Gene Expression in Prokaryotes

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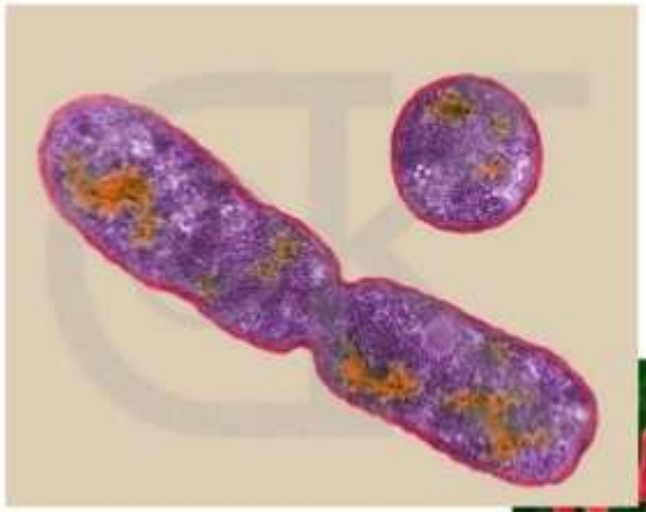
Introduction

- *Genetic expression* is the process by which inheritable information from a gene, such as the DNA sequence, is made into a functional gene product, such as protein or RNA

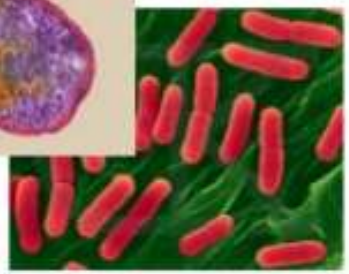
- Non-protein coding genes (e.g. rRNA genes, tRNA genes) are transcribed, but not translated into protein

Prokaryotes

- Group of organisms lacking a cell nucleus or any other membrane-bound organelles.
- Differ from the eukaryotes, which have a cell nucleus
- Mode of division is binary fission
- Prokaryotes exhibit efficient genetic mechanisms to respond to environmental conditions



Rod-Shaped Bacterium, *Escherichia coli* dividing by binary fission



Rod-Shaped Bacterium, hemorrhagic *E. coli*, strain

Types of regulation in Gene Expression

Positive

- *More gene product (Induction)*
- *Effect of activator/inducer*

Negative

- *Less gene product (Repression)*
- *Effect of repressor*

Double Negative

- *More gene product (Derepression)*
- *Effect of inhibitor upon repressor*

Types of genes in Gene Expression

- Inducible gene
  - Regulated by inducer/activator
- Constitutive gene
  - Not subjected to regulation

Regulation of Prokaryotic Gene Expression

- Control at the level of transcription
- ***Induction*** - the production of a specific enzyme/s in response to the presence of a substrate
- ***Repression*** - the cessation of production of a specific enzyme/s in response to an increased level of a substrate

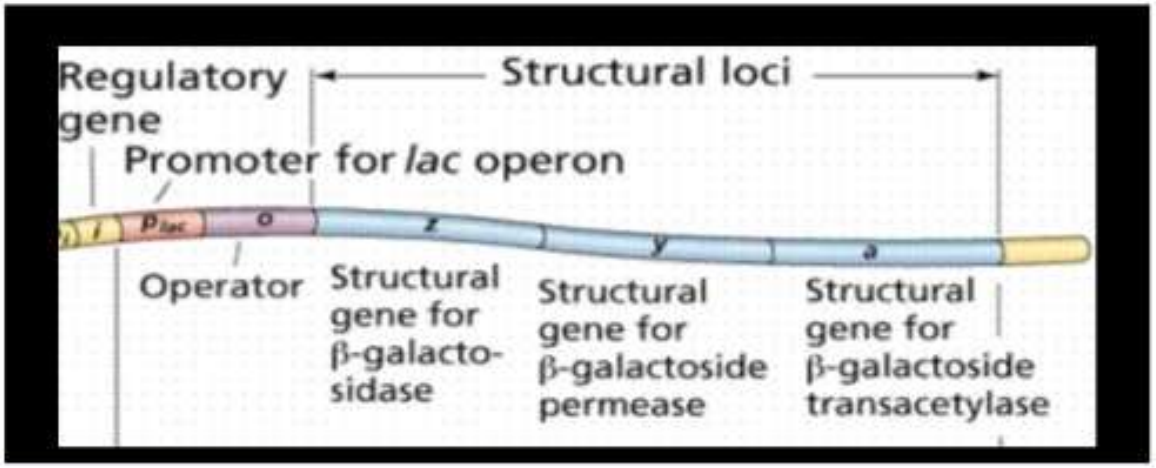
Operon Models

- An operon model is a self-regulating series of genes found on DNA that work in concert
- It includes a special segment of genes that are regulators of the protein synthesis, but ***do not code*** for protein, called the promoter and operator regions
- Lactose (Lac), Tryptophan (Trp), L-Arabinose (Ara)

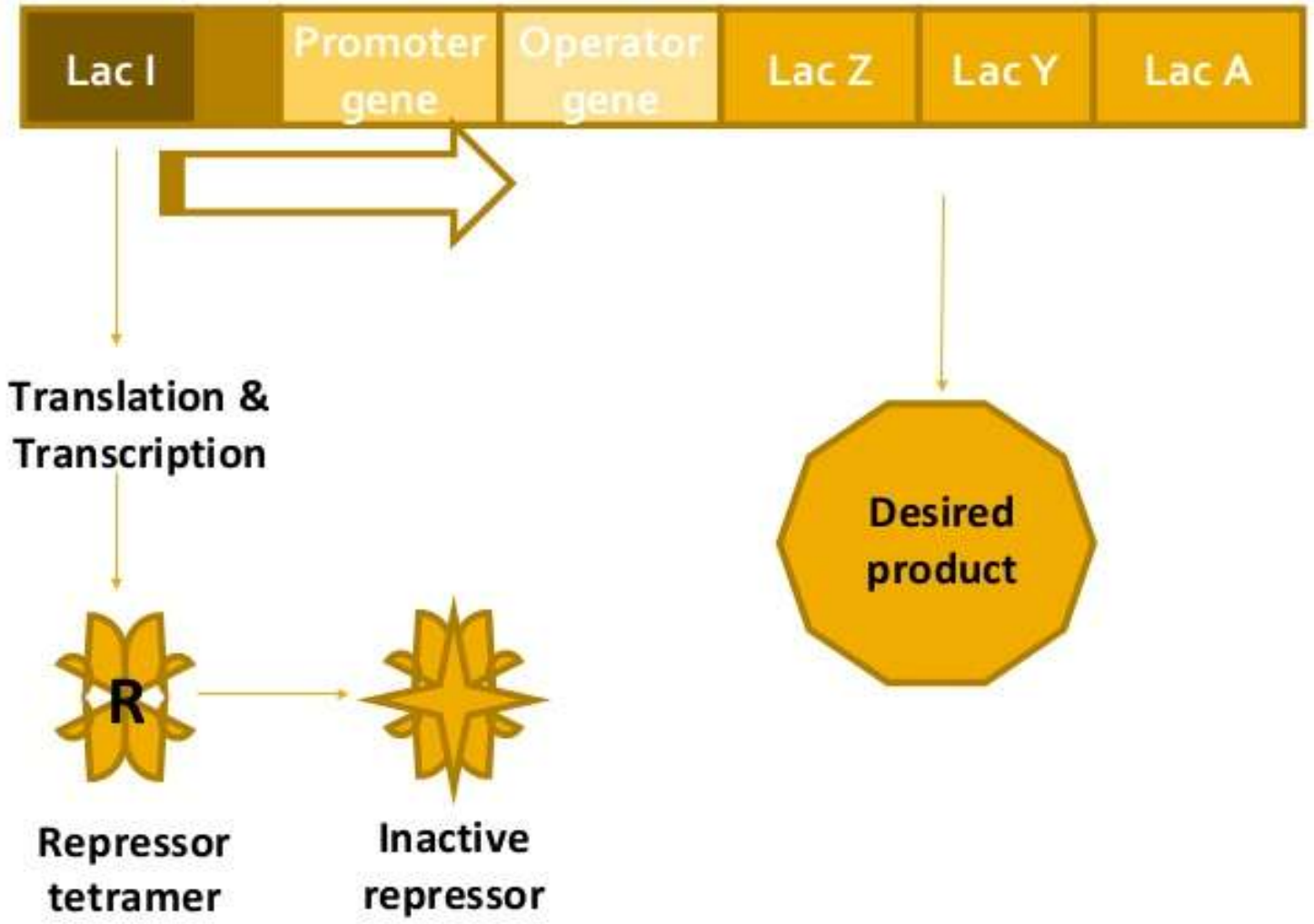
Lac Operon Model

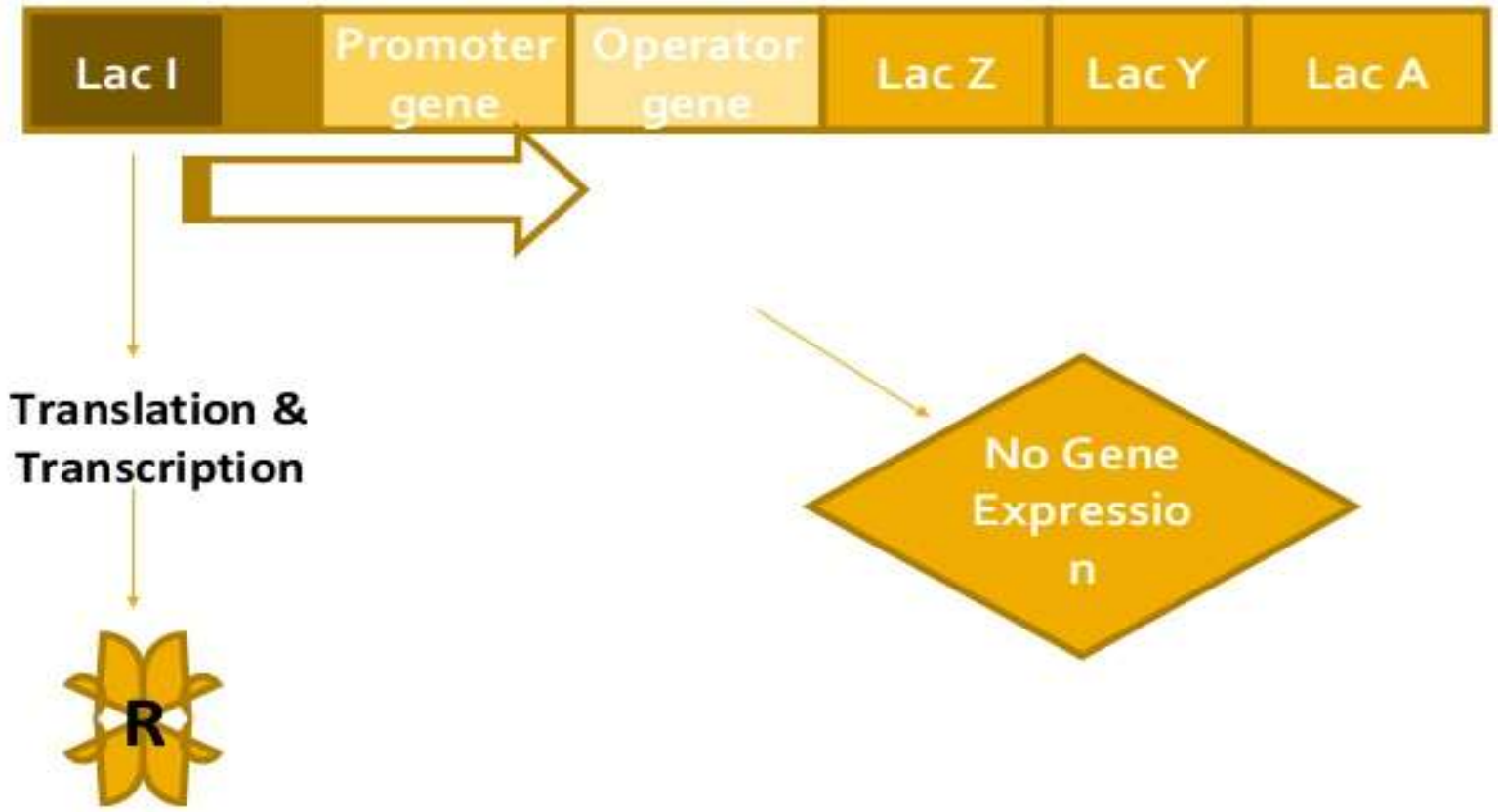
- Inducible system
- Three genes part of an operon that code for three separate enzymes
- Needed for the breakdown of lactose, a simple sugar

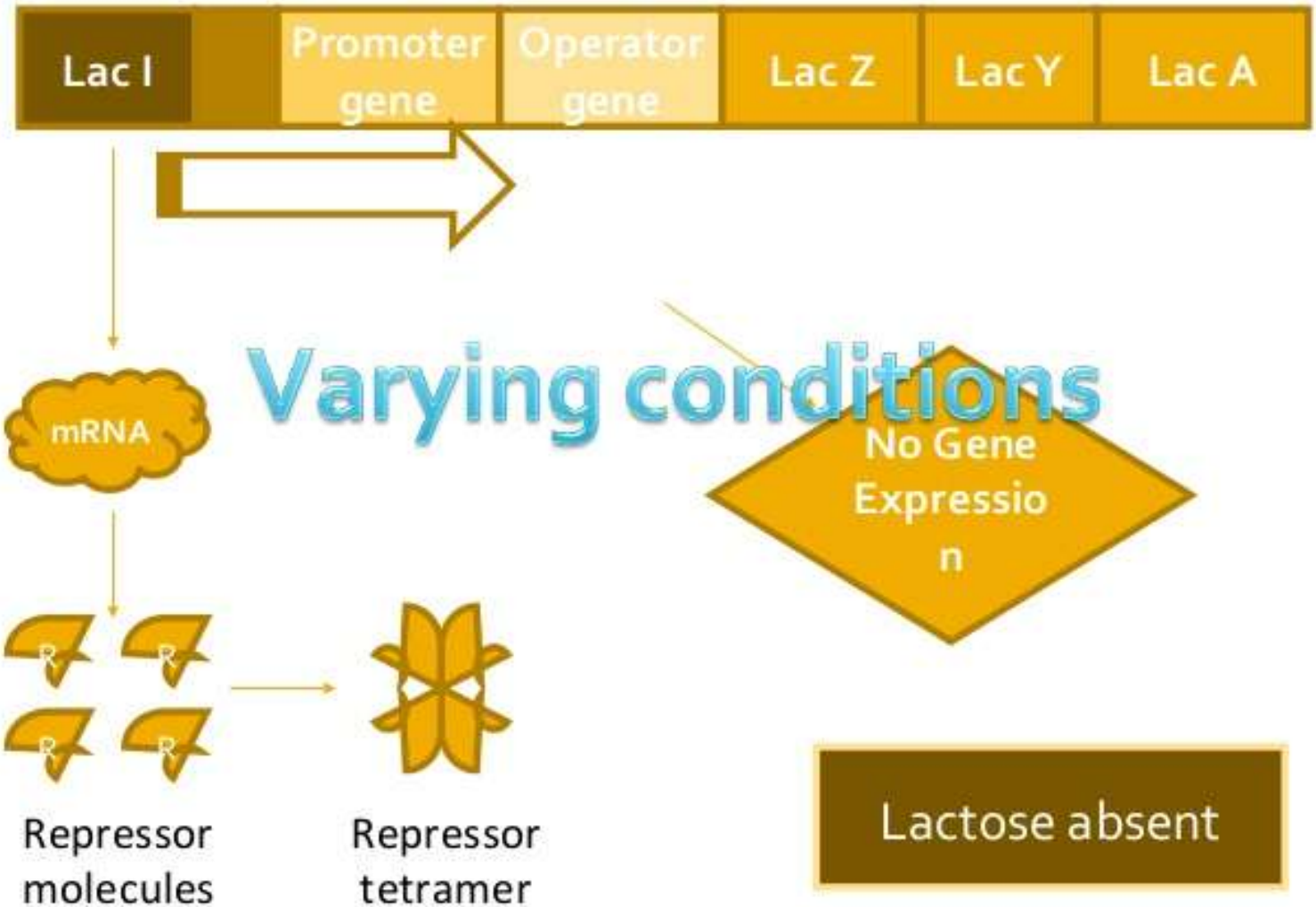
Components of Lac Operon

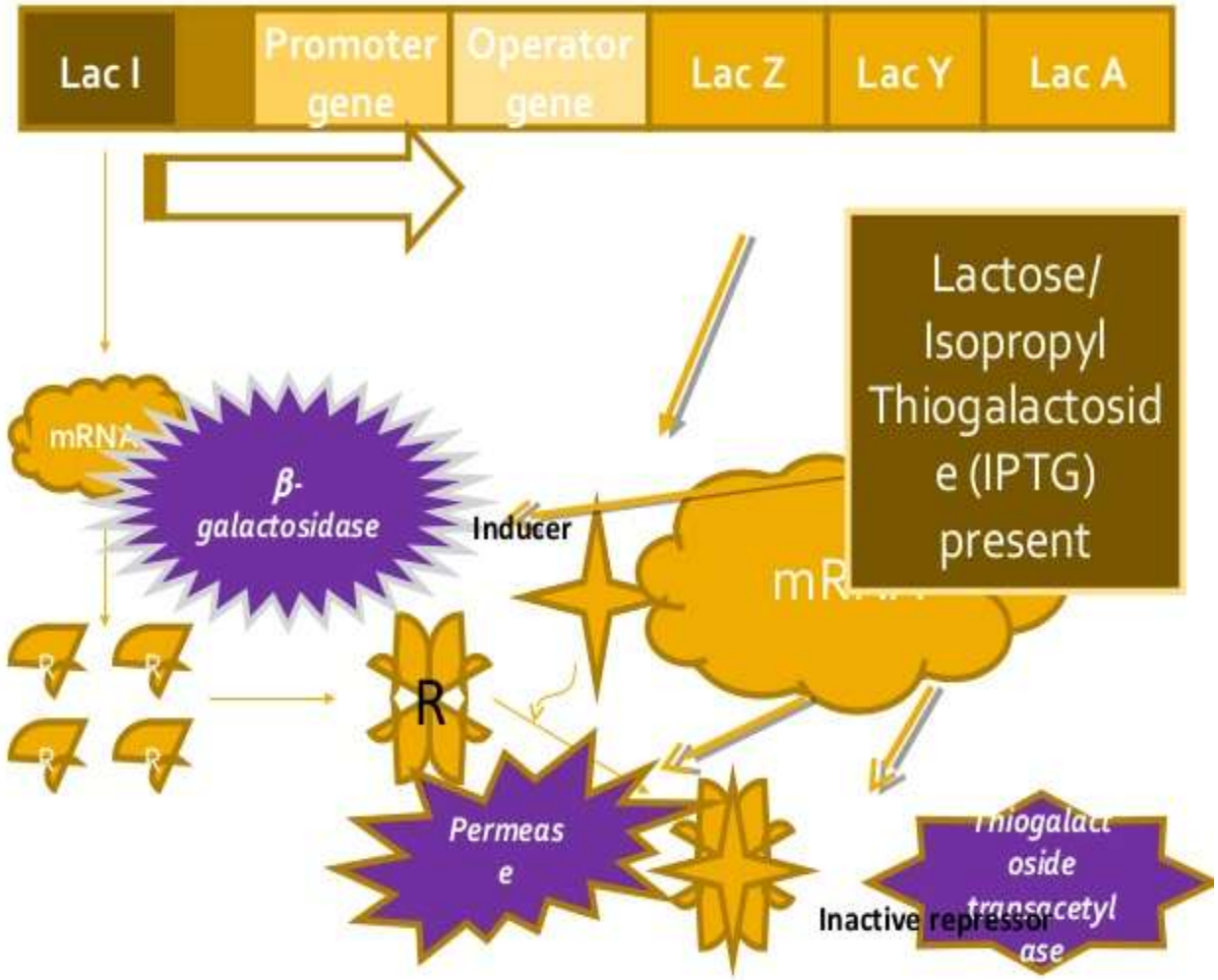


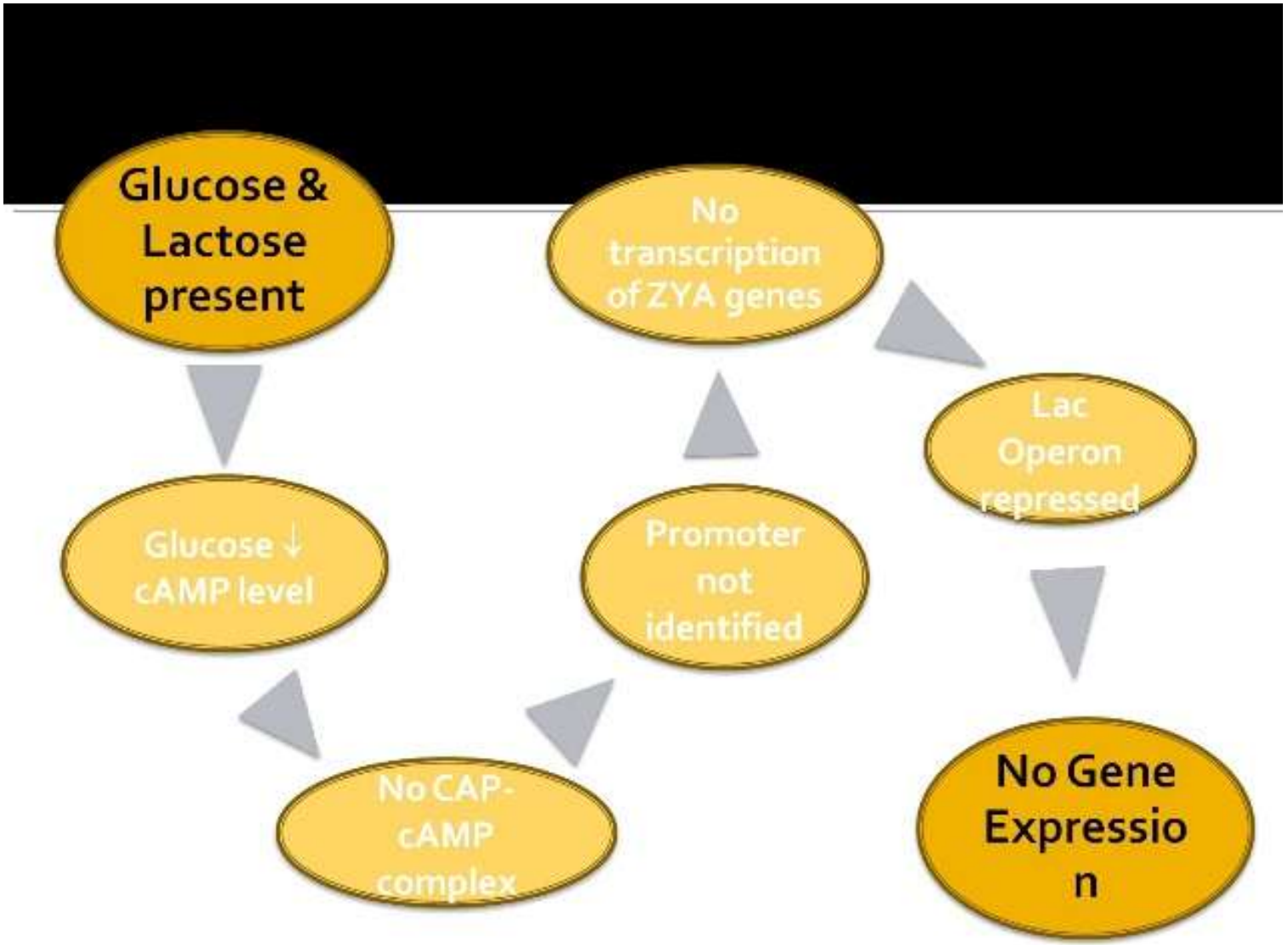
Lac Operon Gene	Gene function
Lac I	Constitutive gene synthesizing repressor constantly
Lac Z	Gene for β-galactosidase subunit
Lac Y	Gene for Permease subunit
Lac A	Gene for Thiogalactoside transacetylase subunit
Promoter or P	RNA polymerase binding & initiator of transcription
Operator or O	Repressor binding site

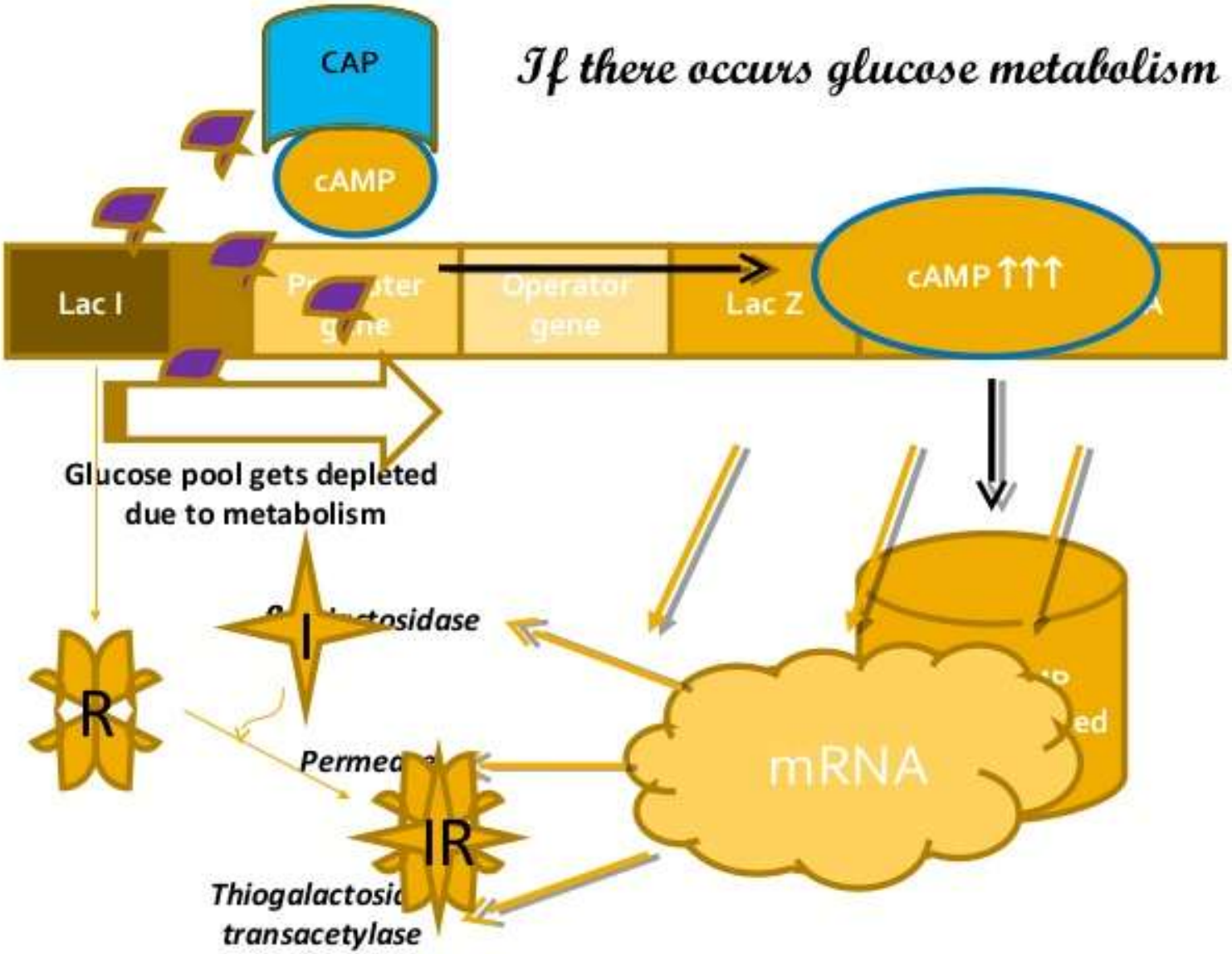

Lac I
Promoter gene
Operator gene
Lac Z
Lac Y
Lac A
Translation & Transcription
Desired product
R
Repressor tetramer
Inactive repressor


Lac I
Promoter gene
Operator gene
Lac Z
Lac Y
Lac A
Translation & Transcription
R
No Gene Expressio n

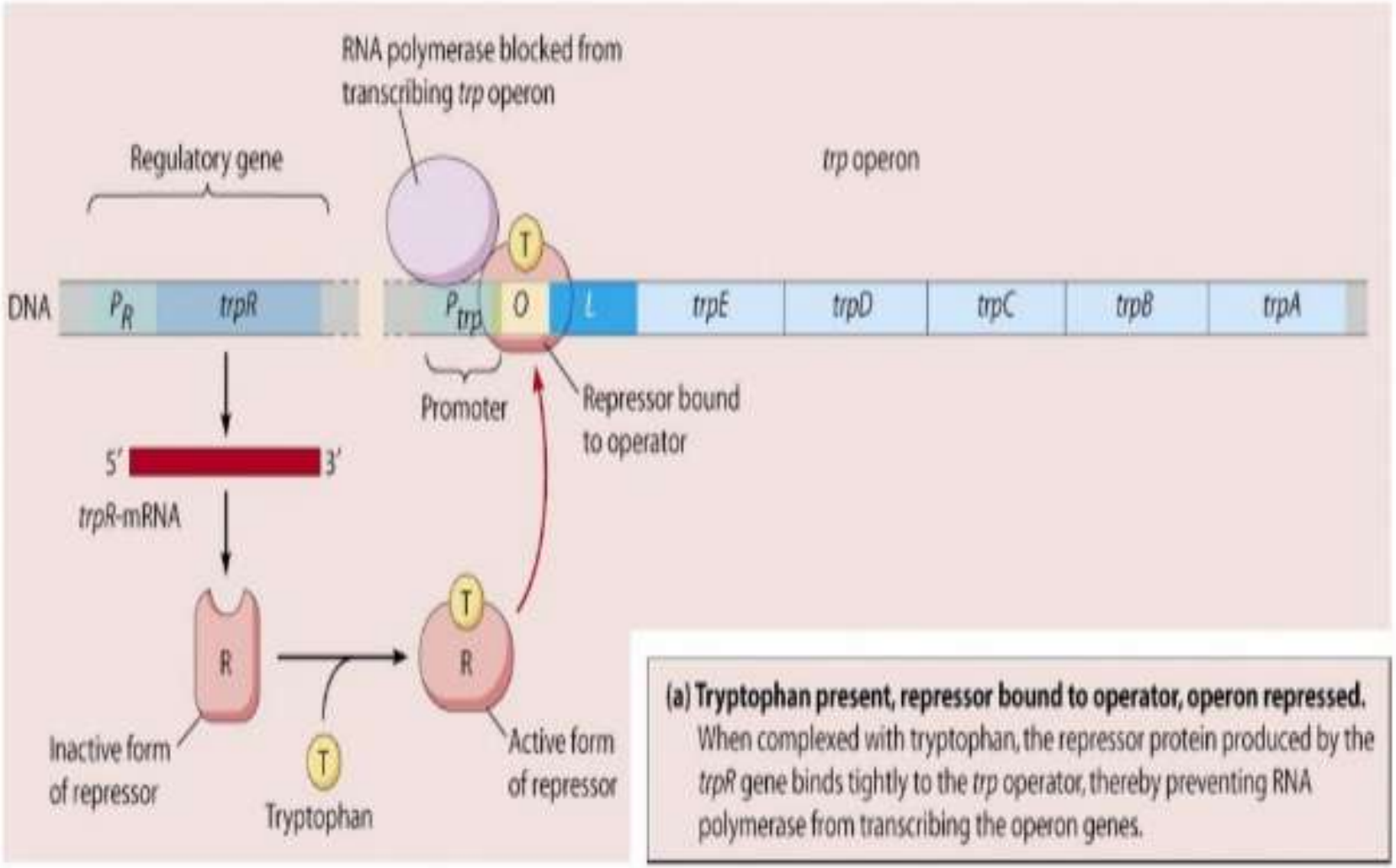

Lac I
Promoter gene
Operator gene
Lac Z
Lac Y
Lac A
mRNA
Varying conditions
No Gene Expressio n
R
R
R
R
Repressor molecules
Repressor tetramer
Lactose absent

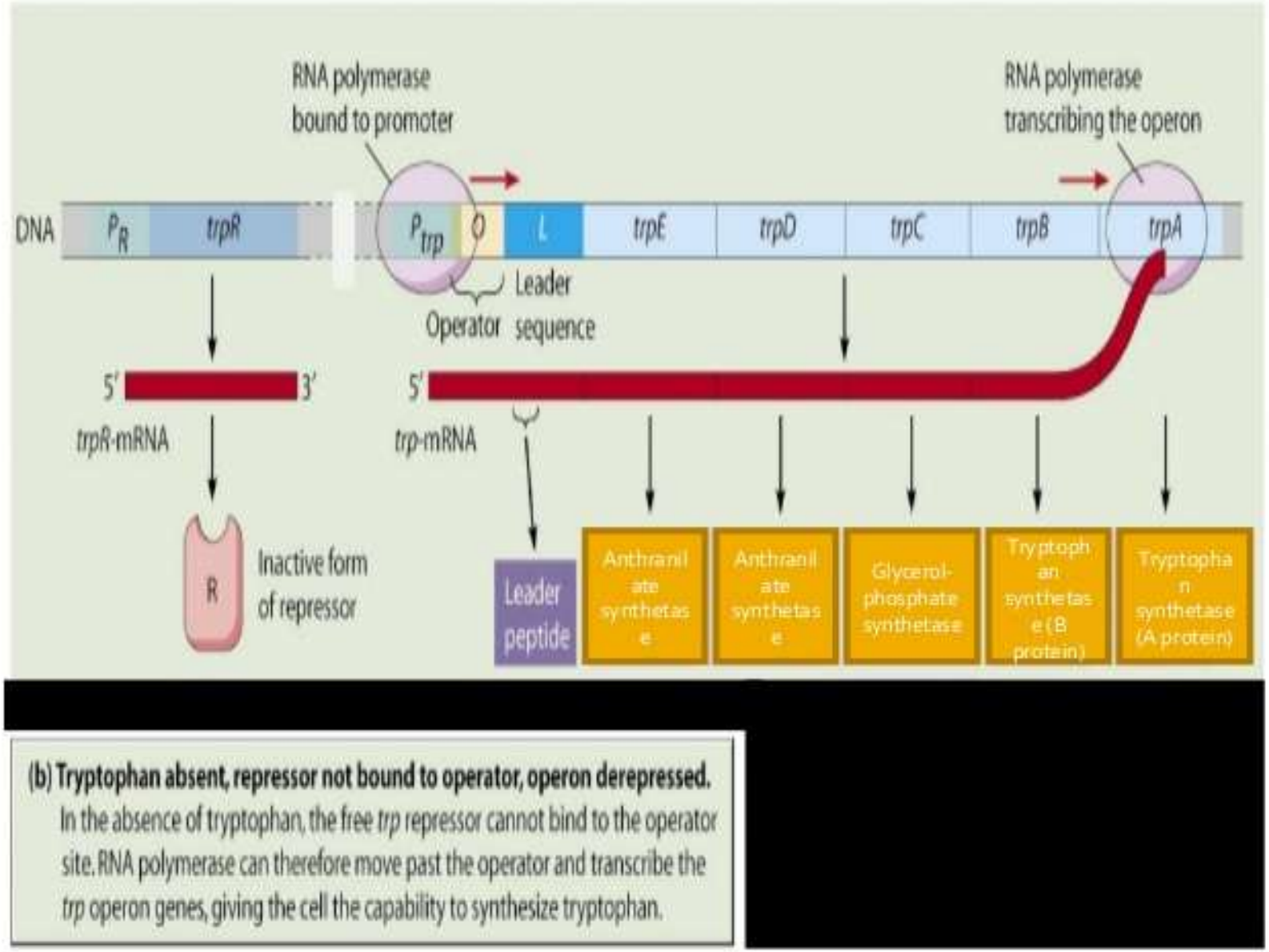

Lac I
Promoter gene
Operator gene
Lac Z
Lac Y
Lac A
Lactose/ Isopropyl Thiogalactosid e (IPTG) present
mRNA
β-galactosidase
Inducer
R
Permeas e
Thiogalact oside transacetyl ase
Inactive repressor


Glucose & Lactose present
Glucose ↓ cAMP level
No CAP-cAMP complex
Promoter not identified
No transcription of ZYA genes
Lac Operon repressed
No Gene Expressio n


If there occurs glucose metabolism
CAP
cAMP
Lac I
Operator gene
Lac Z
cAMP ↑↑↑
Glucose pool gets depleted due to metabolism
I
R
IR
mRNA

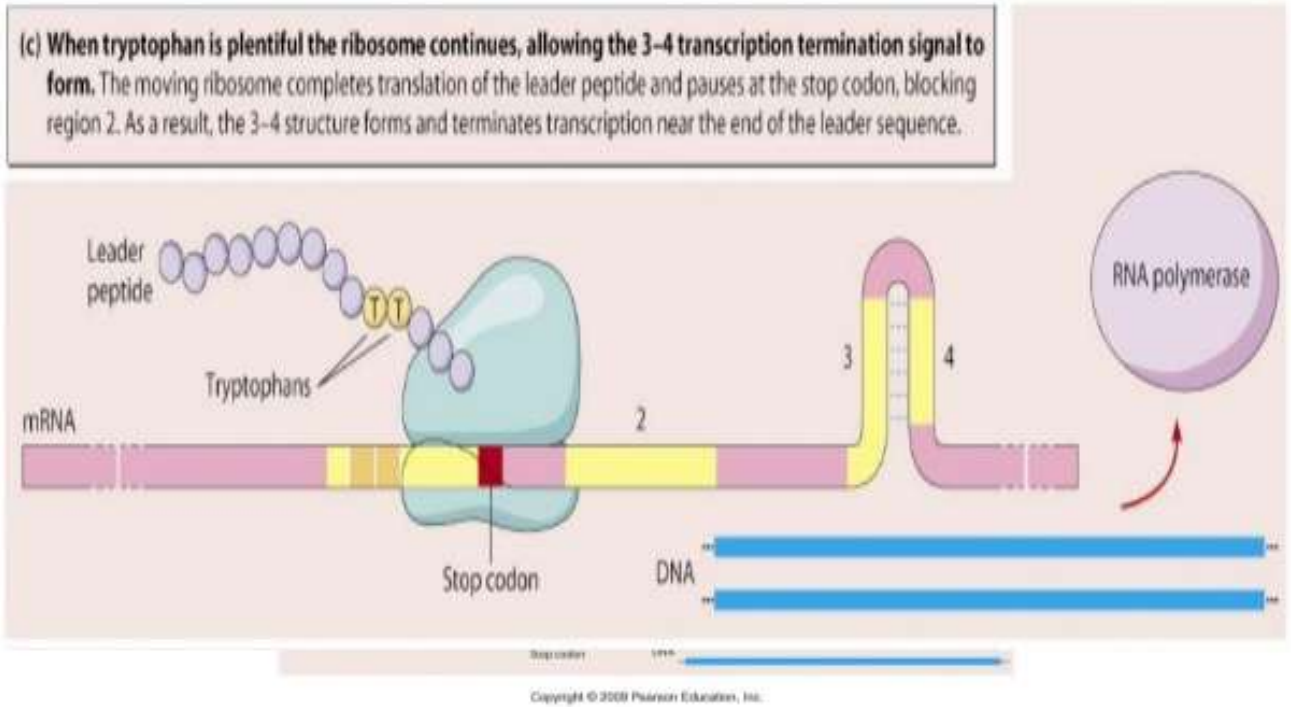
Trp Operon Gene	Gene function
P/O	Promoter; operator sequence is found in the promoter
Trp L	Leader sequence; attenuator (A) sequence is found in the leader
Trp E	Gene for anthranilate synthetase subunit
Trp D	Gene for anthranilate synthetase subunit
Trp C	Gene for glycerol-phosphate synthetase
Trp B	Gene for tryptophan synthetase subunit
Trp A	Gene for tryptophan synthetase subunit


RNA polymerase blocked from transcribing trp operon
Regulatory gene
trp operon
T
DNA
P_R
trpR
P_{trp}
O
L
trpE
trpD
trpC
trpB
trpA
Promoter
Repressor bound to operator
5′
3′
trpR-mRNA
R
T
R
Inactive form of repressor
T
Tryptophan
Active form of repressor
(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.



(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.

Attenuation of Trp Operon Model



Ara Operon Model