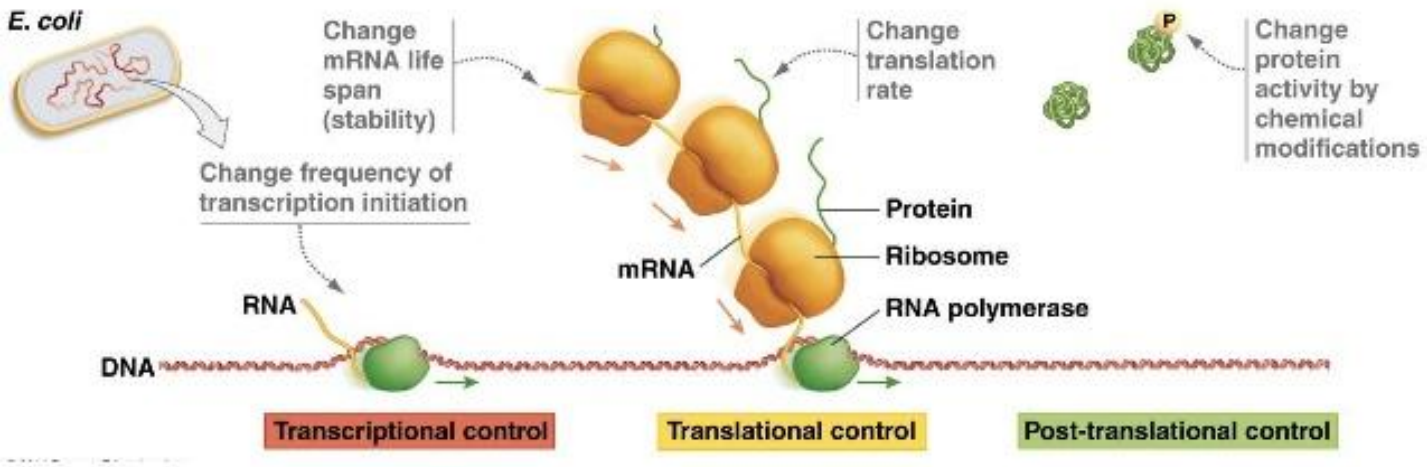
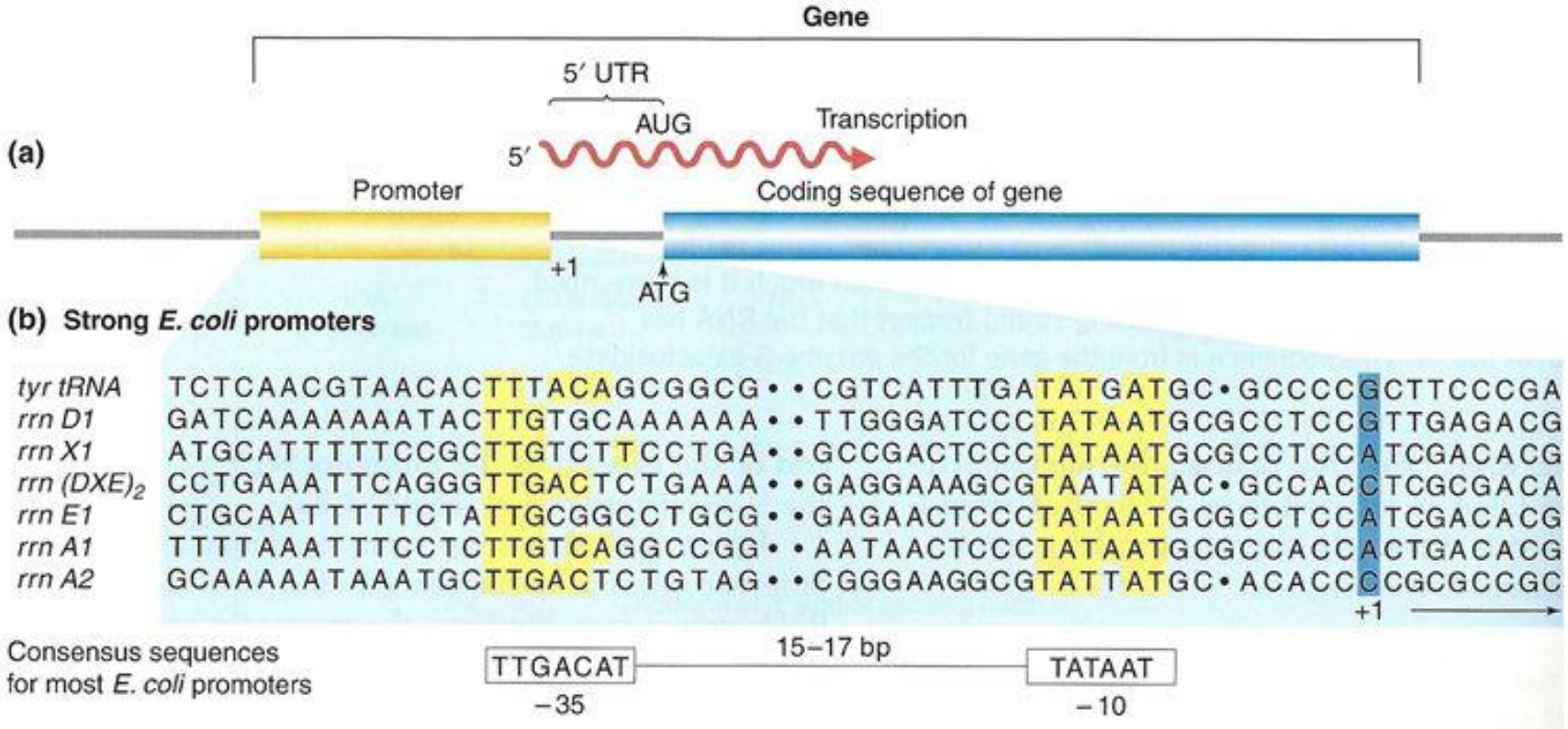
Gene Expression

Regulation of Gene Expression



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

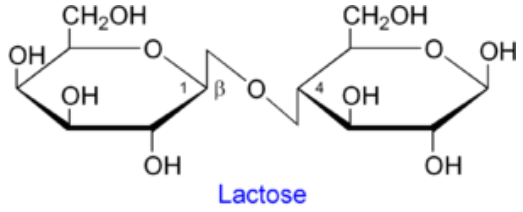
Bacterial promoters may differ from the consensus sequence



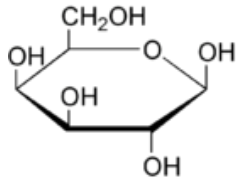
- -35 and -10 sequences determine the rate of a bacterial gene transcription – “strength of the promoter”
- Cell might need some proteins all the time. These proteins are synthesized continuously at the same rate. This is called constitutive gene expression.
- Other proteins could be synthesized in response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

Lactose operon

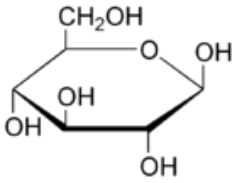
- A cluster of genes under the control of a single promoter is called operon.
- The lac operon (lactose operon) is an operon required for the transport and metabolism of lactose in Escherichia coli



Lactose



D-galactose

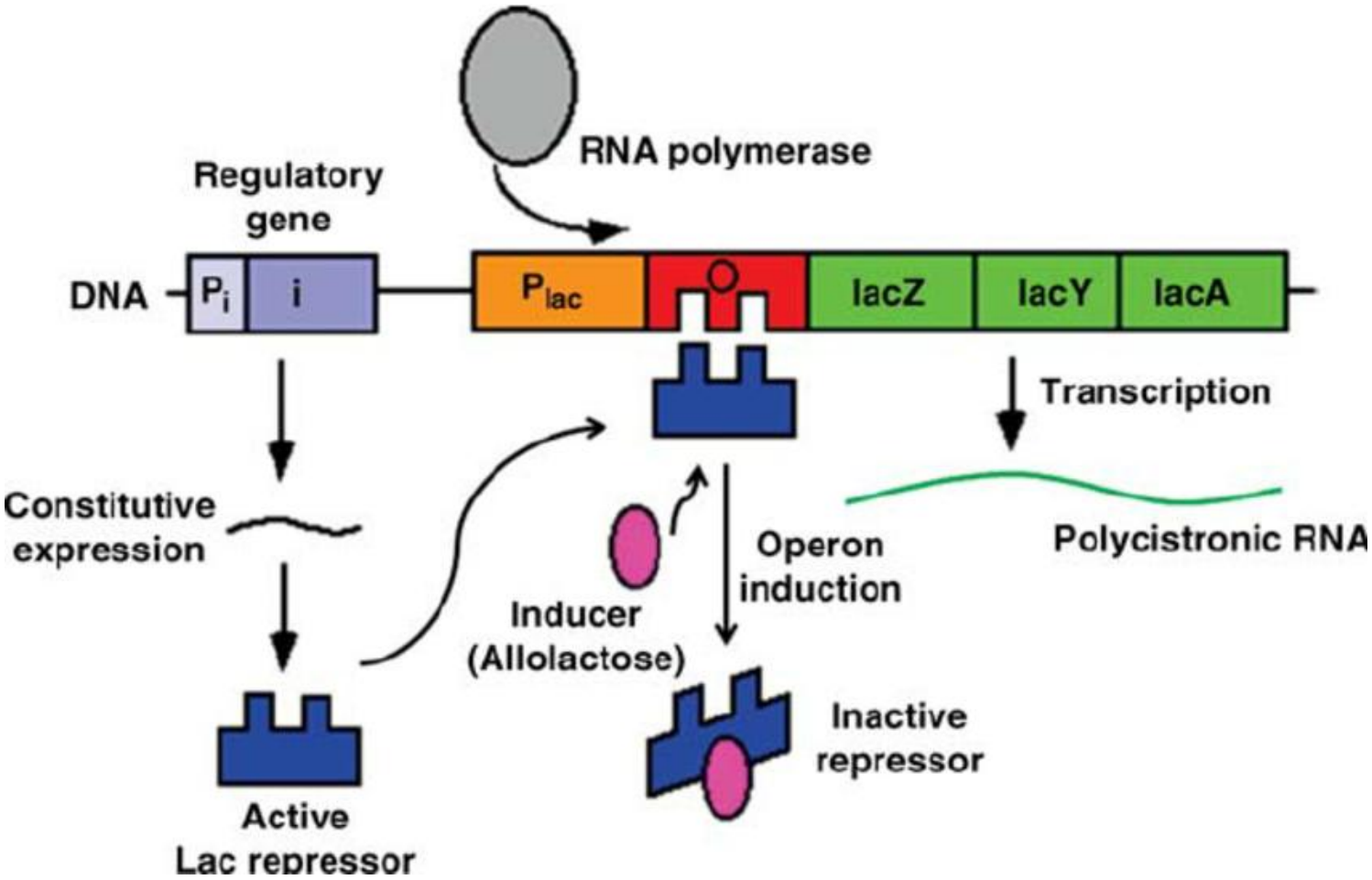


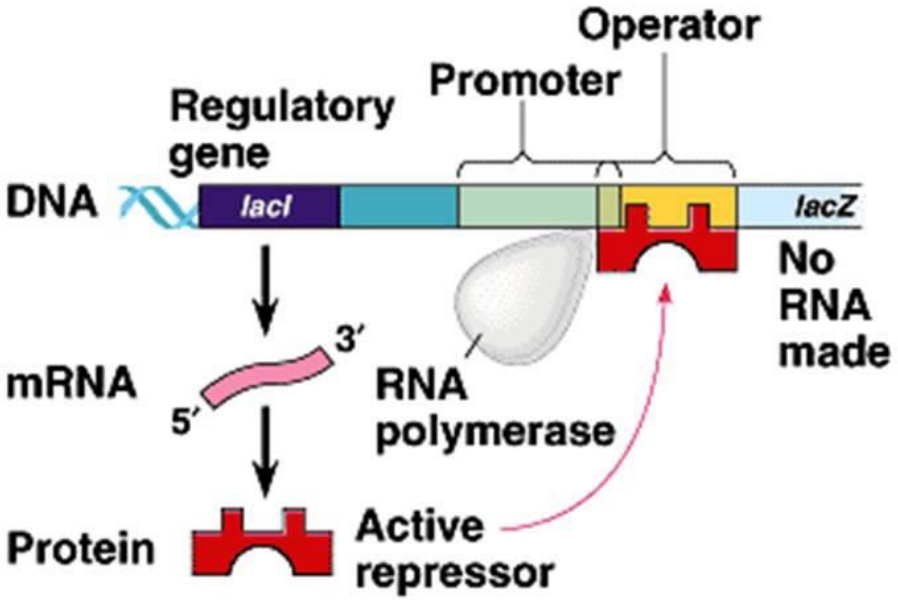
D-glucose

The lac operon consists of three structural genes, and a promoter, a terminator, regulator, and an operator. The three structural genes are: lacZ, lacY, and lacA.

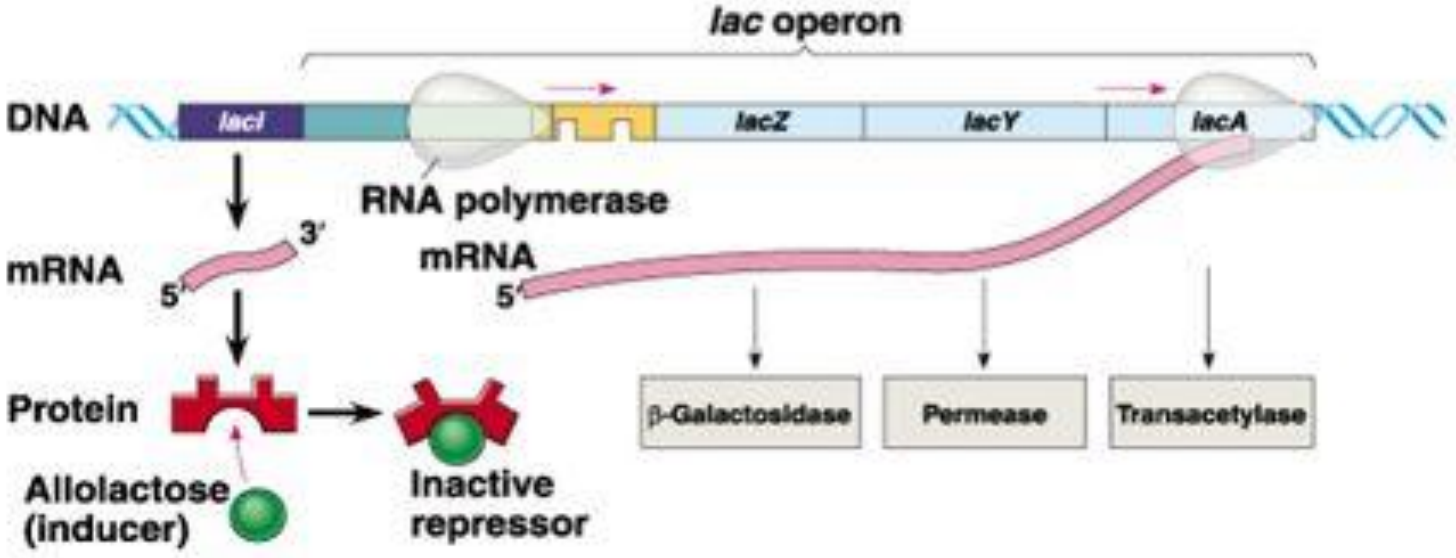
- lacZ encodes β-galactosidase (LacZ), an intracellular enzyme that cleaves the disaccharide lactose into glucose and galactose.
- lacY encodes Beta-galactoside permease (LacY), a transmembrane symporter that pumps β-galactosides including lactose into the cell using a proton gradient in the same direction.
- lacA encodes β-galactoside transacetylase (LacA), an enzyme that transfers an acetyl group from acetyl-CoA to β-galactosides.

Only lacZ and lacY appear to be necessary for lactose catabolism.


RNA polymerase
Regulatory gene
DNA
P_i
i
P_{lac}
lacZ
lacY
lacA
Transcription
Constitutive expression
Polycistronic RNA
Operon induction
Inducer (Allolactose)
Inactive repressor
Active Lac repressor

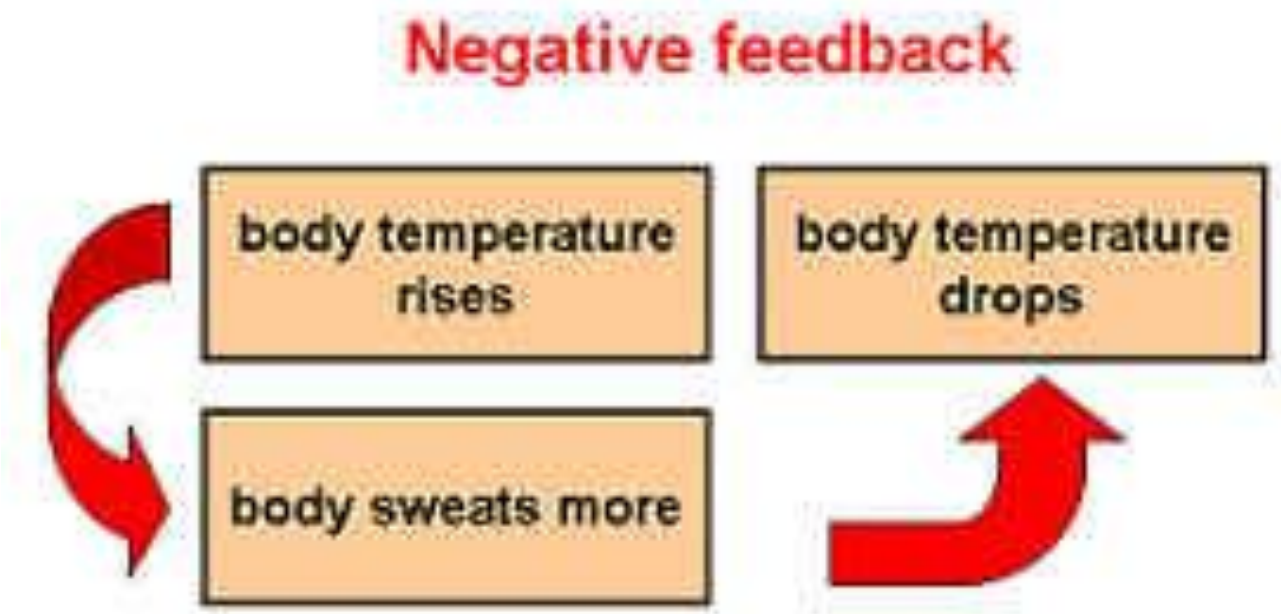


(a) Lactose absent, repressor active, operon off



(b) Lactose present, repressor inactive, operon on

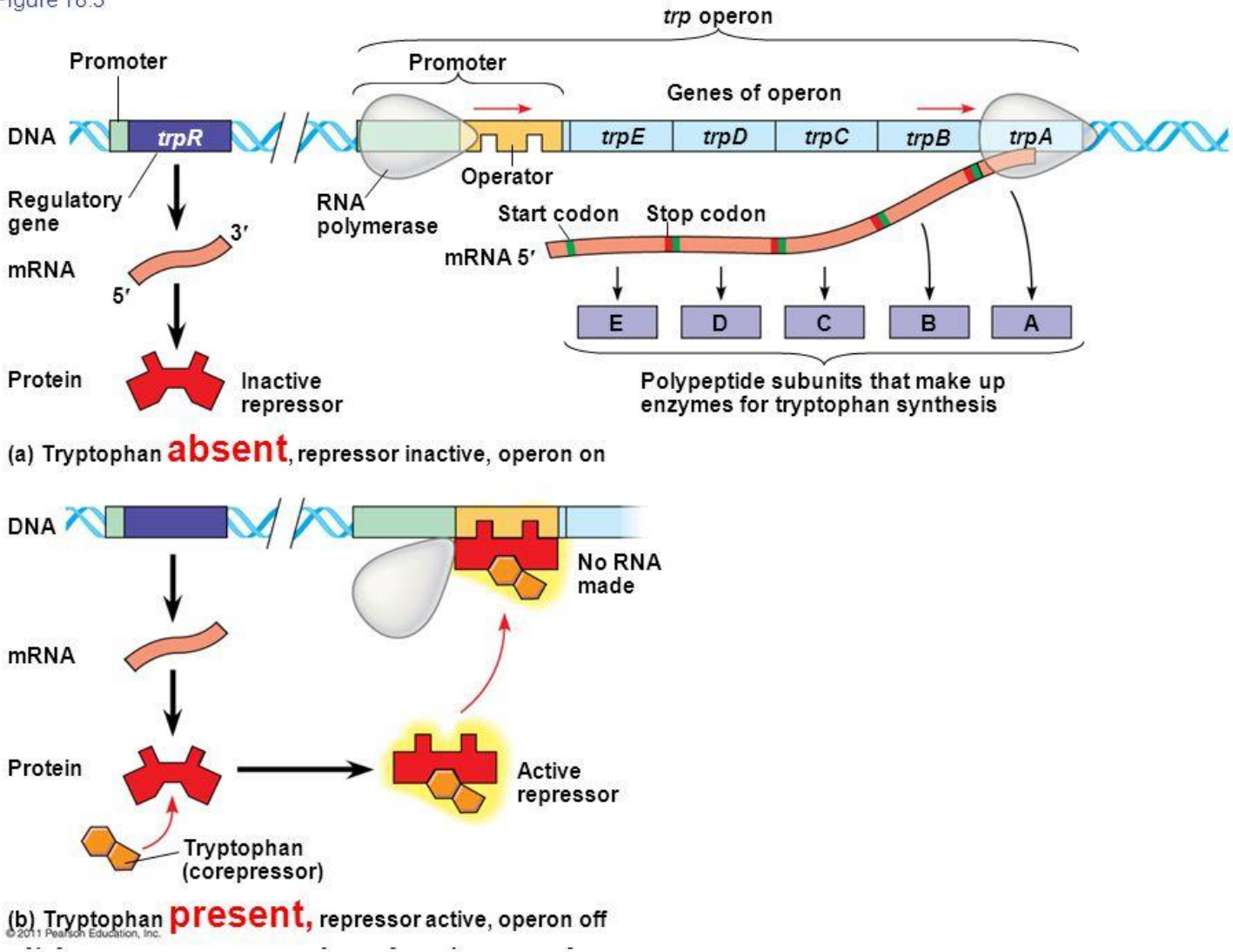
Negative feedback loop

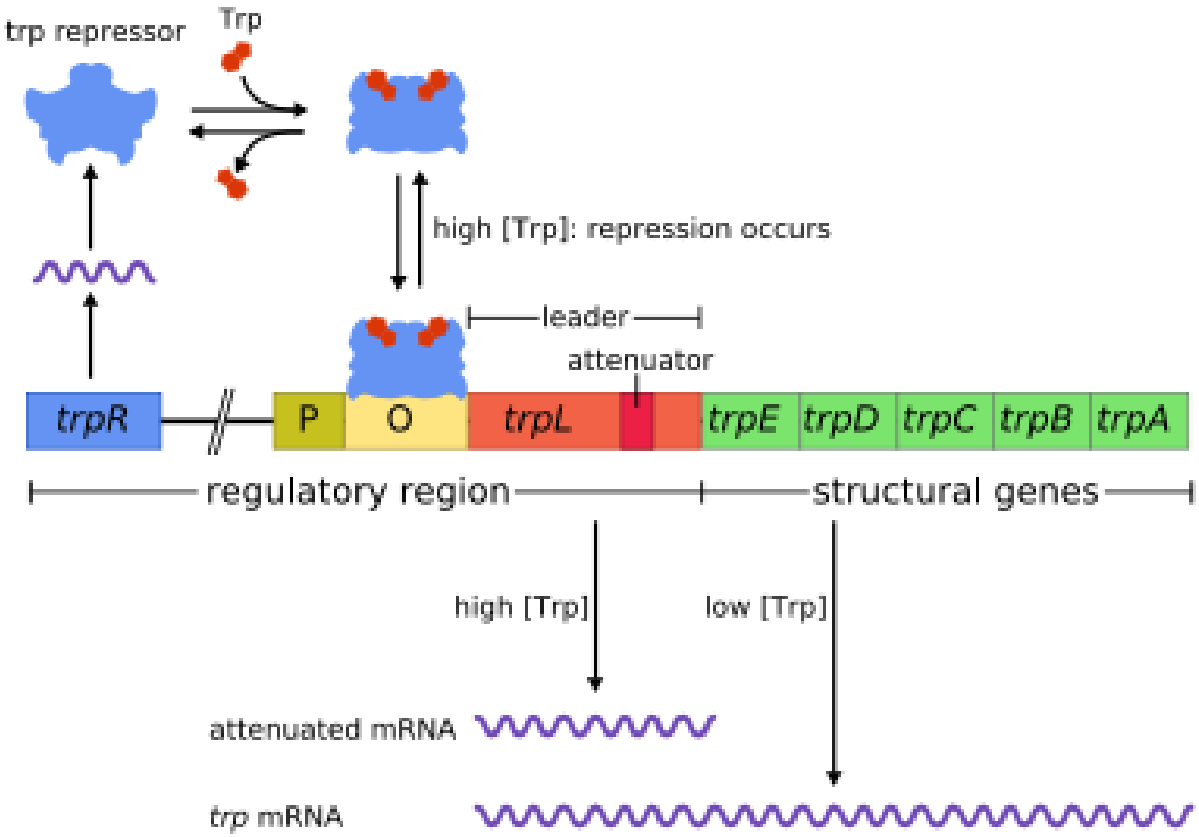


Tryptophan operon

- 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.

Figure 18.3

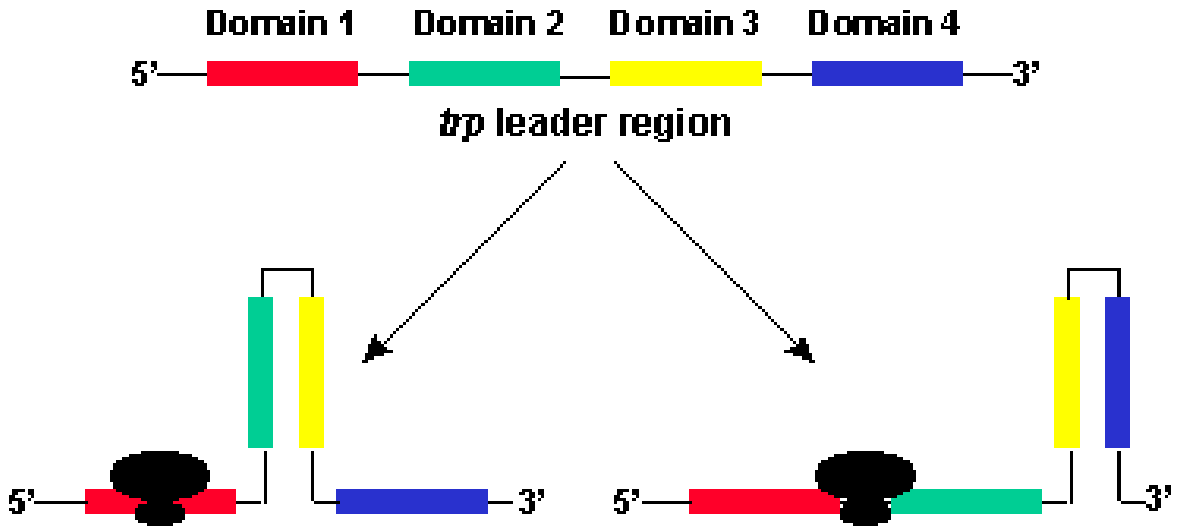



trp repressor
Trp
high [Trp]: repression occurs
leader
attenuator
trpR
P
O
trpL
trpE
trpD
trpC
trpB
trpA
regulatory region
structural genes
high [Trp]
low [Trp]
attenuated mRNA
trp mRNA

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 tRNAtrp
- 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



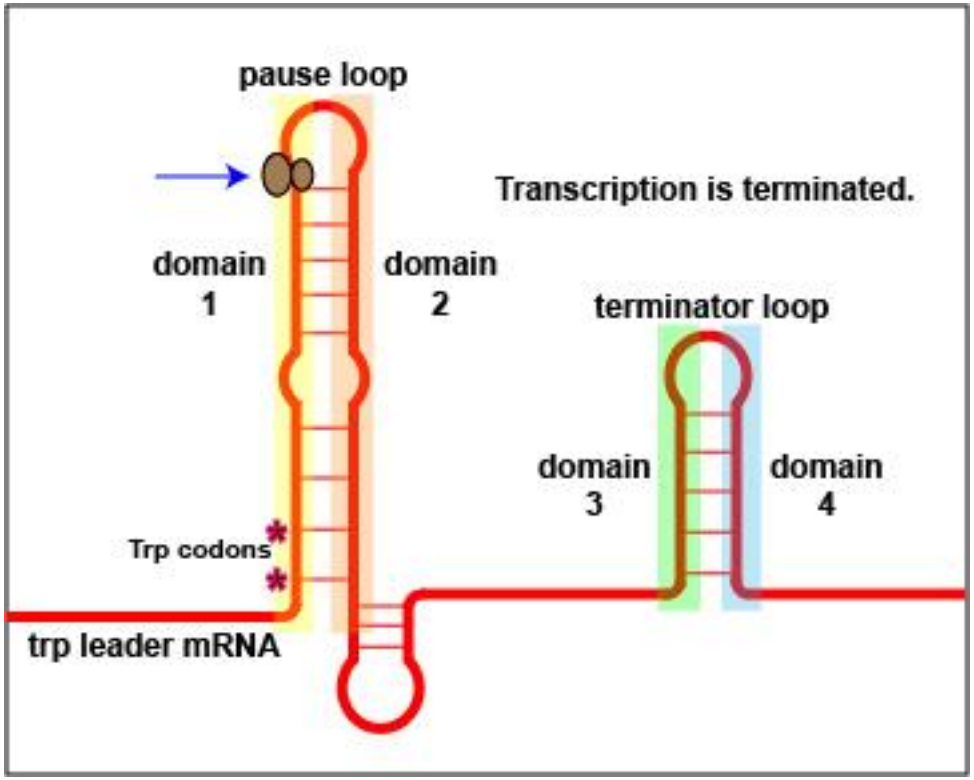
Low Tryptophan Levels

- 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