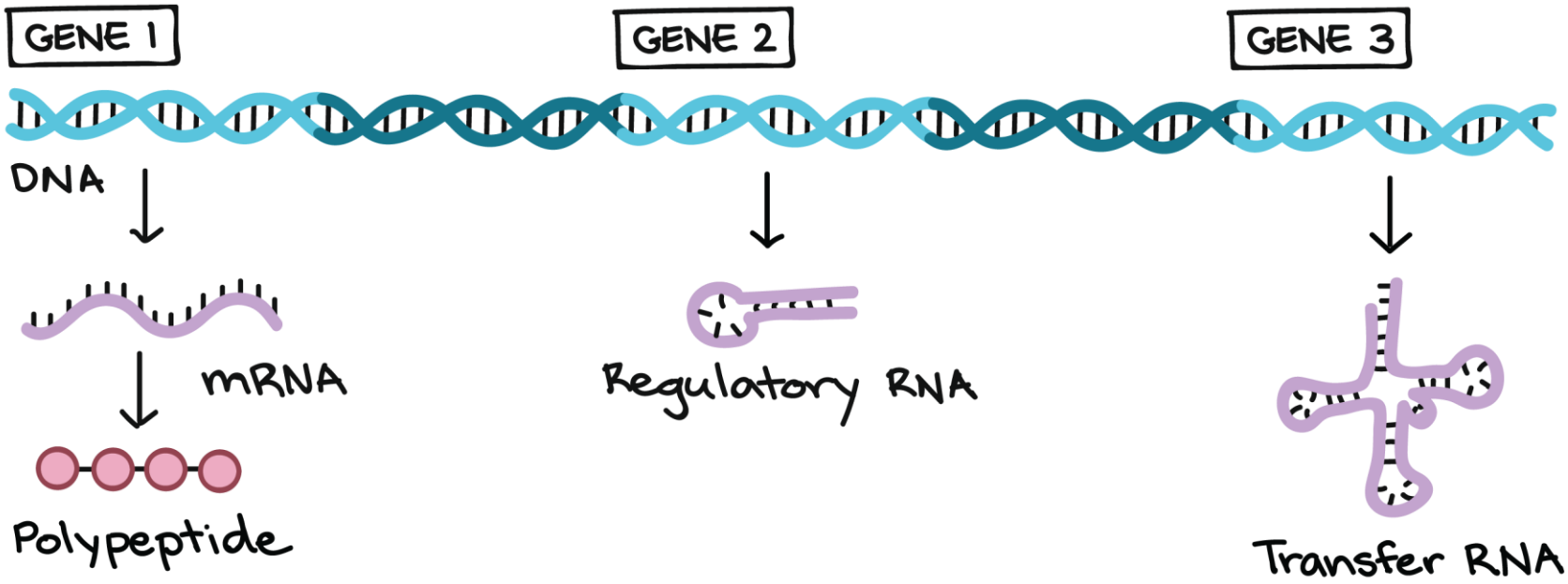
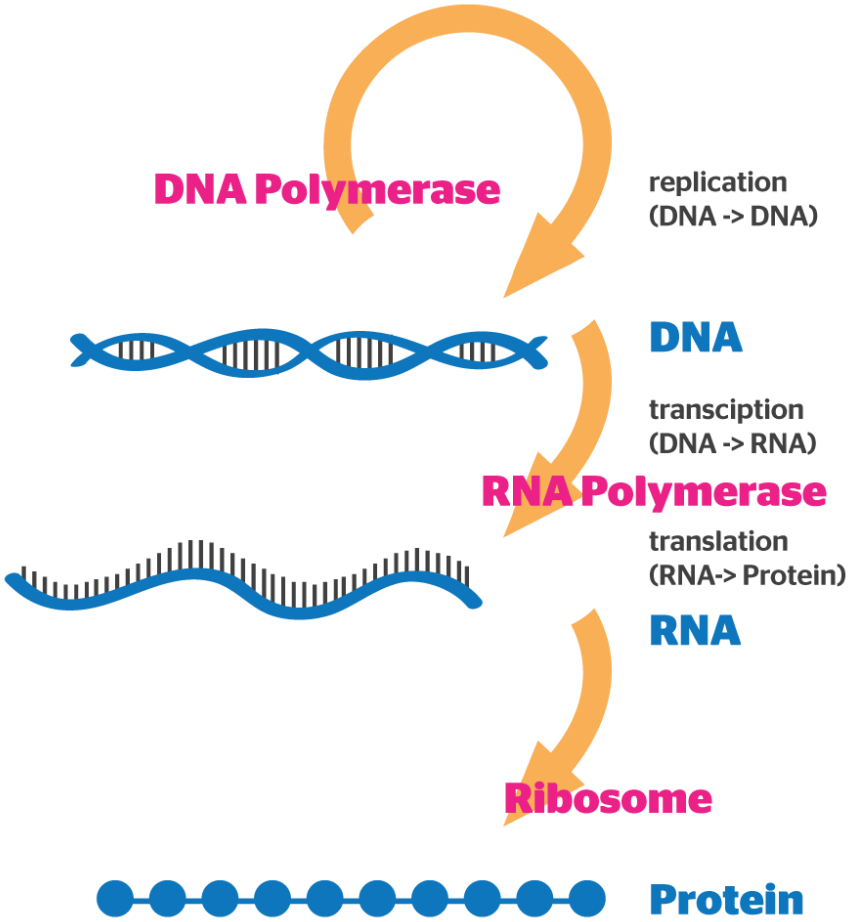
Gene Expression

Gene expression is the process by which information from a gene is used in the synthesis of a functional gene product.

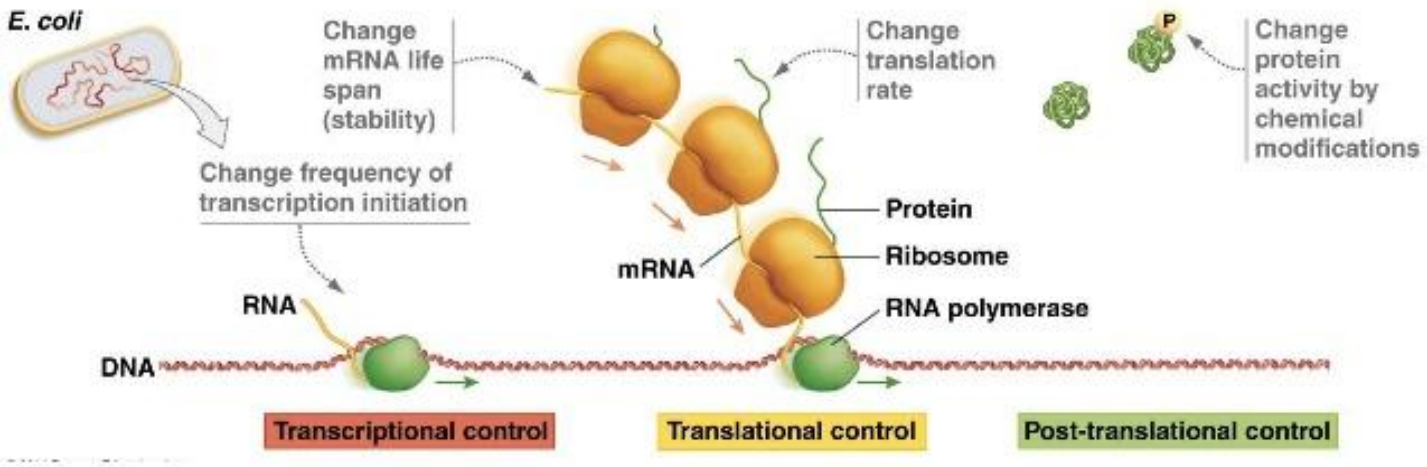
Functional gene products



Central dogma of molecular biology



Regulation of Gene Expression

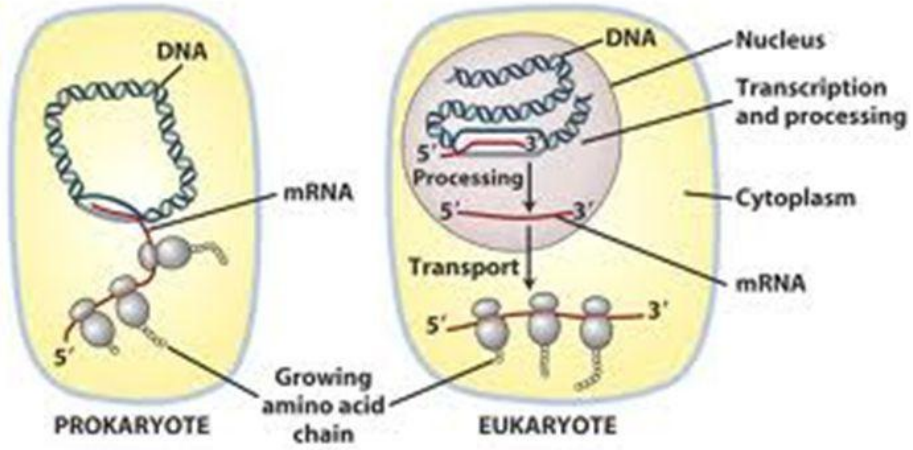


- Gene expression can be regulated:
  - During transcription (transcriptional control).
  - During translation (translational control).
  - After translation (post-translational control).

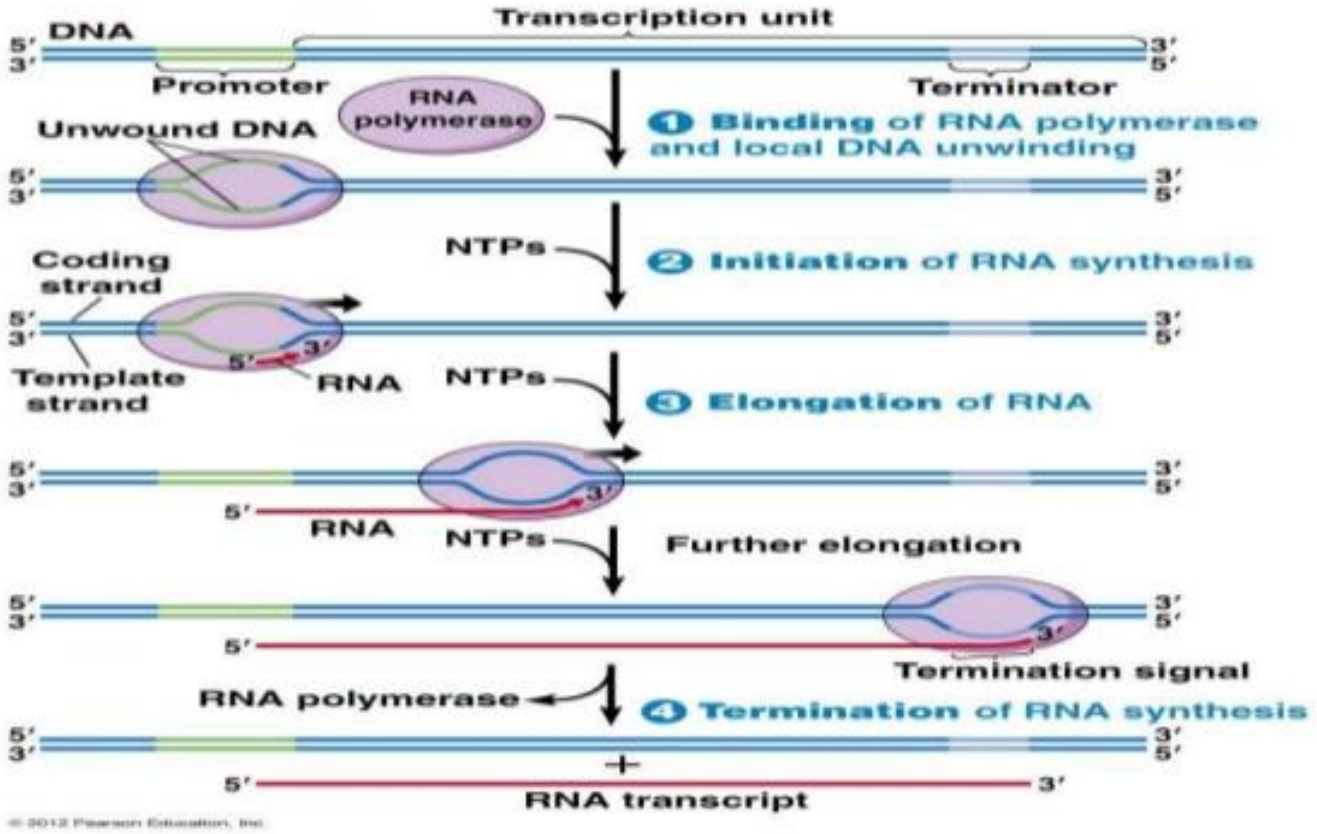
DNA Transcription in prokaryotes

Bacteria vs. Eukaryotes

- Both alter their patterns of gene expression in response to changes in environmental conditions
  - This regulation often happens during transcription

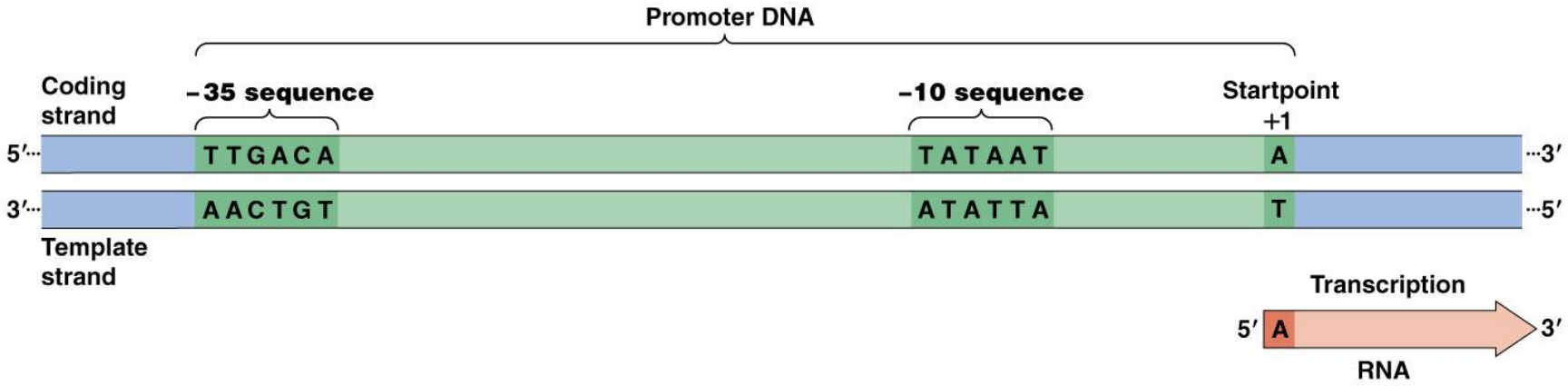


Overview of Prokaryotic DNA Transcription

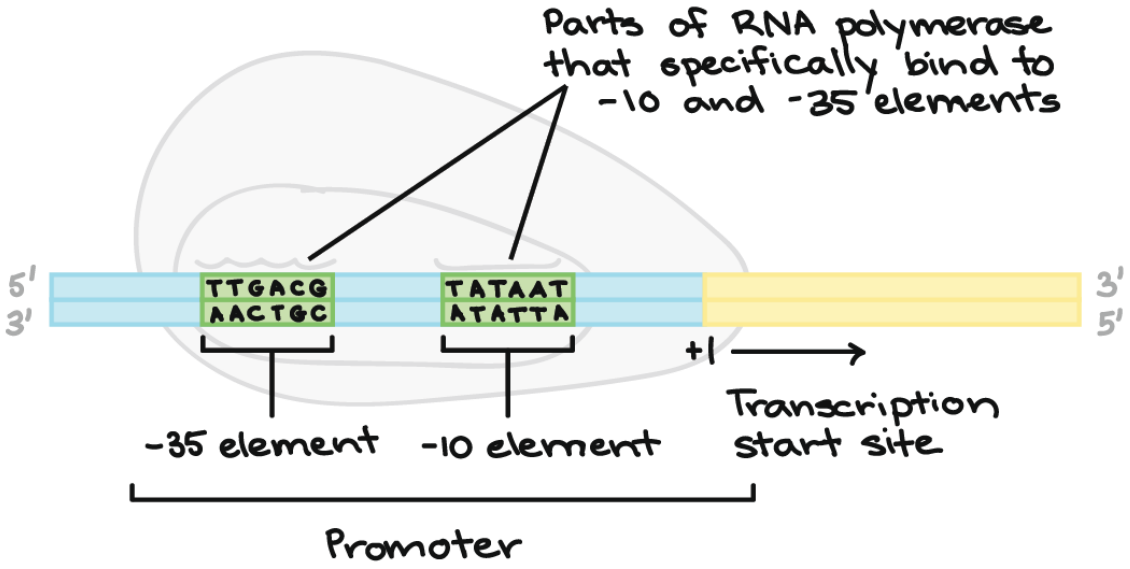


Bacterial promoter

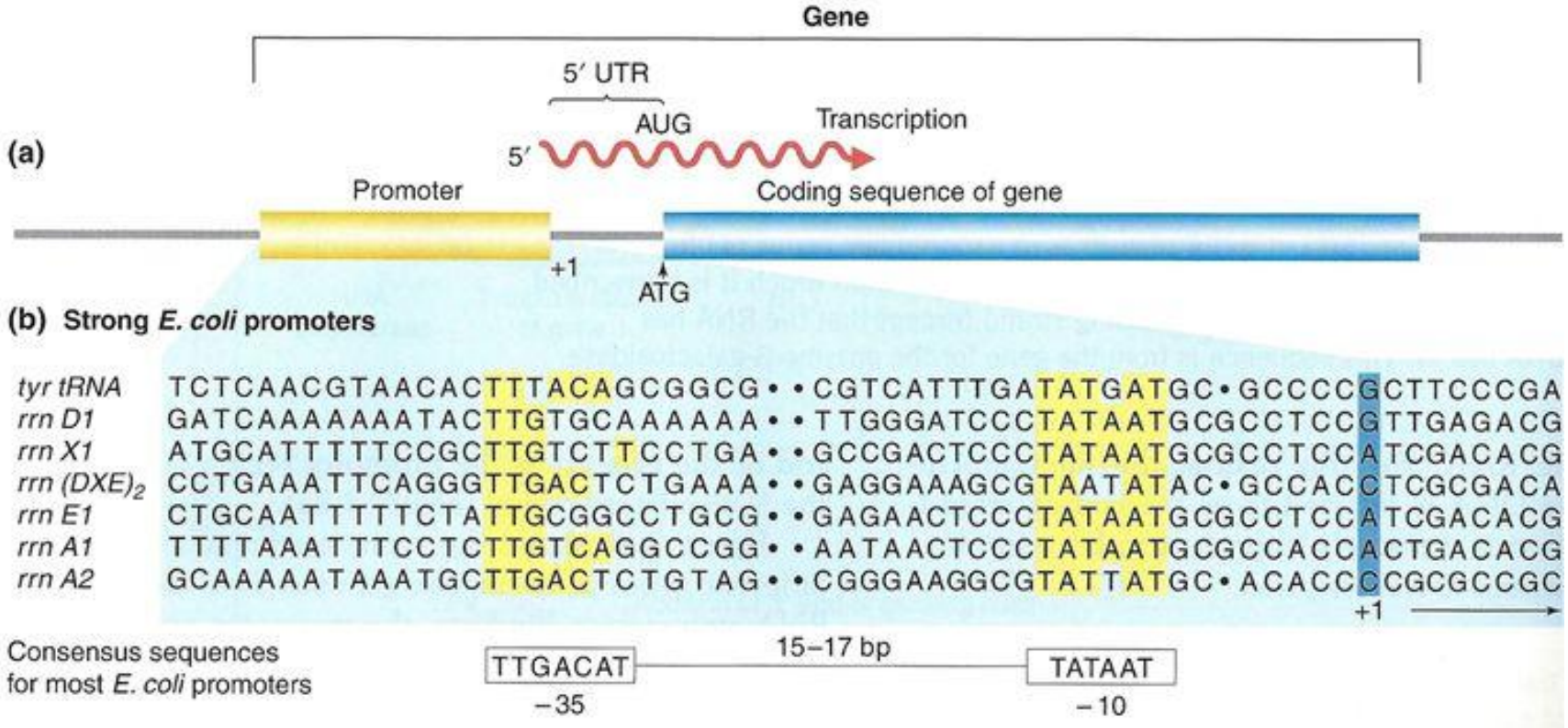
- In genetics, a promoter is a region of DNA that initiates transcription of a particular gene.
- In bacteria, the promoter contains two short sequence elements approximately 10 (Pribnow Box) and 35 nucleotides upstream from the transcription start site.

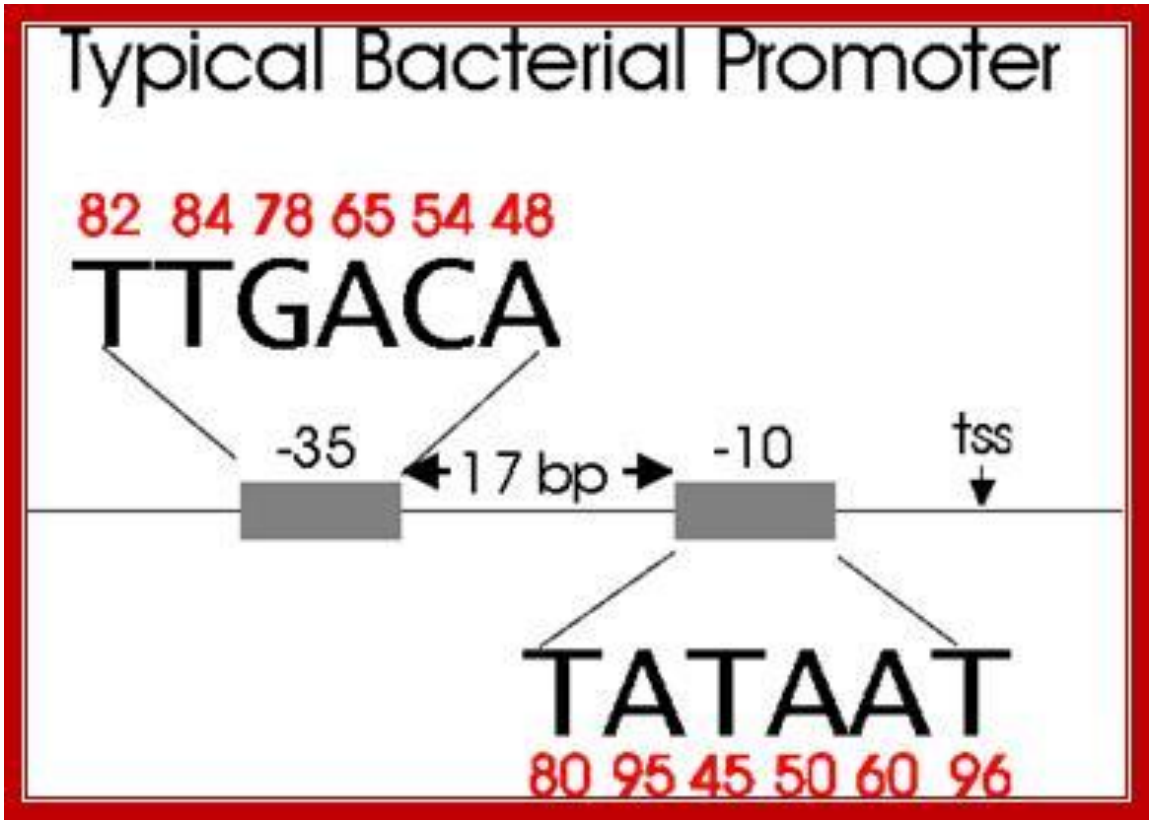


© 2012 Pearson Education, Inc.


Parts of RNA polymerase that specifically bind to -10 and -35 elements
5'
3'
TTGACG
AACTGC
TATAAT
ATATTA
3'
5'
+1
Transcription start site
-35 element
-10 element
Promoter

Promoters may differ from the consensus sequence

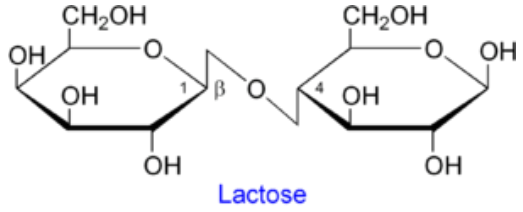



Typical Bacterial Promoter
82 84 78 65 54 48
TTGACA
-35
17 bp
-10
tss
TATAAT
80 95 45 50 60 96

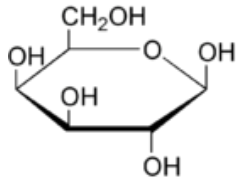
- -35 and -10 sequences determine the rate of a bacterial gene transcription – "strength of the promoter"
- Cell might need some proteins all the time. These proteins are synthesized continuously at the same rate. This is called constitutive gene expression.
- Other proteins could be synthesized in response to an external stimulus, e.g. certain nutrient present in the growth medium.

Lactose operon

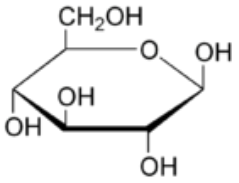
- A cluster of genes under the control of a single promoter is called operon.
- The lac operon (lactose operon) is an operon required for the transport and metabolism of lactose in Escherichia coli



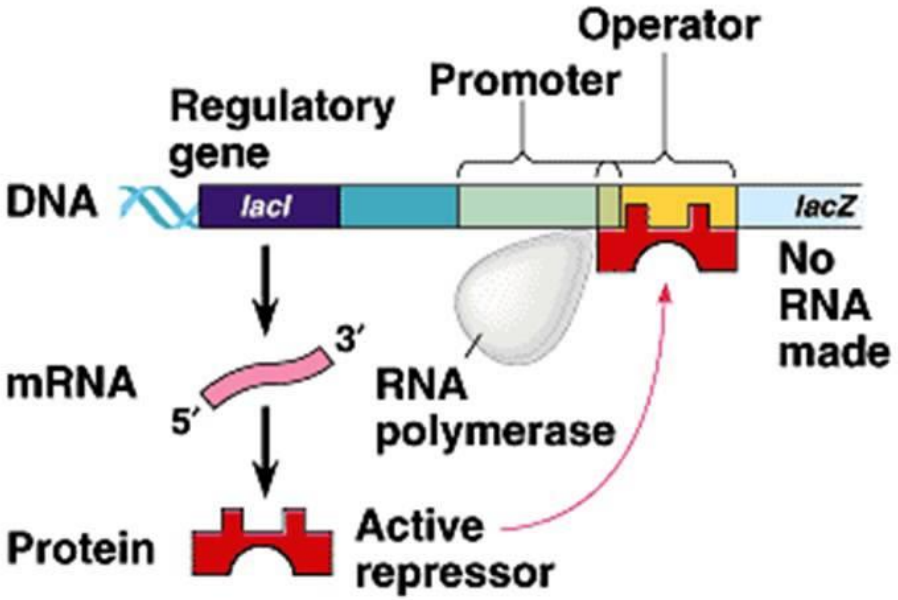
Lactose



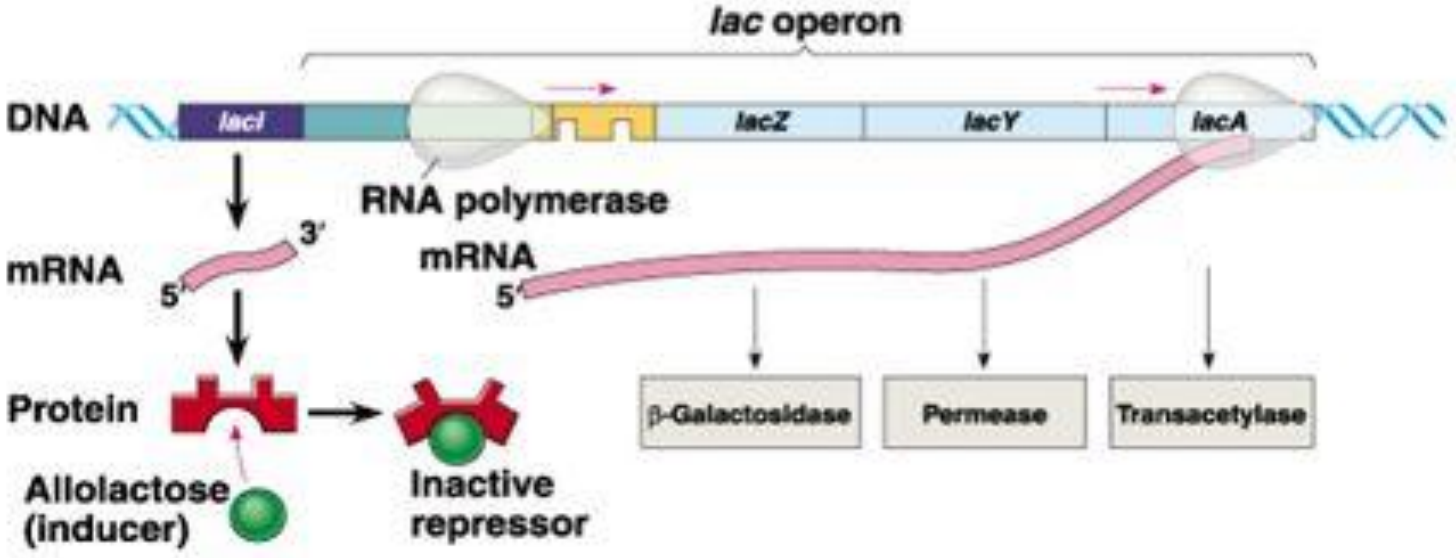
D-galactose



D-glucose



(a) Lactose absent, repressor active, operon off



(b) Lactose present, repressor inactive, operon on

Tryptophan operon

- The trp operon is an operon—a group of genes that is used, or transcribed, together—that codes for the components for production of tryptophan.
- When sufficient amount of tryptophan is present in the cell the expression of the trp operon is repressed. Thus, the operon is regulated through the negative feedback loop mechanism.

Negative feedback loop

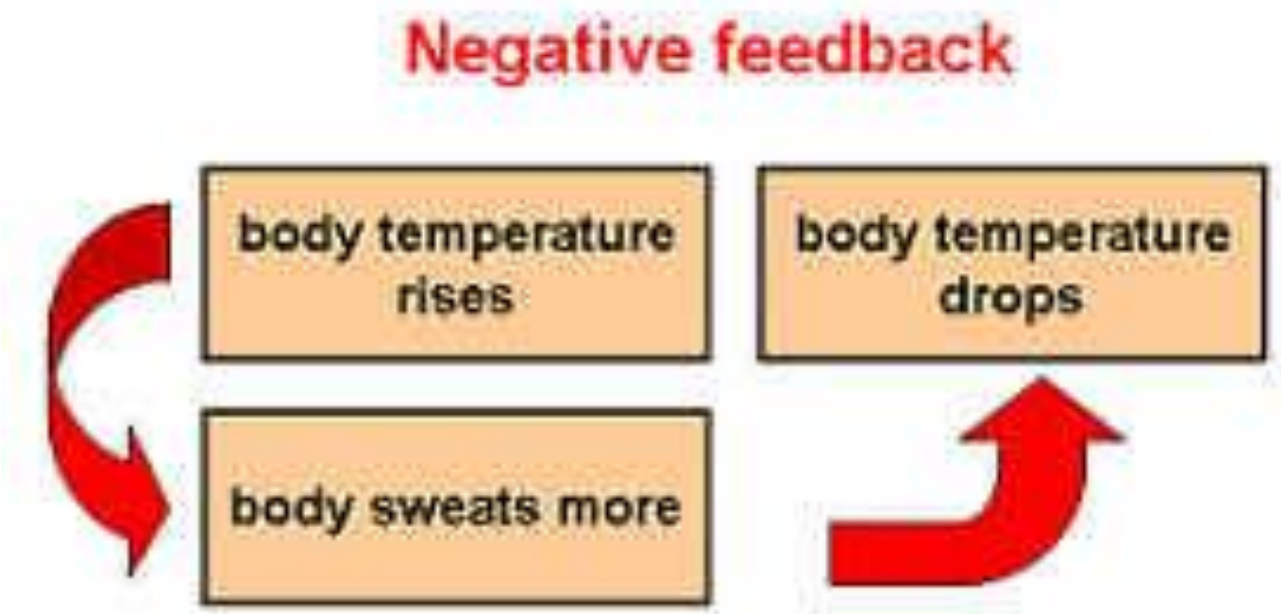
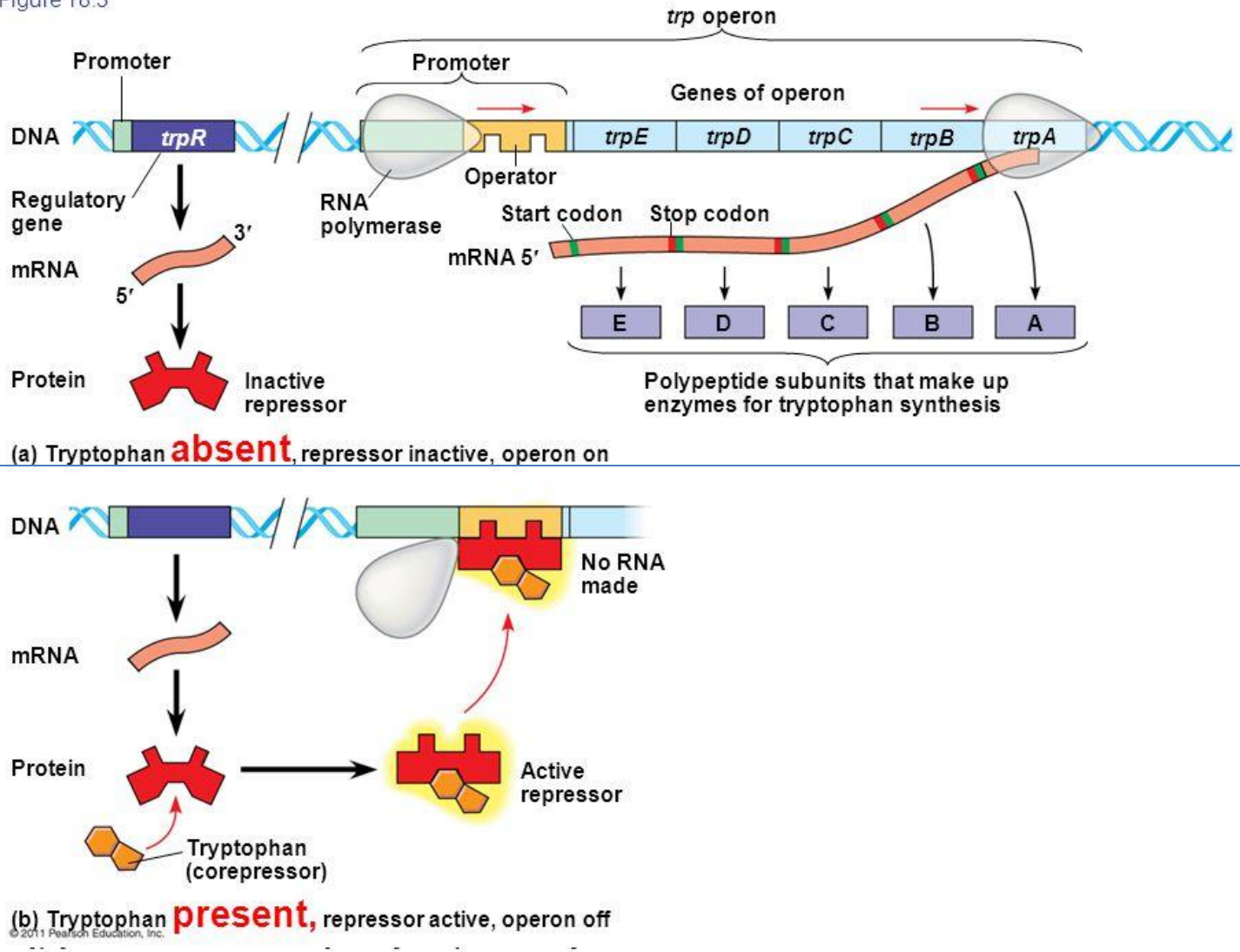
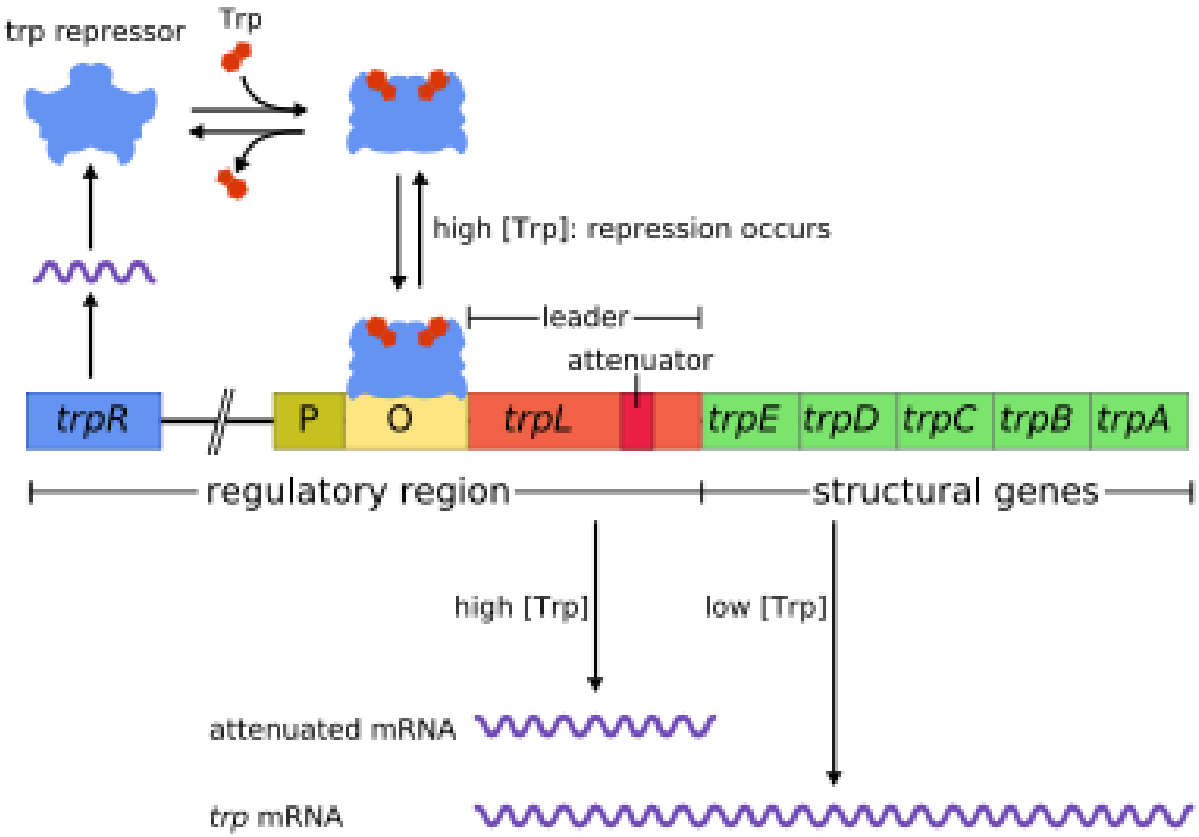


Figure 18.3



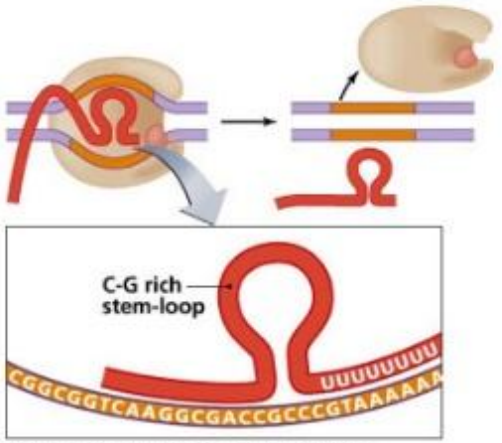
© 2011 Pearson Education, Inc.


trp repressor
Trp
high [Trp]: repression occurs
leader
attenuator
trpR
P
O
trpL
trpE
trpD
trpC
trpB
trpA
regulatory region
structural genes
high [Trp]
low [Trp]
attenuated mRNA
trp mRNA

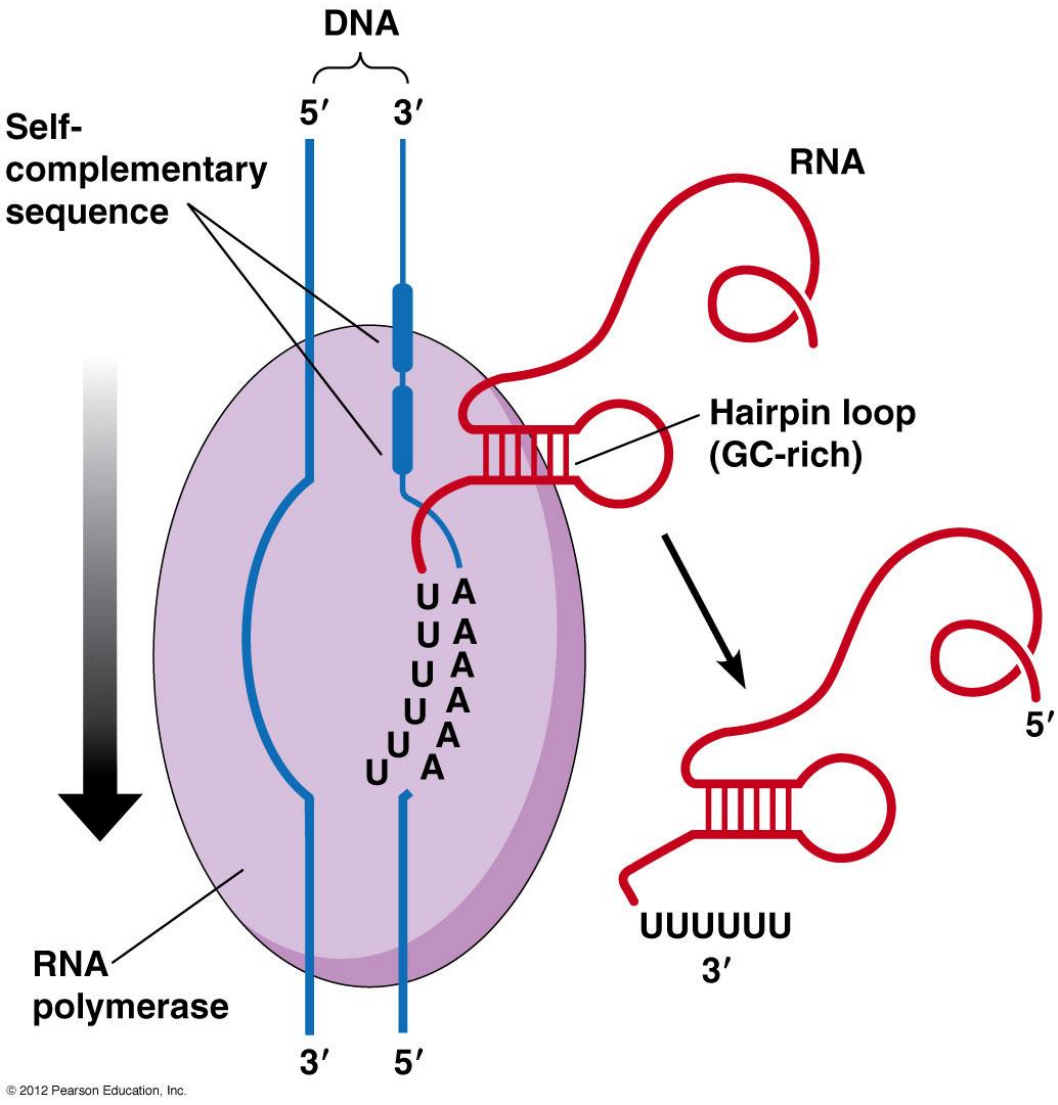
Bacterial transcription termination

Termination (Rho-independent terminator) - type 1 terminator

- RNA moves pass the inverted repeats and transcribes the termination sequence.
- Because of the inverted repeat arrangement → RNA synthesized forms a hairpin loop structure.
- Hairpin loop makes the RNA polymerase slow down and eventually stops.



(c) Termination of transcription

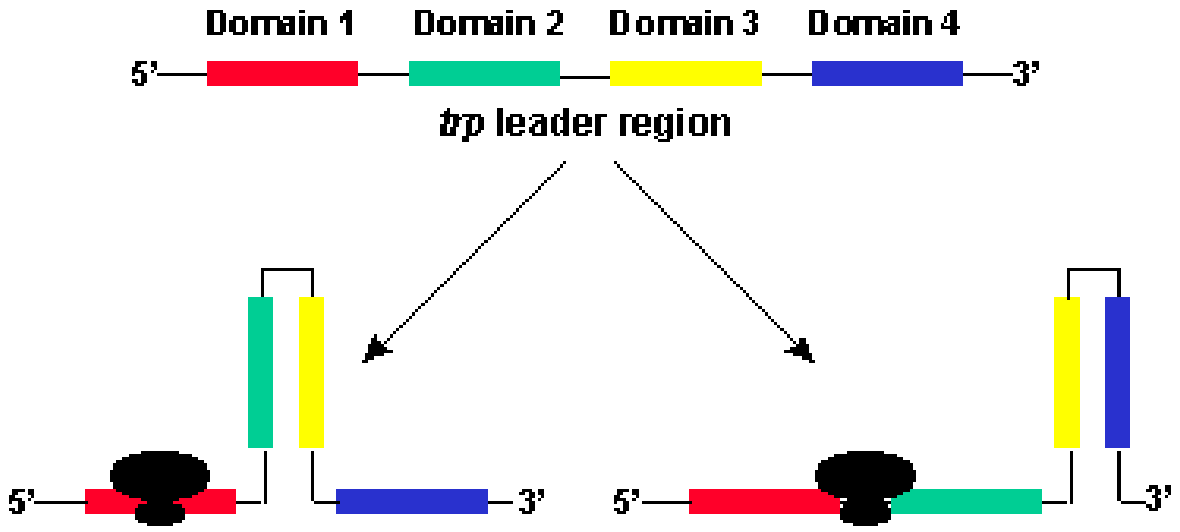


© 2012 Pearson Education, Inc.

Attenuation of trp operon

- Attenuation is a second mechanism of negative feedback in the trp operon. The repression system targets the intracellular trp concentration whereas the attenuation responds to the concentration of charged $tRNA_{Trp}$
- Attenuation is made possible by the fact that in prokaryotes (which have no nucleus), the ribosomes begin translating the mRNA while RNA polymerase is still transcribing the DNA sequence. This allows the process of translation to affect transcription of the operon directly.

Attenuation of the *trp* operon mRNA



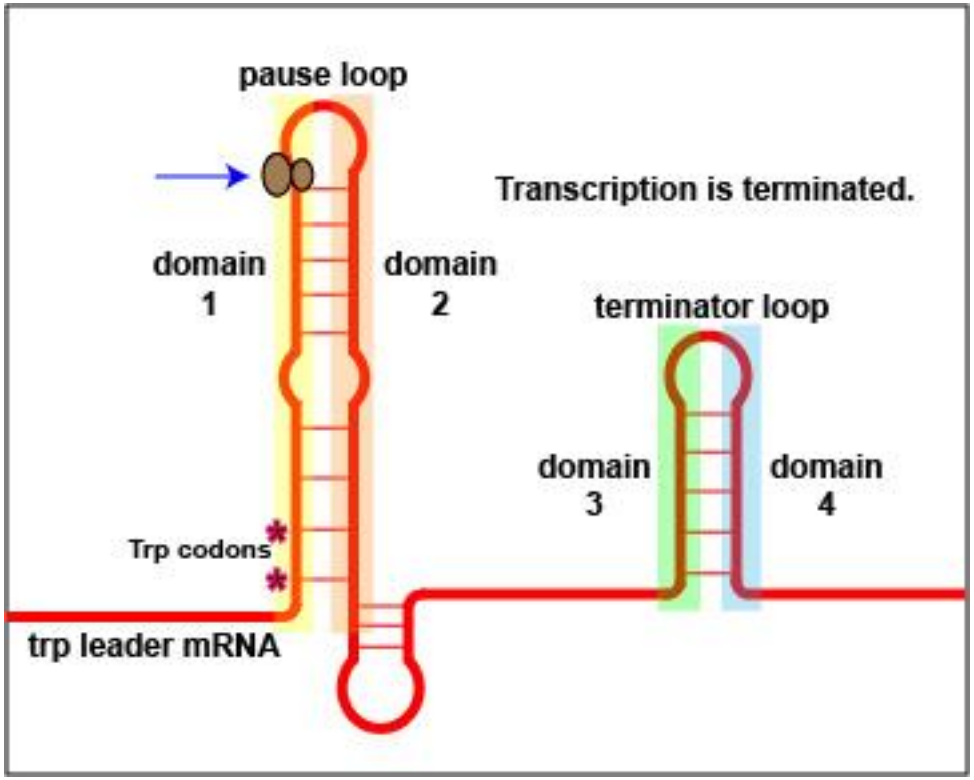
Low Tryptophan Levels

- Slow translation of Domain 1 peptide
- Domain 2-3 pairing occurs
- Normal full gene transcription

High Tryptophan Levels

- Fast translation of domain 1 peptide
- Domain 2 blocked by ribosome
- Domain 3-4 pairing occurs
- Attentuation of transcription occurs
- Only 10% of normal mRNAs made

Attenuation, tryptophan present



Attenuation, no tryptophan