Trp-operon

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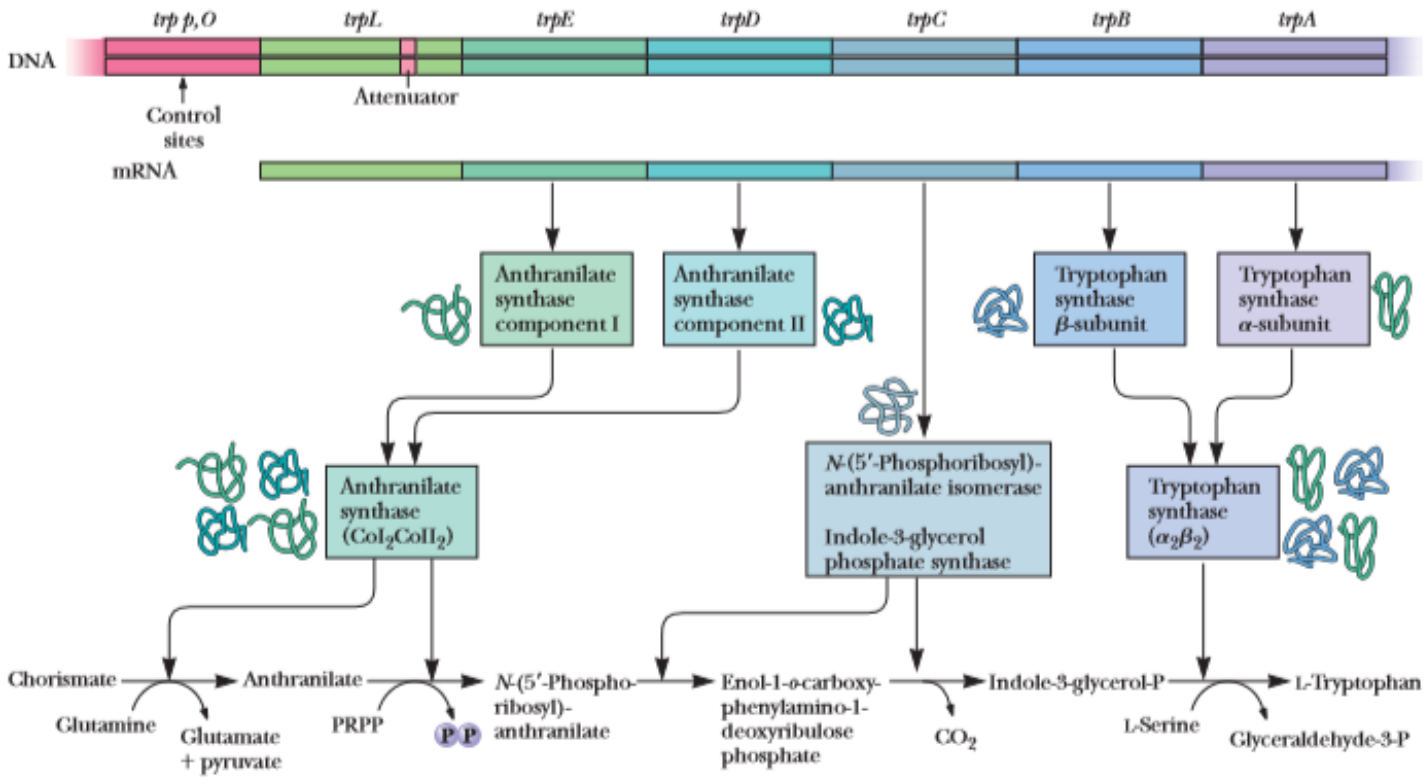
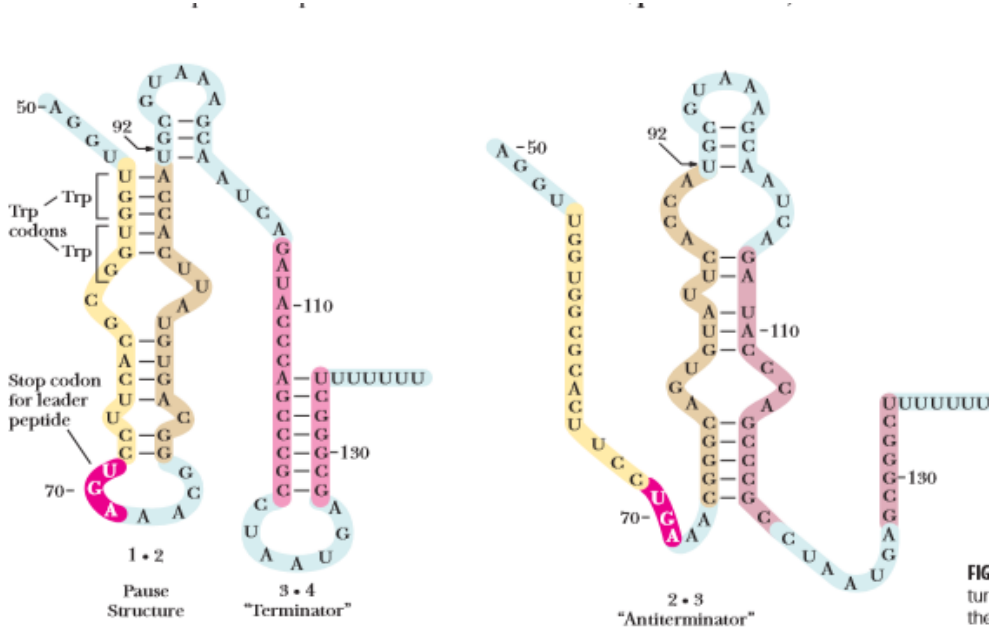
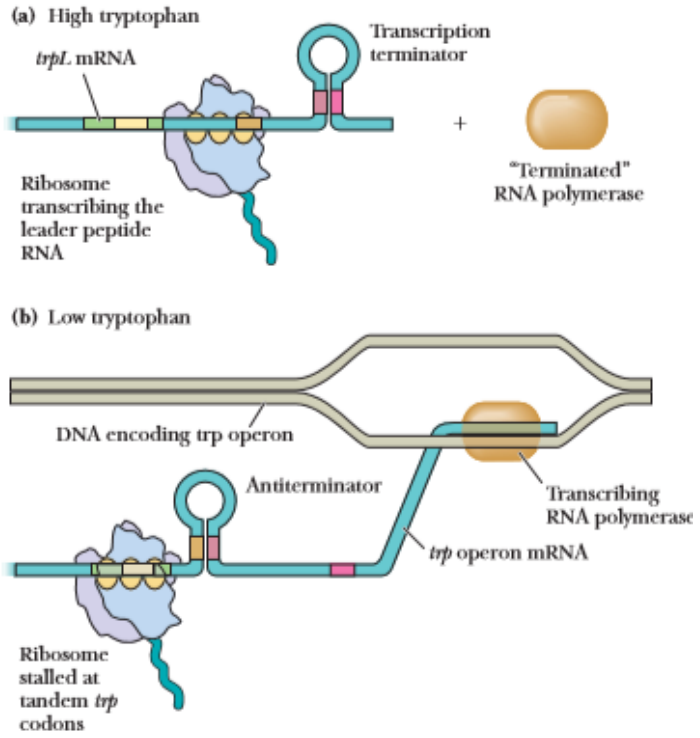

trp p, O
trpL
trpE
trpD
trpC
trpB
trpA
DNA
Control sites
Attenuator
mRNA
Anthranilate synthase component I
Anthranilate synthase component II
Tryptophan synthase β-subunit
Tryptophan synthase α-subunit
Anthranilate synthase (CoI_2CoII_2)
N-(5′-Phosphoribosyl)-anthranilate isomerase
Indole-3-glycerol phosphate synthase
Tryptophan synthase ($\alpha_2\beta_2$)
Chorismate
Anthranilate
N-(5′-Phospho-ribosyl)-anthranilate
Enol-1-o-carboxy-phenylamino-1-deoxyribulose phosphate
Indole-3-glycerol-P
L-Tryptophan
Glutamine
Glutamate + pyruvate
PRPP
P P
CO_2
L-Serine
Glyceraldehyde-3-P

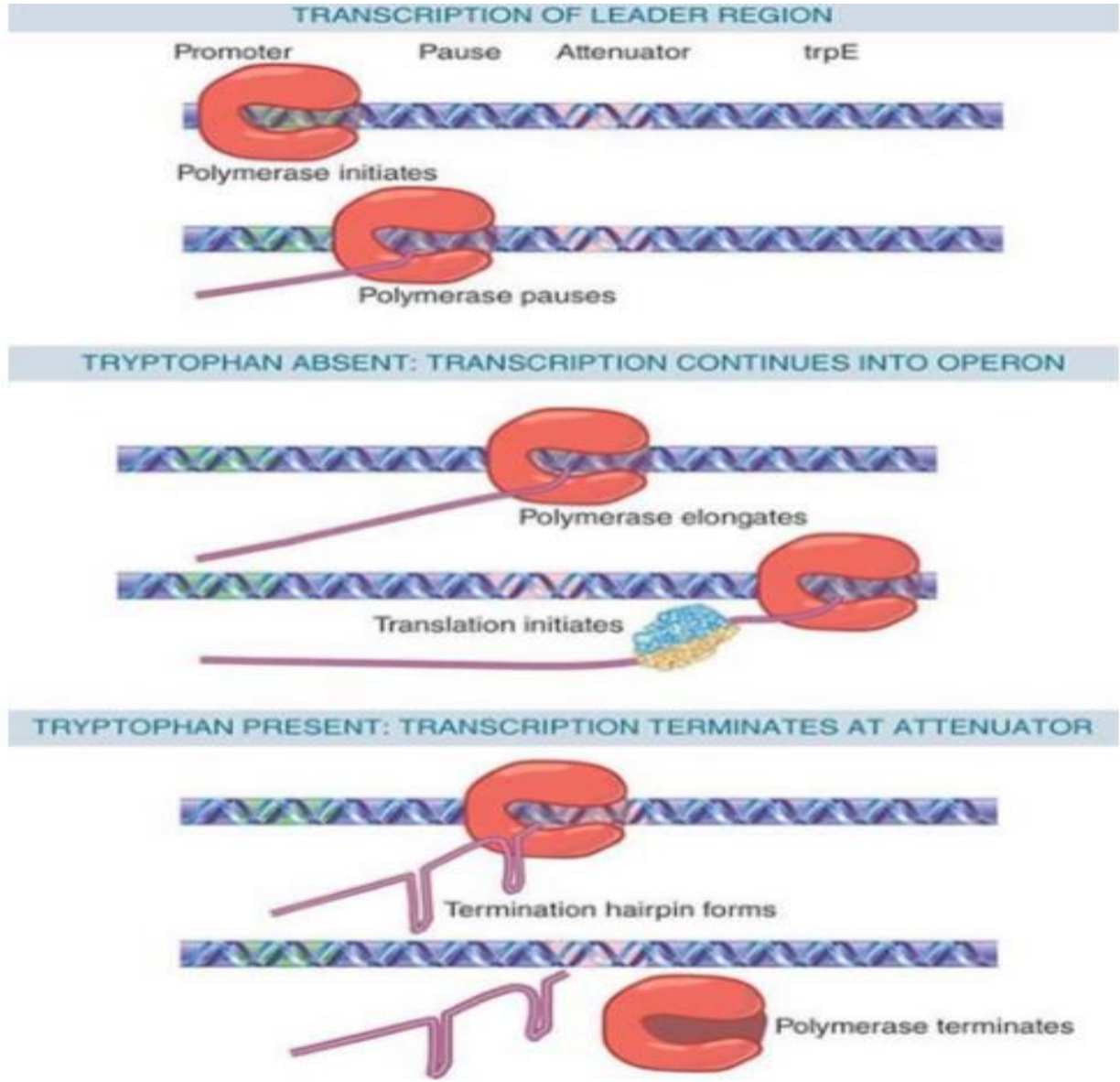
Attenuation

- Any regulatory mechanism that manipulates transcription termination or transcription pausing to regulate gene transcription downstream. In prokaryotes, transcription and translation are coupled, and the translating ribosome is affected by the formation and persistence of secondary structures in the mRNA.
- In many operons encoding enzymes of amino acid biosynthesis, a transcribed 150- to 300-bp leader region is positioned between the promoter and the first major structural gene. These regions encode a short leader peptide containing multiple codons for the pertinent amino acid. For example, the leader peptide of the leu operon has four leucine codons, the trp operon has two tandem tryptophan codons, and so forth . Translation of these codons depends on an adequate supply of the relevant aminoacyl-tRNA, which in turn rests on the availability of the amino acid.
- When tryptophan is scarce, the entire trpoperon from trpL to trpA is transcribed to give a polycistronic mRNA. But, as [Trp] increases, more and more of the trp transcripts consist of only a 140-nucleotide fragment corresponding to the 5-end of trpL. Tryptophan availability is causing premature termination of trp transcription, that is, transcription attenuation. Although attenuation occurs when tryptophan is abundant, attenuation is blocked when levels of tryptophan are low and little tryptophanyl-tRNA is available. The secondary structure of the 160-bp leader region transcript is the principal control element in transcription attenuation . This RNA segment includes the coding region for the 14-residue leader peptide. Three critical base-paired hairpins can form in this RNA:
- the 1:2 pause structure
- the3:4 terminator, and
- 2:3 antiterminator.
- Obviously, the 1:2 pause, 3:4 terminator, and the 2:3 antiterminator represent mutually exclusive alternatives. A significant feature of this coding region is the tandem UGG tryptophan codons. Transcription of the trp operon by RNA polymerase begins and progresses until position 92 is reached, whereupon the 1:2 hairpin is formed, causing RNA polymerase to pause in its elongation cycle. While RNA polymerase is paused, a 3:4 terminator, and the 2:3 antiterminator. Obviously, the 1:2 pause, 3:4 terminator, and the 2:3 antiterminator represent mutually exclusive alternatives. A significant feature of this coding region is the tandem UGG tryptophan codons. Transcription of the trp operon by RNA polymerase begins and progresses until position 92 is reached, whereupon the 12 hairpin is formed, causing RNA polymerase to pause in its elongation cycle. While RNA polymerase is paused, a ribosome begins to translate the leader region of the transcript. Translation by the ribosome releases the paused RNA polymerase and transcription continues

Attenuation






TRANSCRIPTION OF LEADER REGION
Promoter
Pause
Attenuator
trpE
Polymerase initiates
Polymerase pauses
TRYPTOPHAN ABSENT: TRANSCRIPTION CONTINUES INTO OPERON
Polymerase elongates
Translation initiates
TRYPTOPHAN PRESENT: TRANSCRIPTION TERMINATES AT ATTENUATOR
Termination hairpin forms
Polymerase terminates