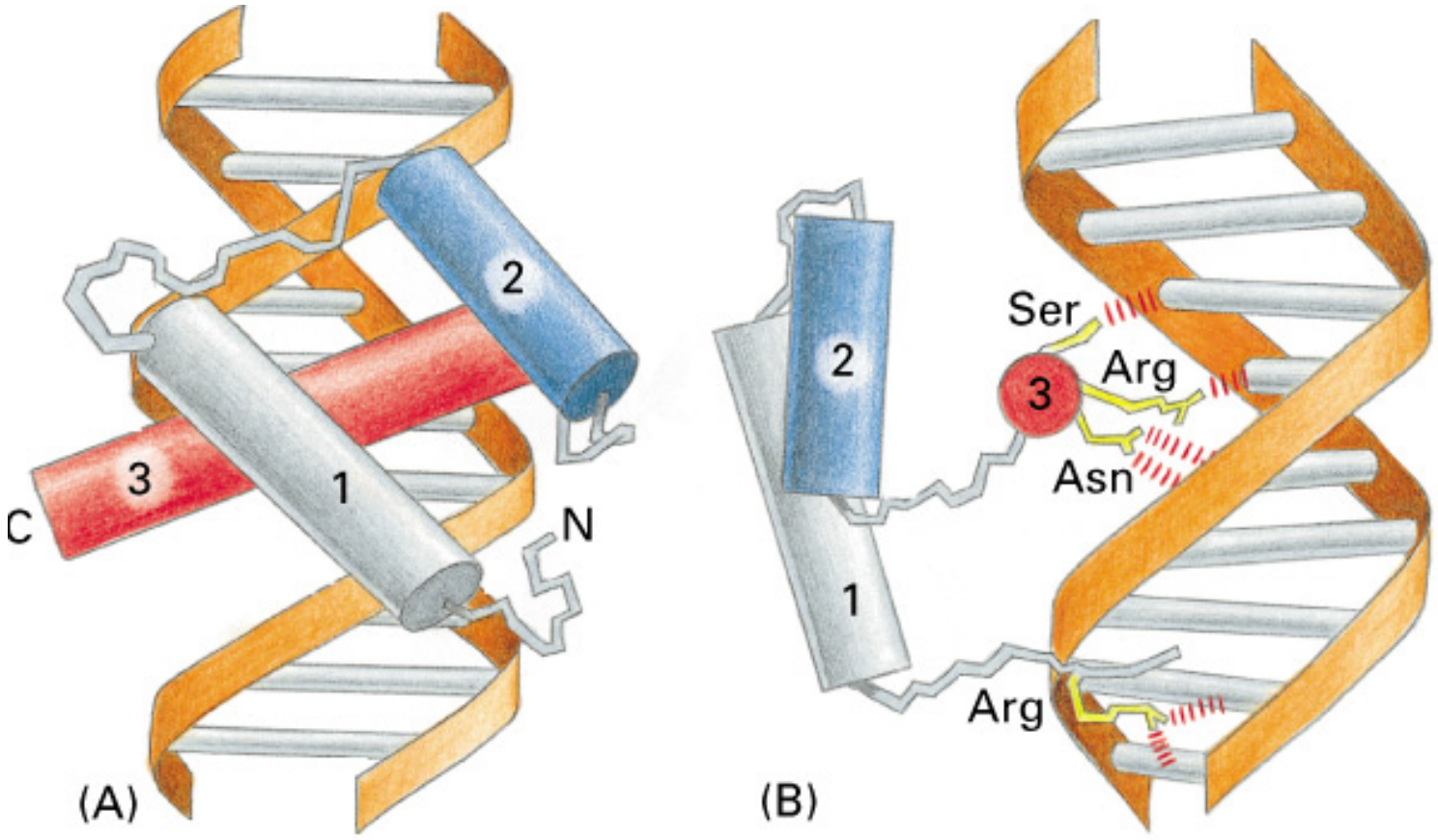


Figure 7–16. Molecular Biology of the Cell, 4th Edition.

Most gene regulatory proteins bind as dimers (2 identical subunits). The DNA binding site generally has a symmetrical structure and each monomer binds a similar sequence

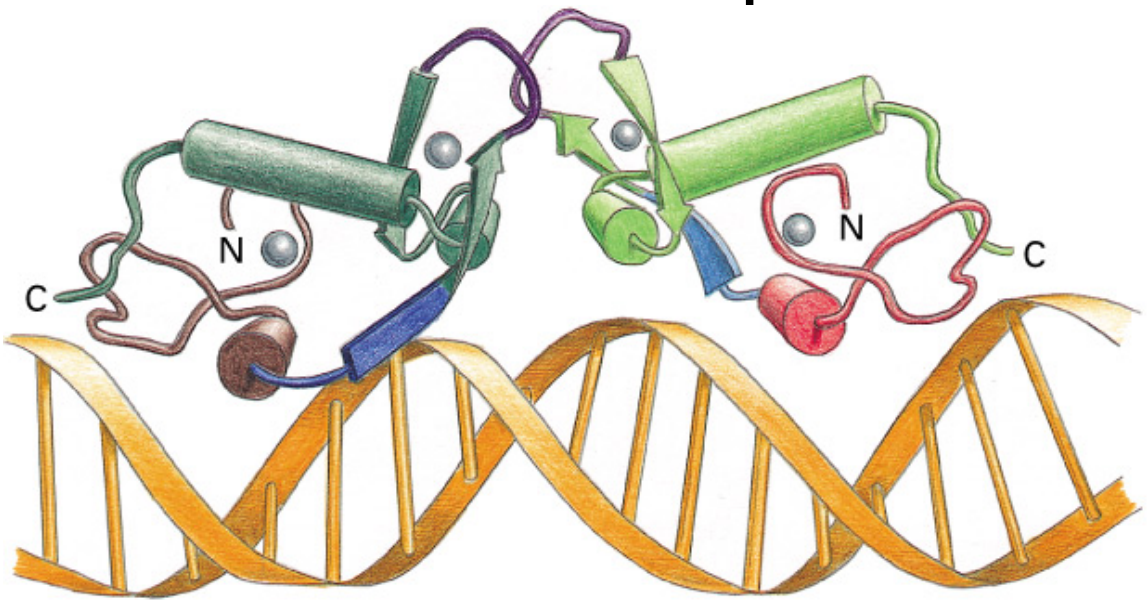


Figure 7–19. Molecular Biology of the Cell, 4th Edition.

Figure 7–15. Molecular Biology of the Cell, 4th Edition.

The Trp Operon as an example of Regulation of Gene Expression in Prokaryotes

The Trp Operon encodes the genes required for the biosynthesis of the amino acid tryptophan

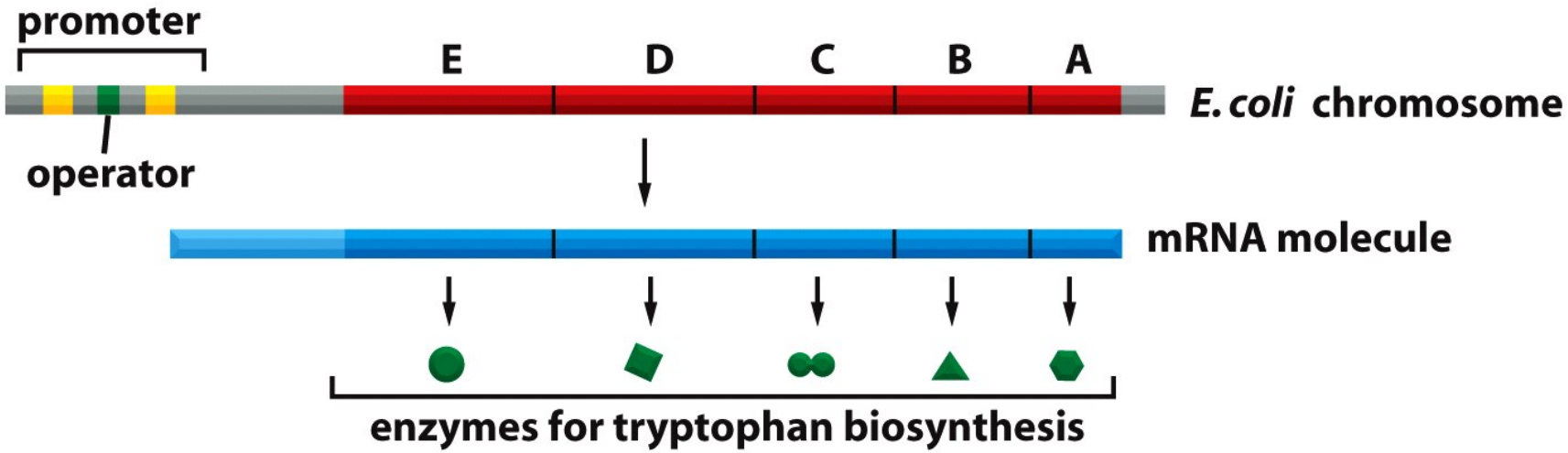


Figure 7-34 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Tryptophan Biosynthetic Pathway

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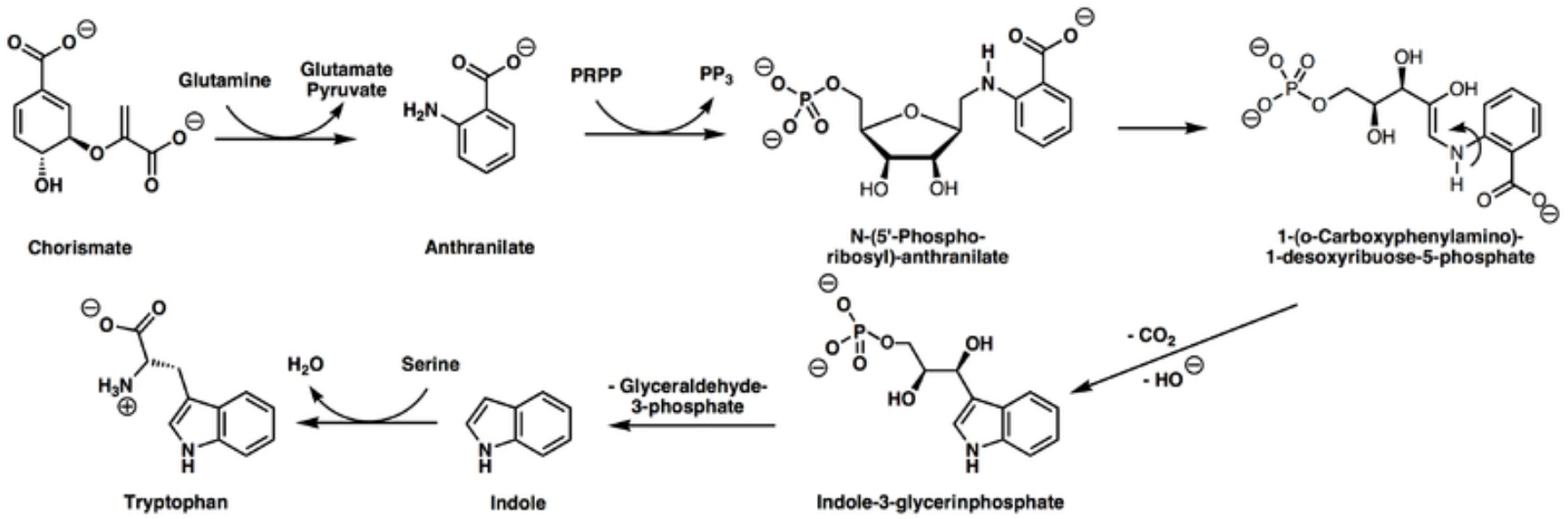


The Trp operon is repressed by the tryptophan repressor protein under conditions of excess tryptophan. The presence of the repressor at the operator inhibits the binding of RNA polymerase to the promoter, thus inhibiting transcription of the operon.

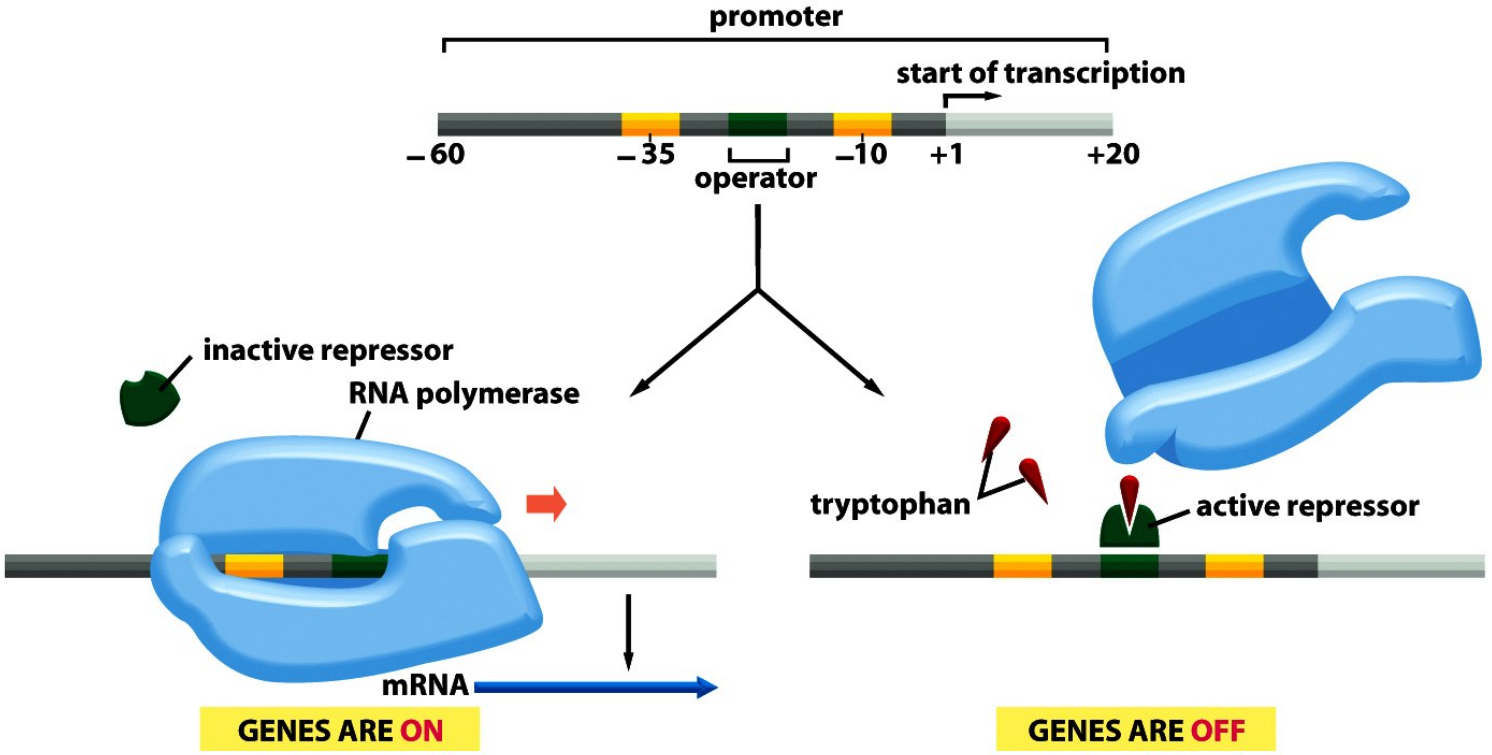


Figure 7-35 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Binding of tryptophan activates the repressor protein by altering its shape and thus allowing it to bind to the operator.

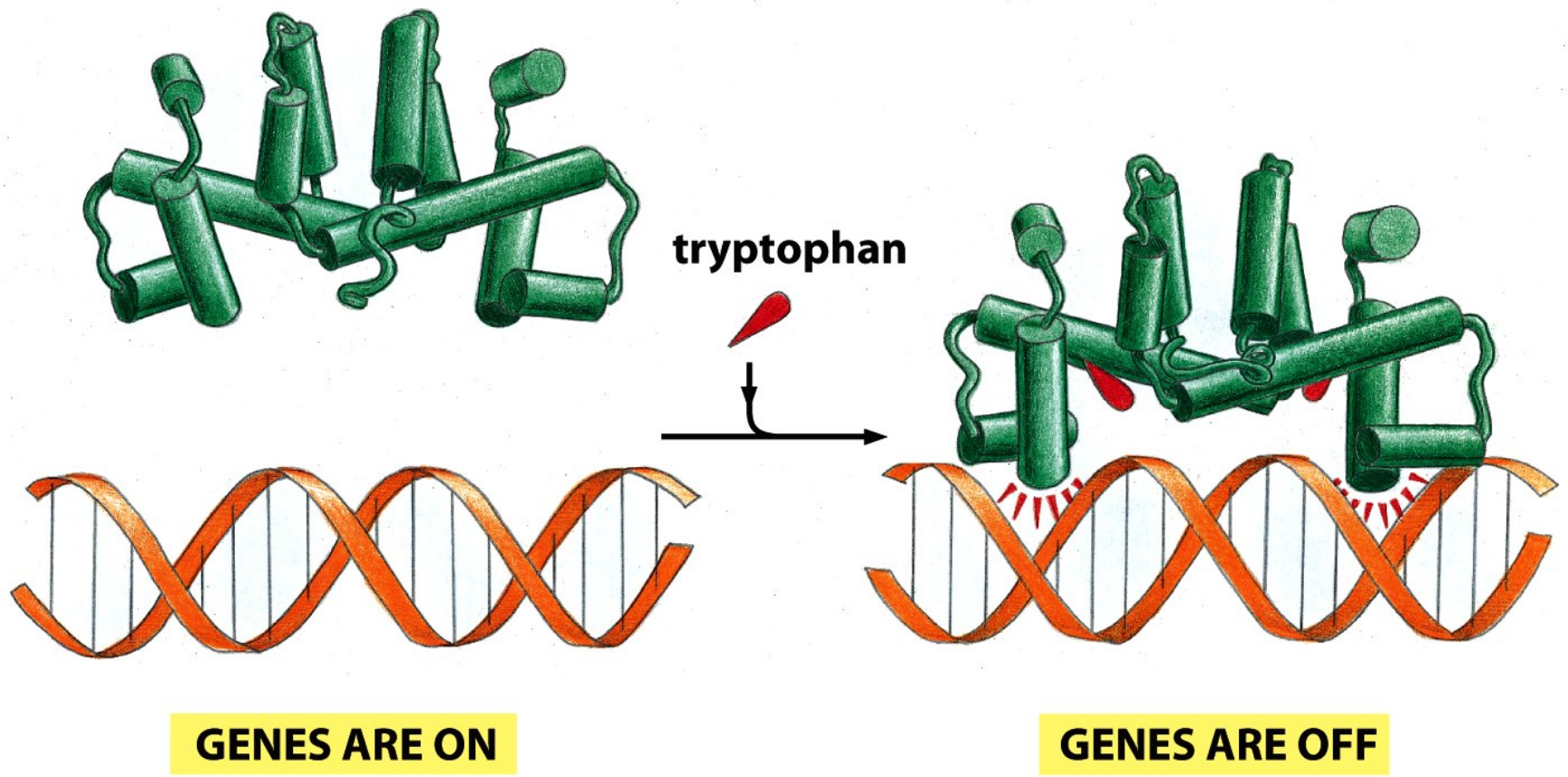
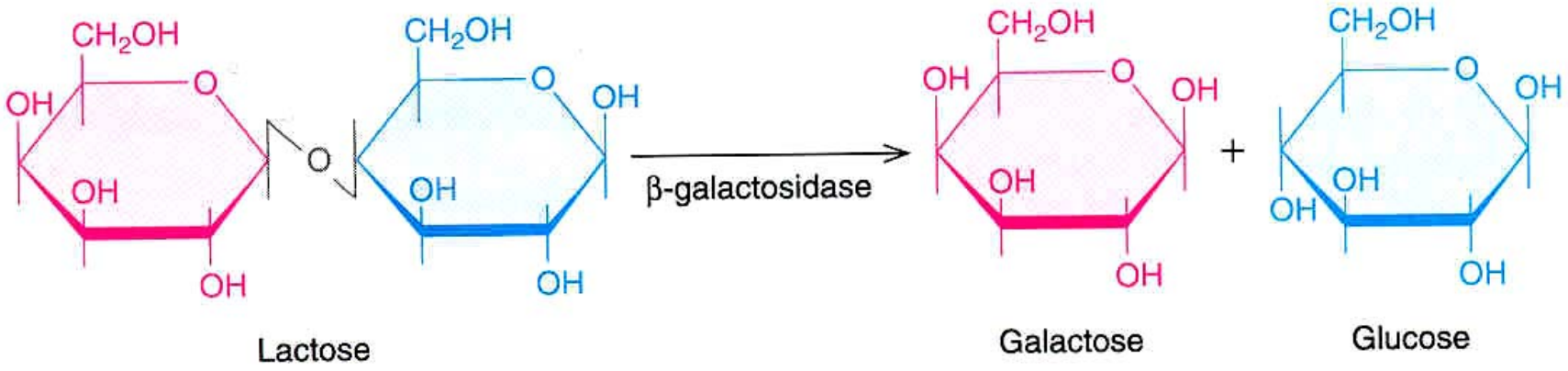


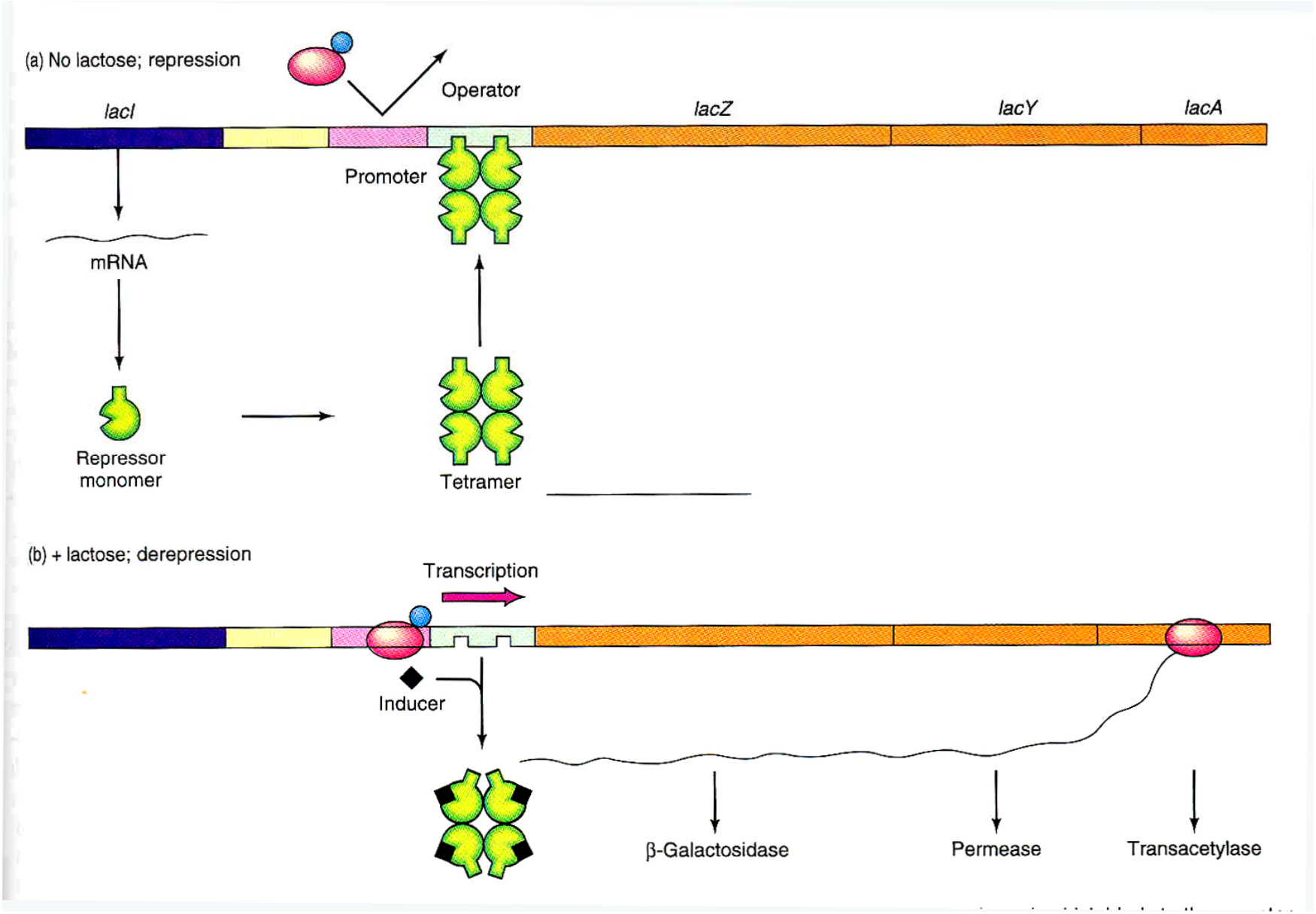
Figure 7-36 Molecular Biology of the Cell 5/e (© Garland Science 2008)

The Lac Operon as an example of Regulation of Gene Expression in Prokaryotes

βGalactosidase catalyzes the conversion of lactose to galactose plus glucose.



Negative Regulation of the Lac Operon



Negative Regulation of the Lac Operon

- In the absence of lactose, the repressor protein bind to the operator, which denies RNA polymerase access to the promoter and inhibits transcription of the operon.
- When lactose is present it binds to the repressor, changing its shape and causing it to dissociate from the operator. RNA polymerase now binds to the promoter and transcribes the operon.

Positive Regulation of the Lac Operon

- E. coli can metabolize glucose faster than lactose. Therefore, when given both sugars at the same time, E. coli will continue to repress the Lac operon and express only those genes required for glucose metabolism.
- E. coli uses the catabolite activator protein (CAP) to “sense” levels of glucose in the cell.
- If glucose is absent, c-AMP is abundant. c-AMP binds to CAP, activating it. Activated CAP binds to the CAP binding site upstream of the promoter and functions to recruit RNA Polymerase to the promoter, thus stimulating transcription of the Lac operon.

Positive/Negative Regulation of the Lac Operon

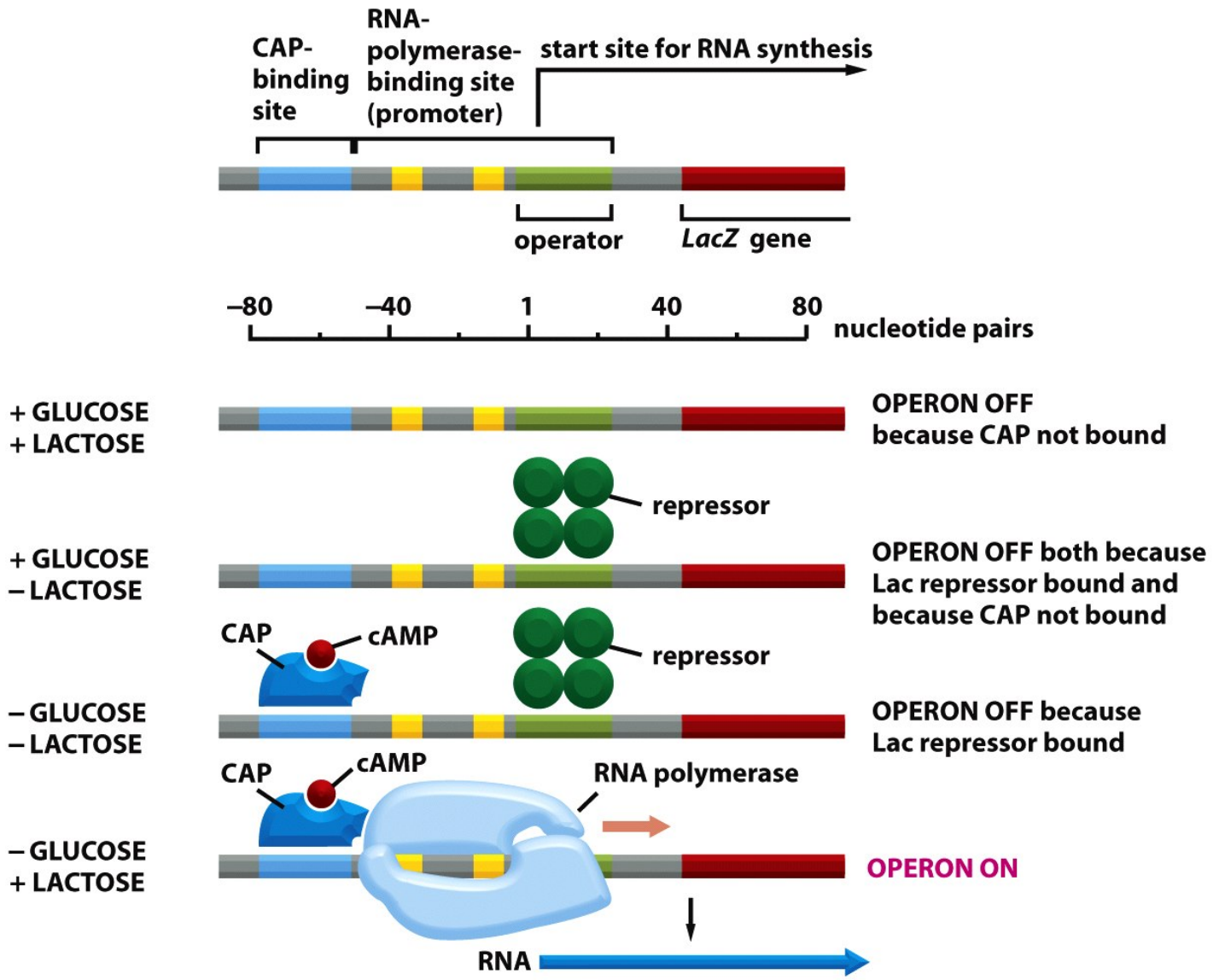
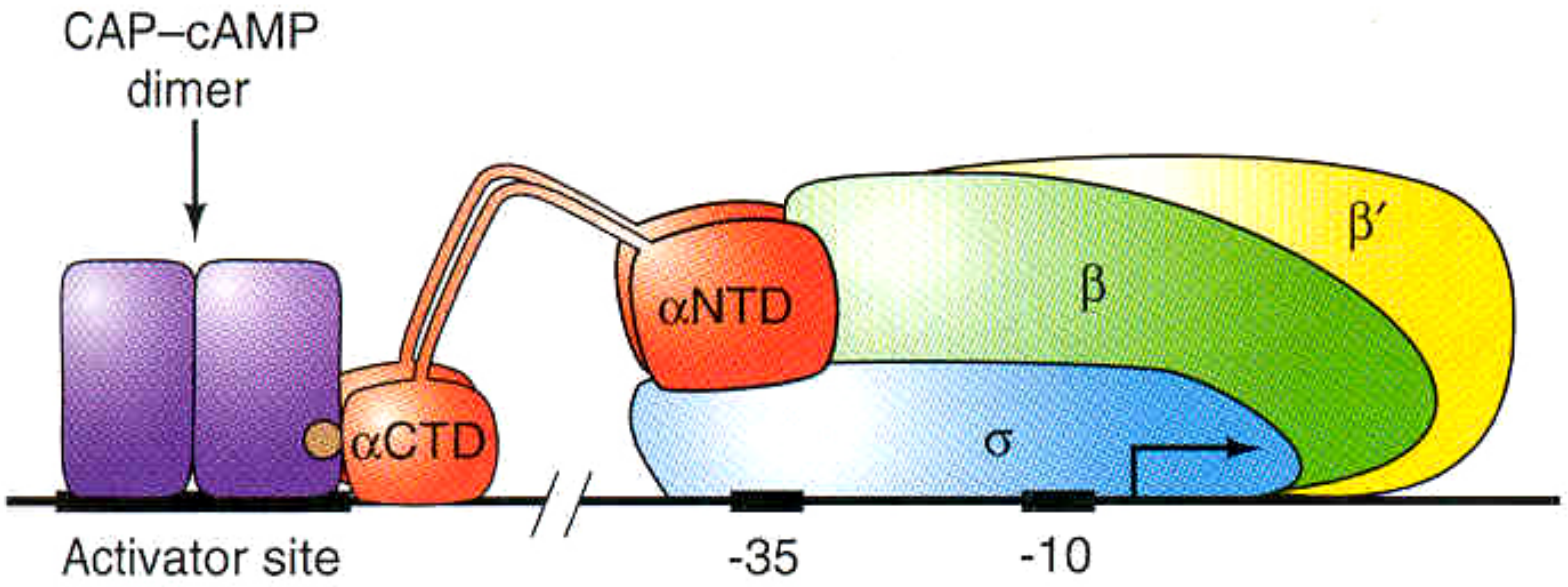


Figure 7-39 Molecular Biology of the Cell 5/e (© Garland Science 2008)

In the absence of glucose, c-AMP levels in the cell are high. Binding of c-AMP to CAP activates it. Activated CAP binds to the CAP binding site (Activator site) upstream of the promoter and functions to recruit RNA Polymerase to the promoter, thus increasing transcription rate.



Positive/Negative Regulation of the Lac Operon

- Full expression of the Lac operon requires
  1. Dissociation of the repressor from the operator.
  2. Binding of CAP (catabolite activator protein) to the cap binding site upstream of the promoter.

  Both condition are met when lactose is present and glucose is absent from the bacterial growth media