General and Molecular Genetics

Regulation of Gene Expression (e.g. Trp Operon).

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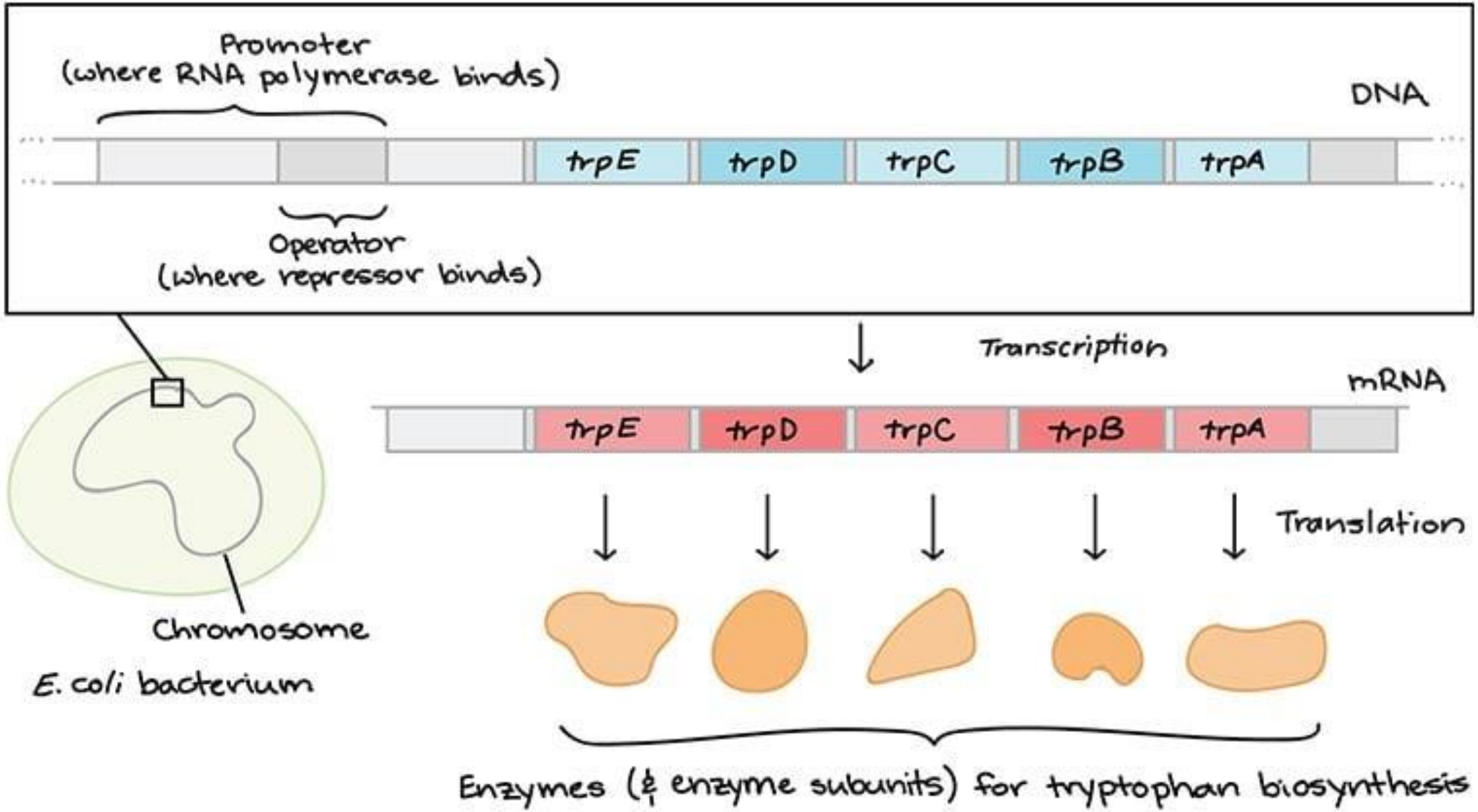
Represive Operon (e.g., Trp Operon)

- Normally on but can be turned off when the product is abundant.
- Requires a corepressor molecule to stop transcription.
- Example: Trp Operon (*E. coli*)
- Regulates tryptophan biosynthesis.
- When tryptophan levels are low, the operon is active, and enzymes for tryptophan synthesis are produced.
- When tryptophan is abundant, it acts as a corepressor, binding to the repressor protein, activating it, and blocking transcription to prevent excess tryptophan production.

Tryptophan (Trp) Operon

- The tryptophan operon is the regulation of transcription of the gene responsible for biosynthesis of tryptophan.
- The tryptophan (trp) operon contains five structural genes encoding enzymes for tryptophan biosynthesis with an upstream trp promoter **(Ptrp)** and trp operator sequence **(Otrp)**.
- The trp operator region partly overlaps the trp promoter.
- The operon is regulated such that transcription occurs only when tryptophan in the cell is in short supply.

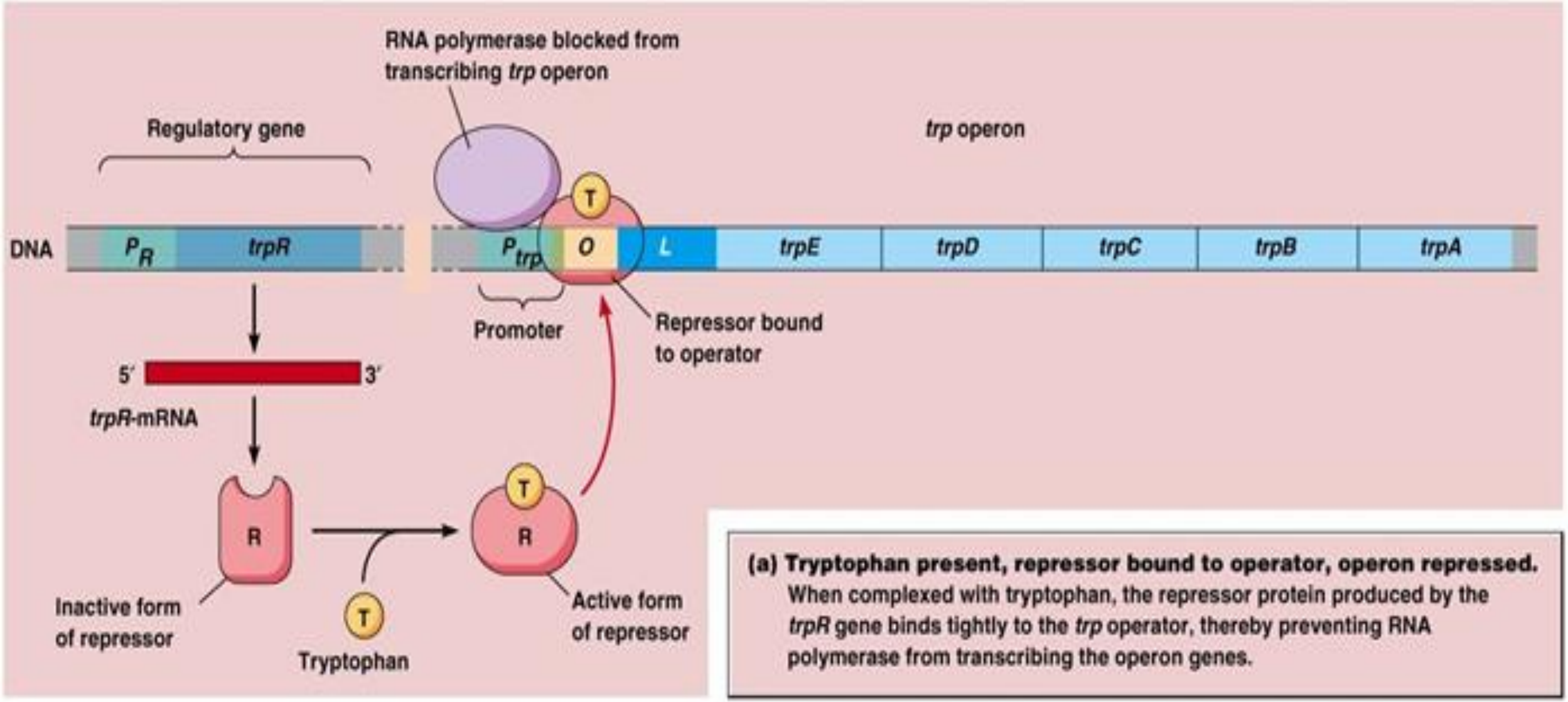

Promoter
(where RNA polymerase binds)
DNA
trpE
trpD
trpC
trpB
trpA
Operator
(where repressor binds)
Transcription
mRNA
trpE
trpD
trpC
trpB
trpA
Translation
Chromosome
E. coli bacterium
Enzymes (& enzyme subunits) for tryptophan biosynthesis

Structural genes of Tryptophan (Trp) Operon

- **1. trpE:** It enodes the enzyme **Anthranilate synthase**
- **2. trpD:** It encodes the enzyme **Anthranilate phosphoribosyl transferase**
- **3. trpC:** It encodes the enzyme **N-5'-Phosphoribosyl anthranilate isomerase** and **Indole-3-glycerolphosphate synthase**
- **4. trpB:** It encodes the enzyme **tryptophan synthase-B sub unit**
- **5. trpA:** It encode the enzyme **tryptophan synthase-A sub unit**

In the Presence of Tryptophan

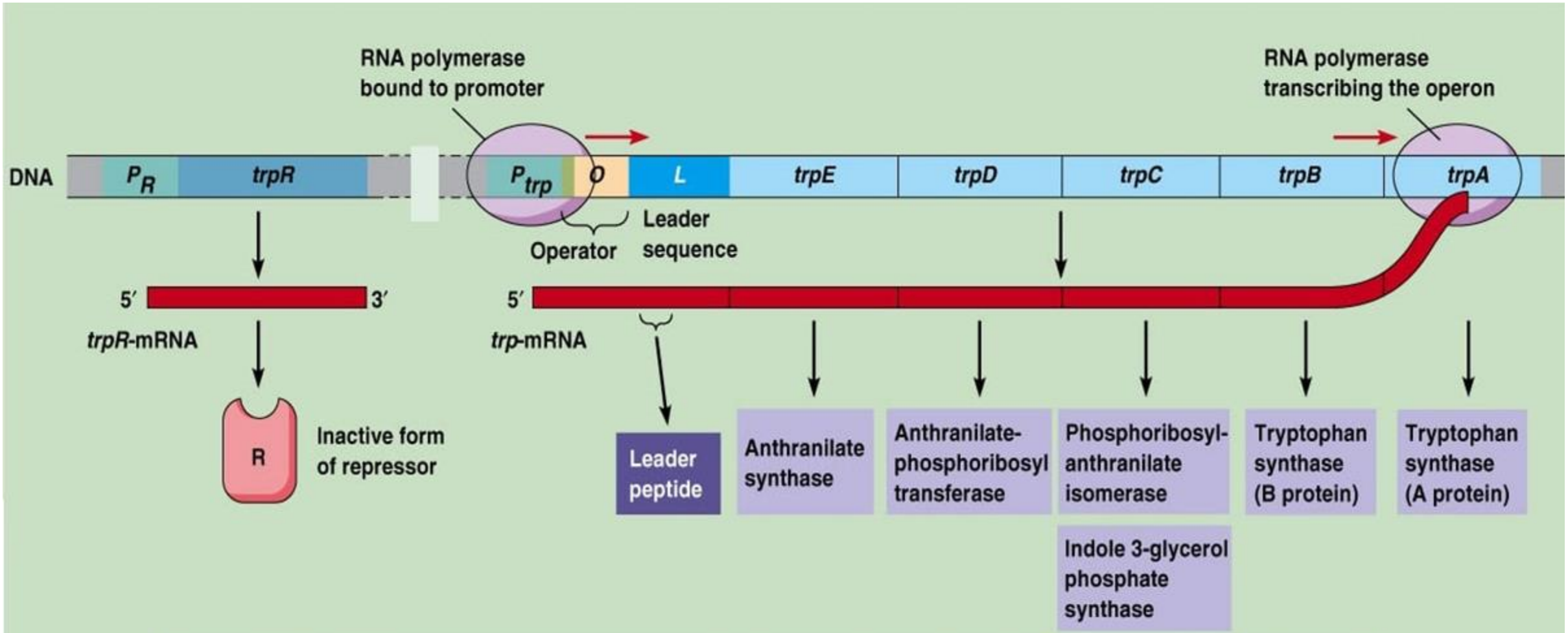
- When tryptophan is present, the enzymes for tryptophan biosynthesis are not needed and so expression of these genes is turned off.
- This is achieved by tryptophan binding to the repressor to activate it so that it now binds to the operator and stops transcription of the structural genes.
- Binding of repressor protein to operator overlaps the promoter, so RNA polymerase cannot bind to the prometer. Hence transcription is halted.
- In this role, tryptophan is said to be a co-repressor. This is negative control, because the bound repressor prevents transcription.



(a) Tryptophan present, repressor bound to operator, operon repressed. When complexed with tryptophan, the repressor protein produced by the *trpR* gene binds tightly to the *trp* operator, thereby preventing RNA polymerase from transcribing the operon genes.

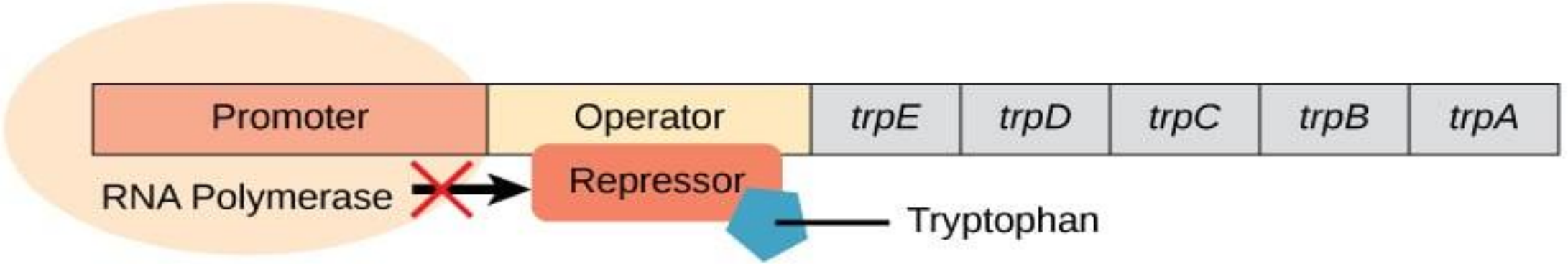
In the Absence of Tryptophan

- In the absence of tryptophan, a trp repressor protein encoded by a separate operon, trpR, is synthesized and forms a dimer.
- However, this is inactive and so is unable to bind to the trp operator and the structural genes of the trp operon are transcribed.

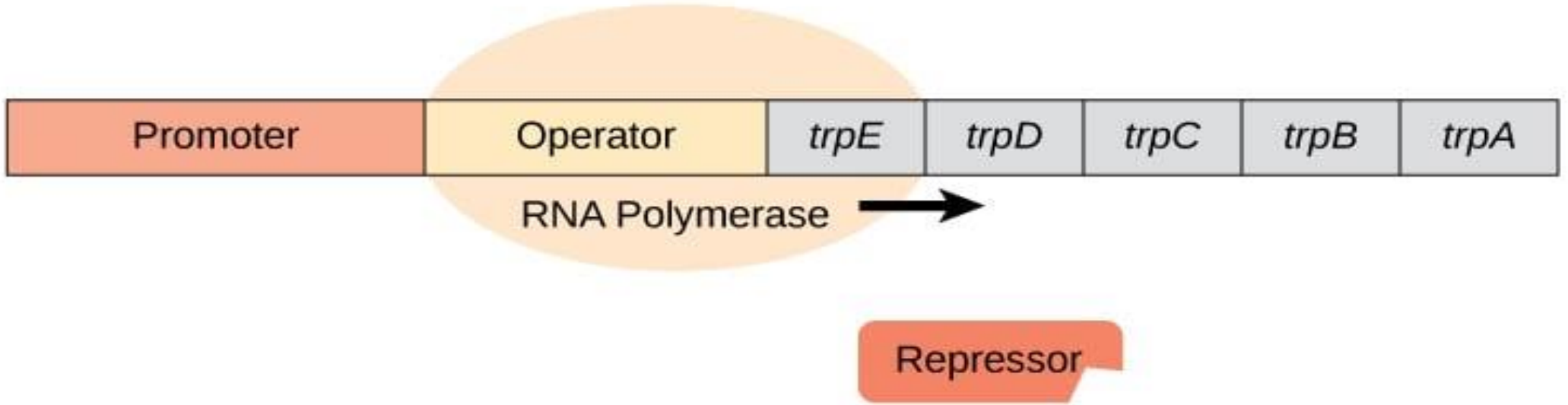


(b) Tryptophan absent, repressor not bound to operator, operon derepressed. In the absence of tryptophan, the free *trp* repressor cannot bind to the operator site. RNA polymerase can therefore move past the operator and transcribe the *trp* operon genes, giving the cell the capability to synthesize tryptophan.

When tryptophan is present, the trp repressor binds the operator, and RNA synthesis is blocked.

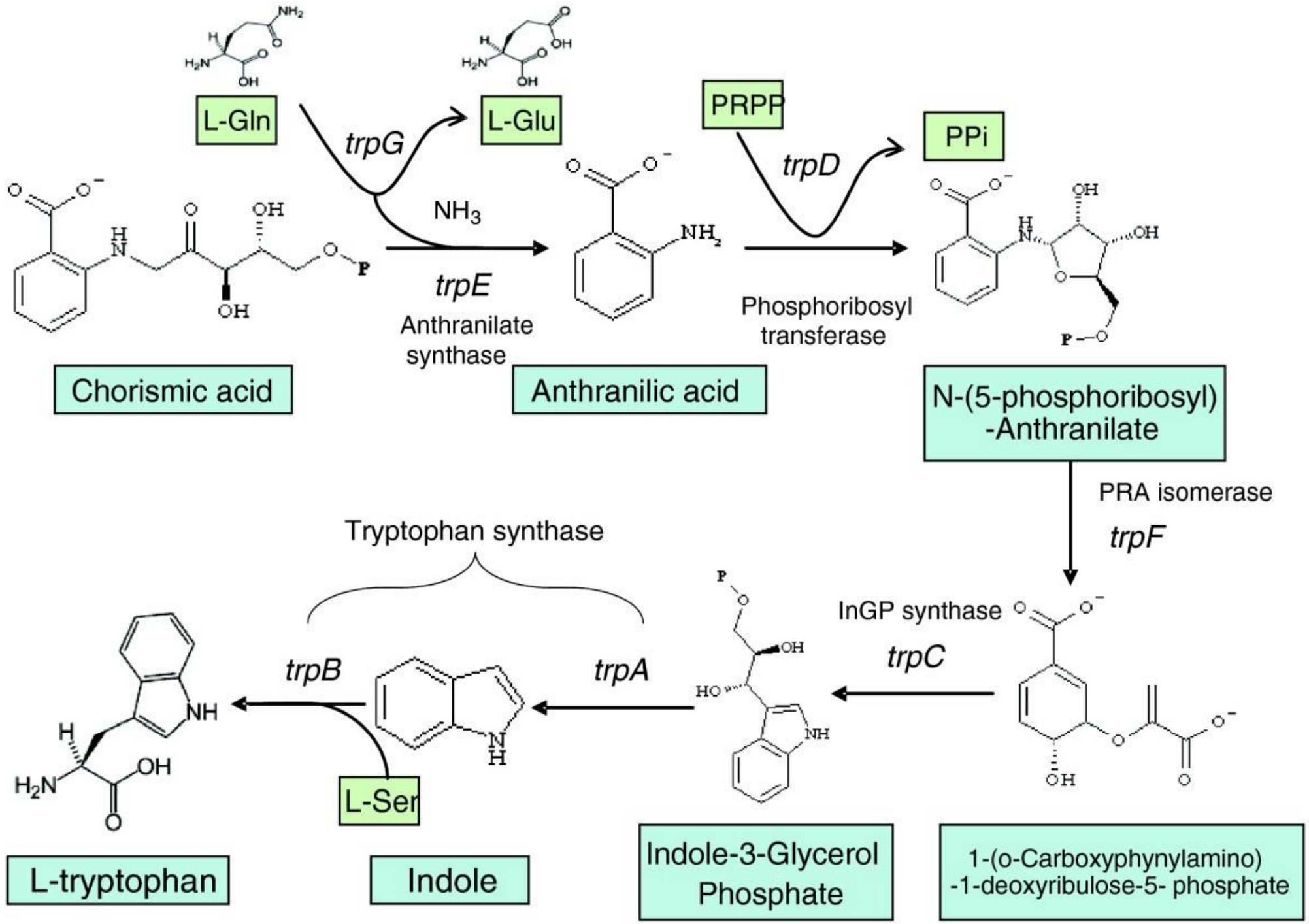


In the absence of tryptophan, the repressor dissociates from the operator, and RNA synthesis proceeds.



Summary

- High levels of tryptophan in the cell shut down the expression of the trp operon. This makes sense, since high levels of tryptophan mean that the cell does not need to make more biosynthetic enzymes to produce additional tryptophan.
- During low level of tryptophan or when tryptophan is absent in cell, trp operon works normally and synthesize all enzyme required for the synthesis of Tryptophan so its level in cell can be increased.


L-Gln
L-Glu
trpG
NH3
trpE
Anthranilate synthase
Chorismic acid
Anthranilic acid
PRPP
trpD
PPi
Phosphoribosyl transferase
N-(5-phosphoribosyl) -Anthranilate
PRA isomerase
trpF
InGP synthase
trpC
1-(o-Carboxyphynylamino) -1-deoxyribulose-5- phosphate
Indole-3-Glycerol Phosphate
trpA
Tryptophan synthase
trpB
L-Ser
Indole
L-tryptophan


Thank
You!