Variety of mechanisms regulate gene expression at different levels including transcription, RNA processing and translation.

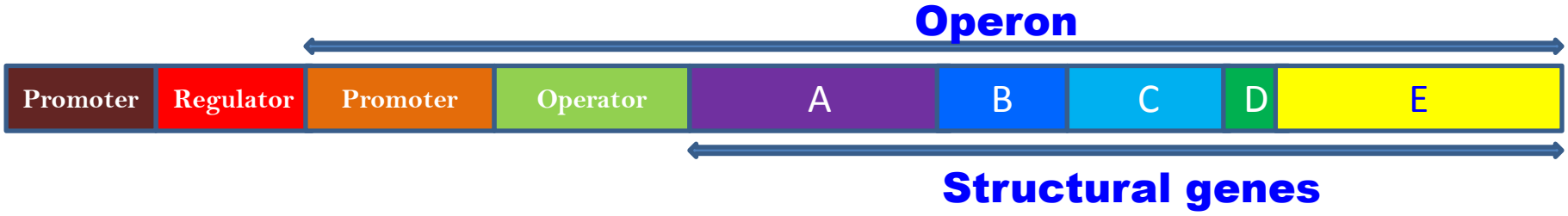
OPERON MODEL

F. Jacob and J. Monad proposed the model

on the inducible system for synthesis of β-galactosidase in *E. coli*

An operon is a unit of coordinated control of protein synthesis

This unit consists of a promoter, an operator, a number of structural genes



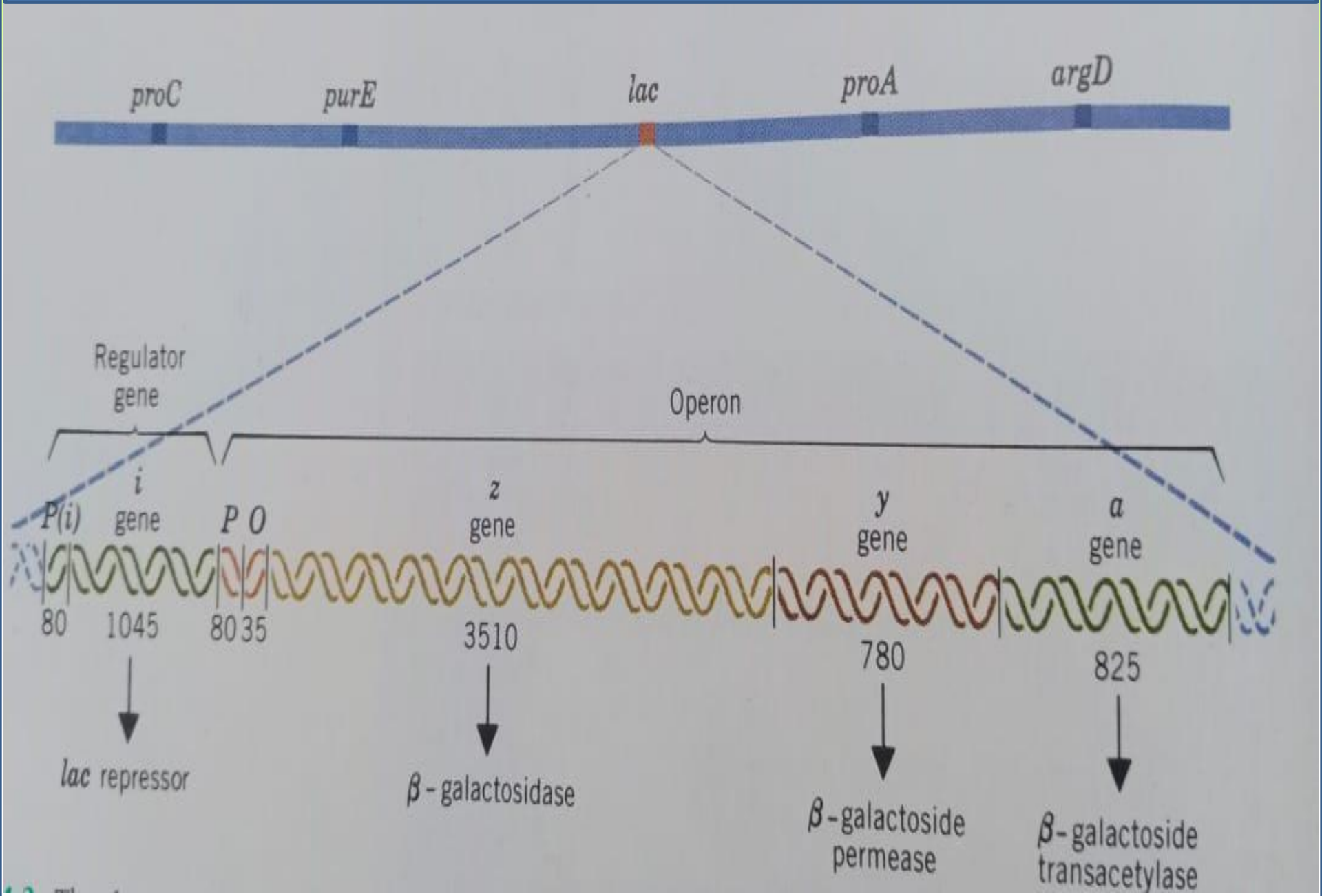
lac Operon

Transcription in *lac* operon requires

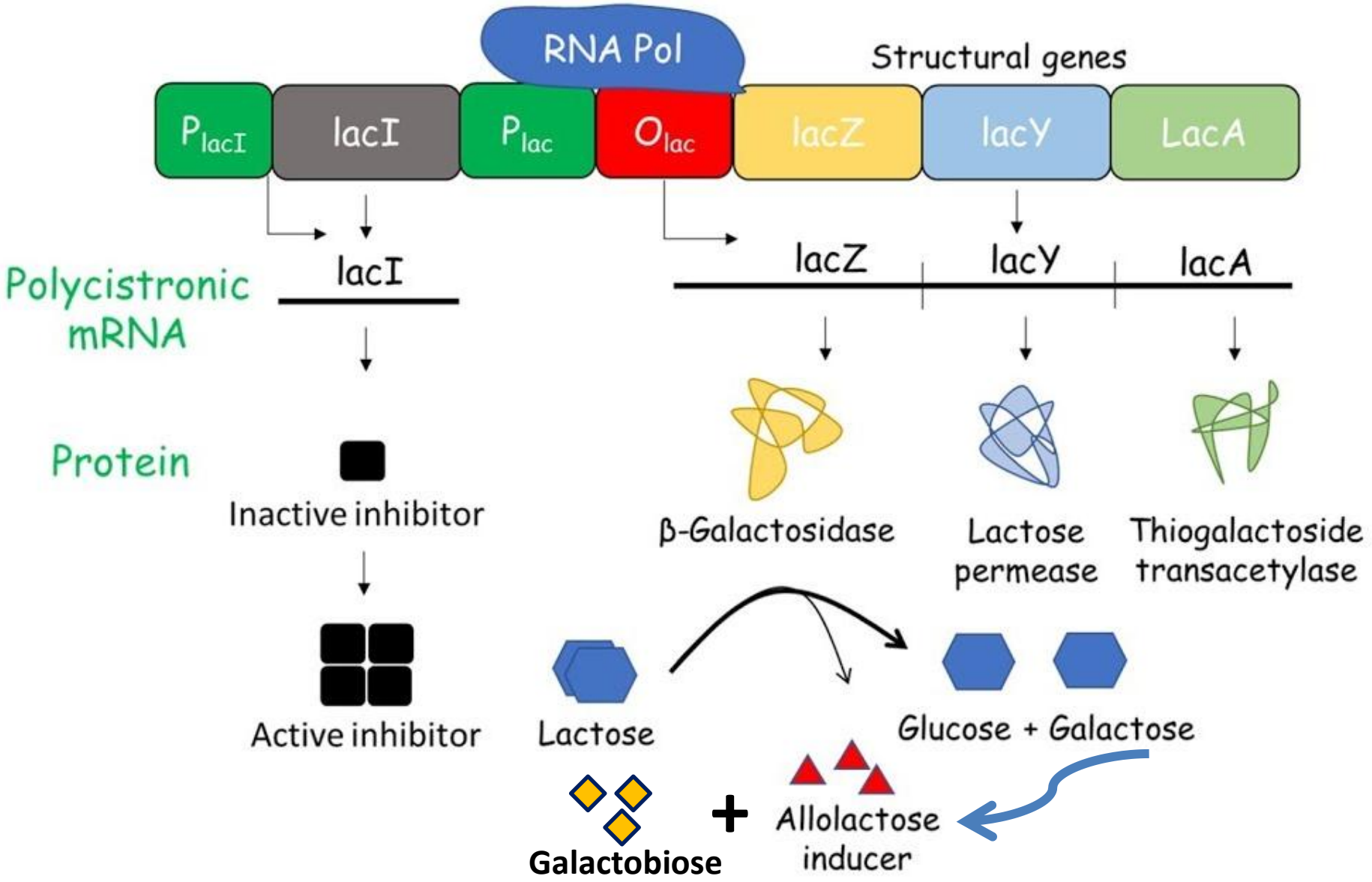
1. ***lac* repressor is inactivated by inducer – a negative control**

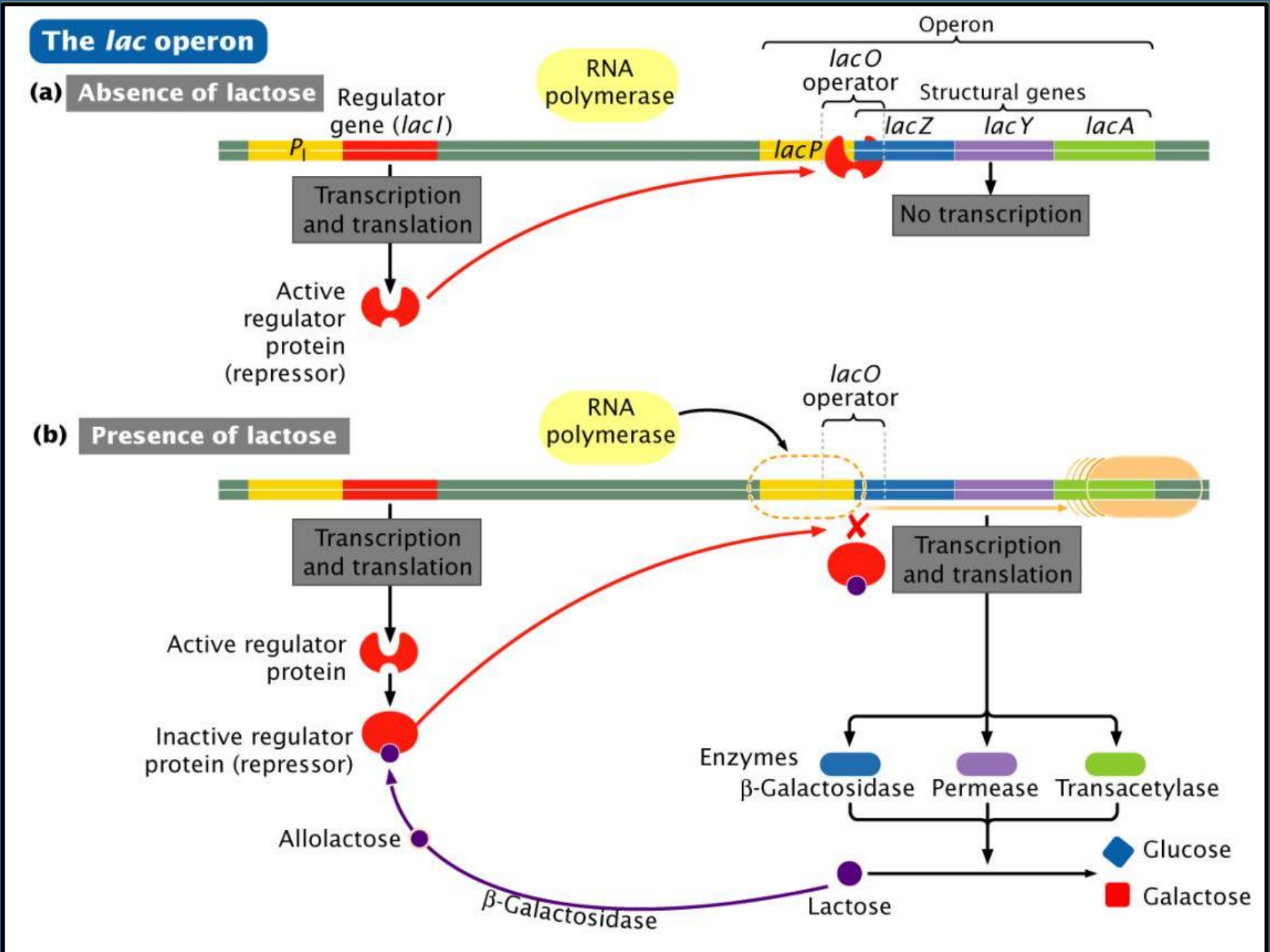
2. **c-AMP activates cga protein – a positive control**

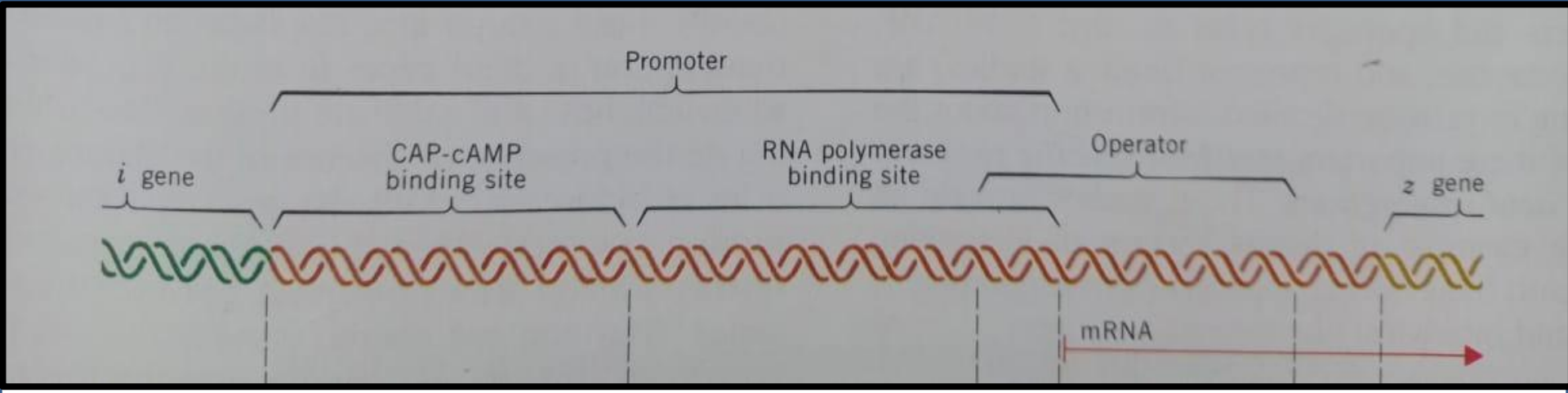
Structure of *lac* operon



Lac Operon model




The lac operon
(a) Absence of lactose
Regulator gene (lacI)
RNA polymerase
Operon
lacO operator
Structural genes
lacZ
lacY
lacA
P
lacP
Transcription and translation
No transcription
Active regulator protein (repressor)
(b) Presence of lactose
lacO operator
RNA polymerase
Transcription and translation
Transcription and translation
Active regulator protein
Inactive regulator protein (repressor)
Enzymes
β-Galactosidase
Permease
Transacetylase
Allolactose
Glucose
Galactose
β-Galactosidase
Lactose



***lac* promoter contains two separate binding sites: 1. One for RNA polymerase and 2. One for the CAP - c-AMP complex**

Two proteins regulate lactose operon:

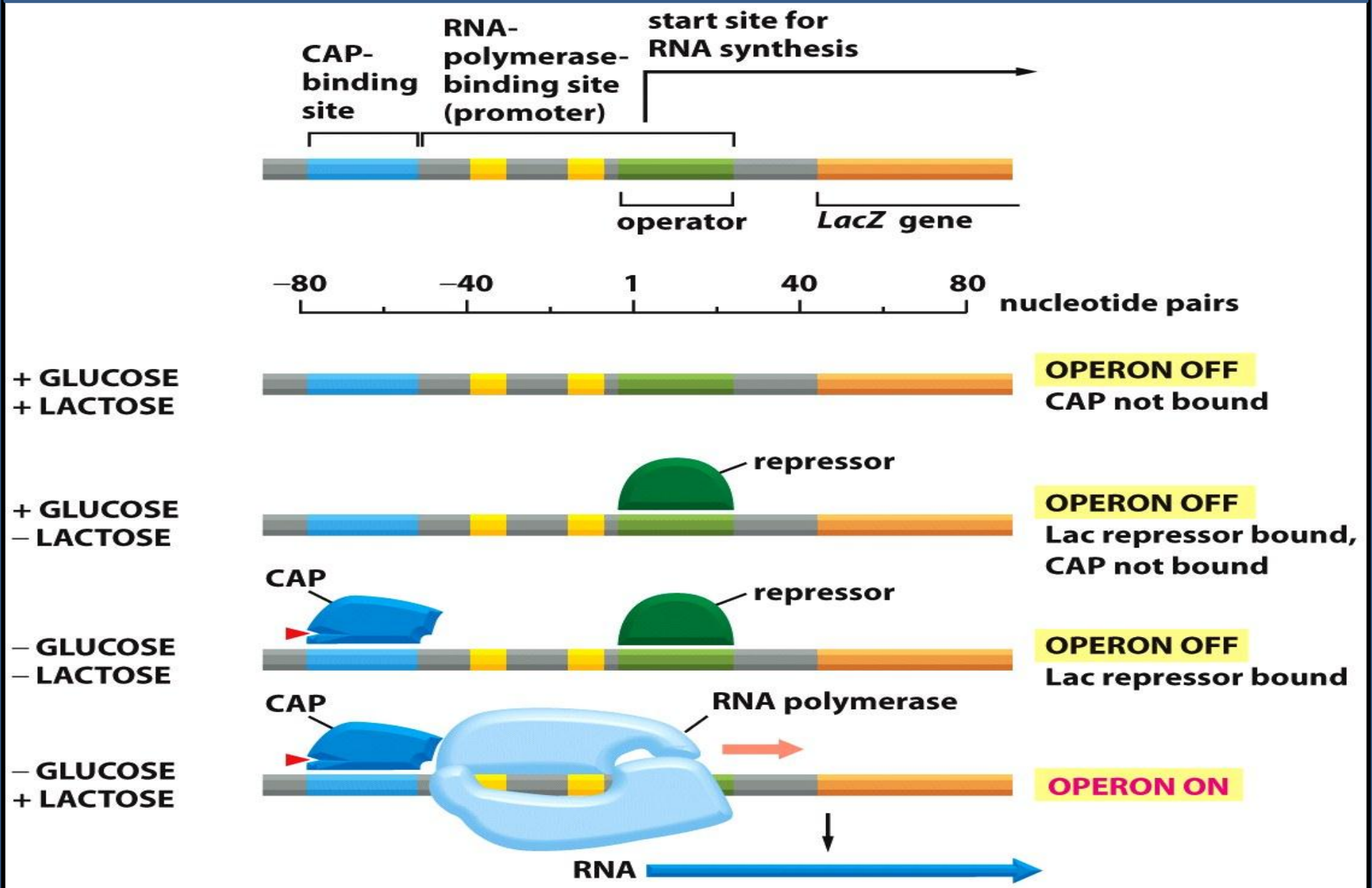
1. ***lac* repressor**
2. **Catabolite gene activator (cga) protein, also known as CAP (Cyclic AMP Protein or Catabolite Activator Protein), or CRP (Cyclic AMP Receptor Protein).**

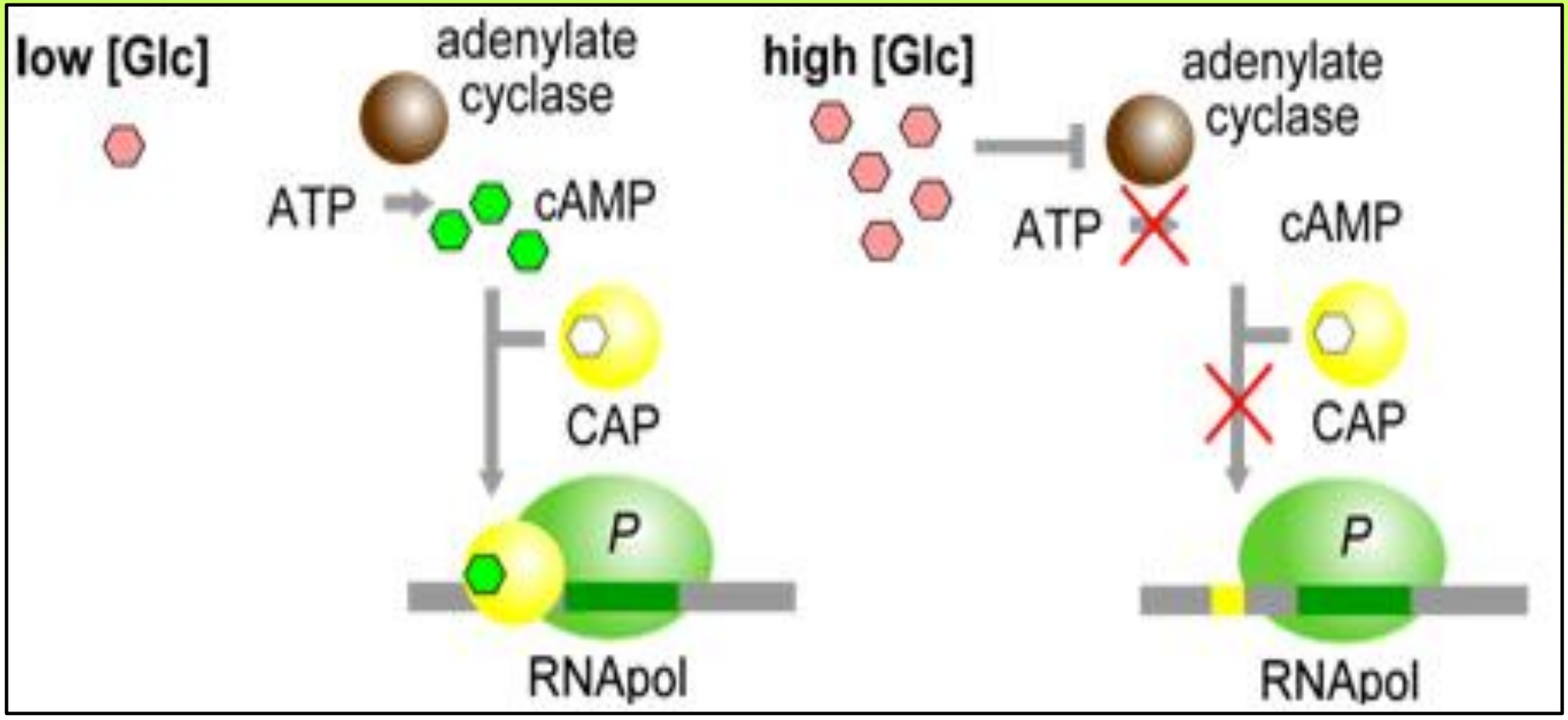
Repressor binds to operator site, cga protein binds to cga site

Repressor exercises a control by checking RNA polymerase to travel through operator, i.e. in a negative way

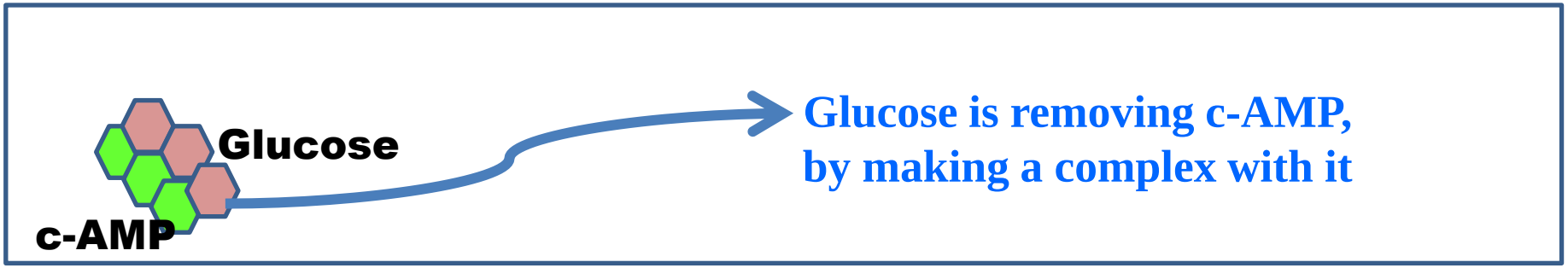
CAP exercises a positive control. Only when c-AMP molecule activates CAP, then RNA polymerase bind and promote transcription.

Glucose effect

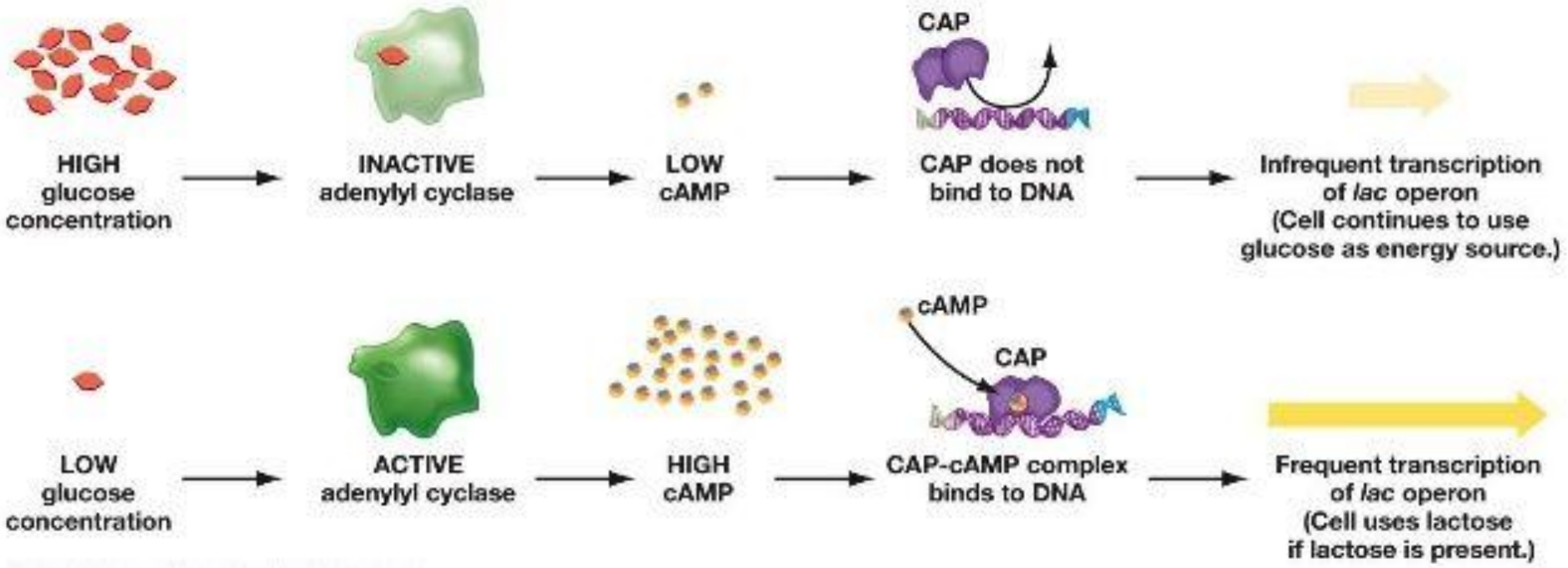



low [Glc]
adenylate cyclase
ATP
cAMP
CAP
P
RNApol
high [Glc]
adenylate cyclase
ATP
cAMP
CAP
P
RNApol

OR

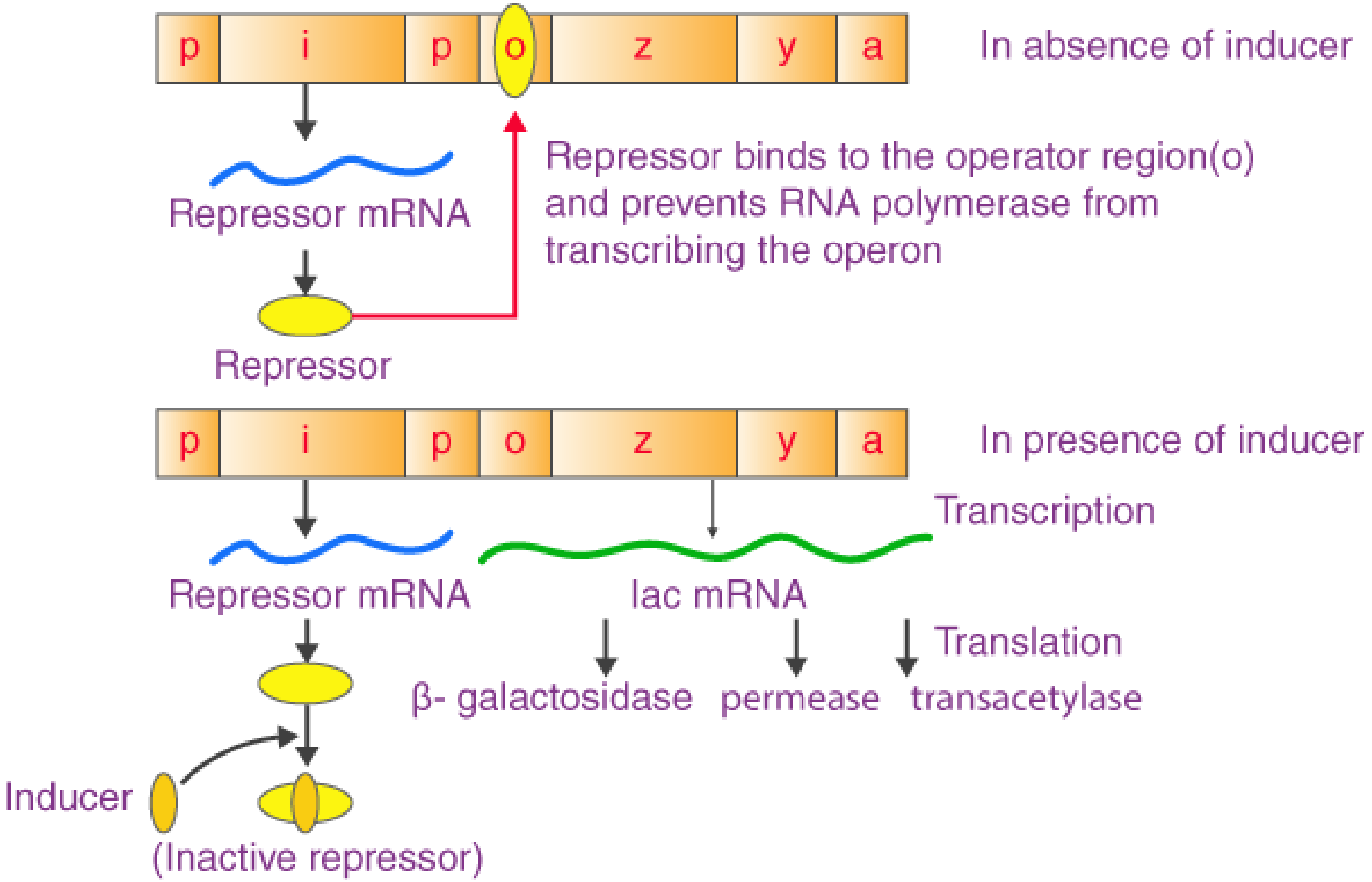

Glucose
c-AMP
Glucose is removing c-AMP,
by making a complex with it

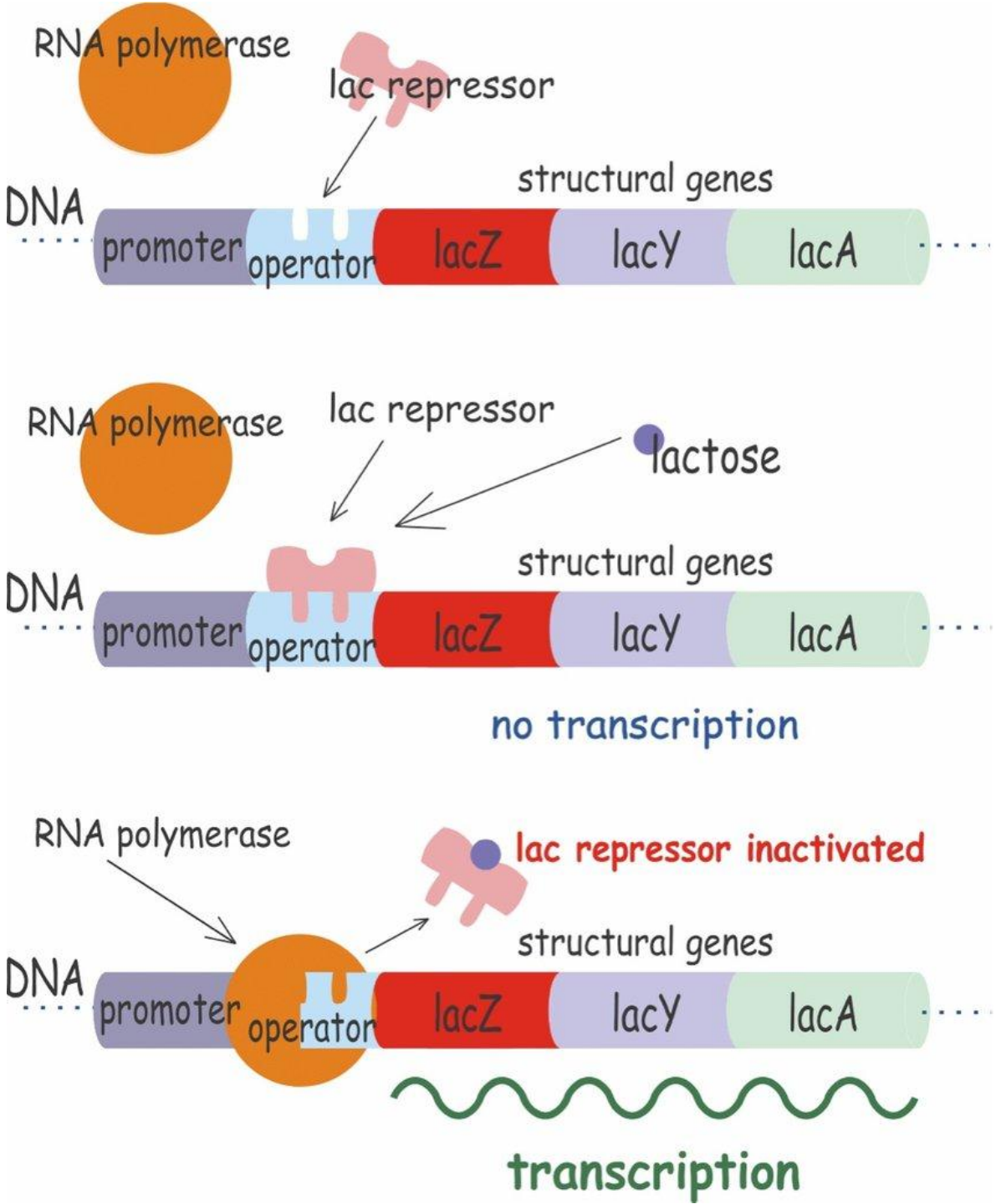
Glucose Regulates cAMP Levels

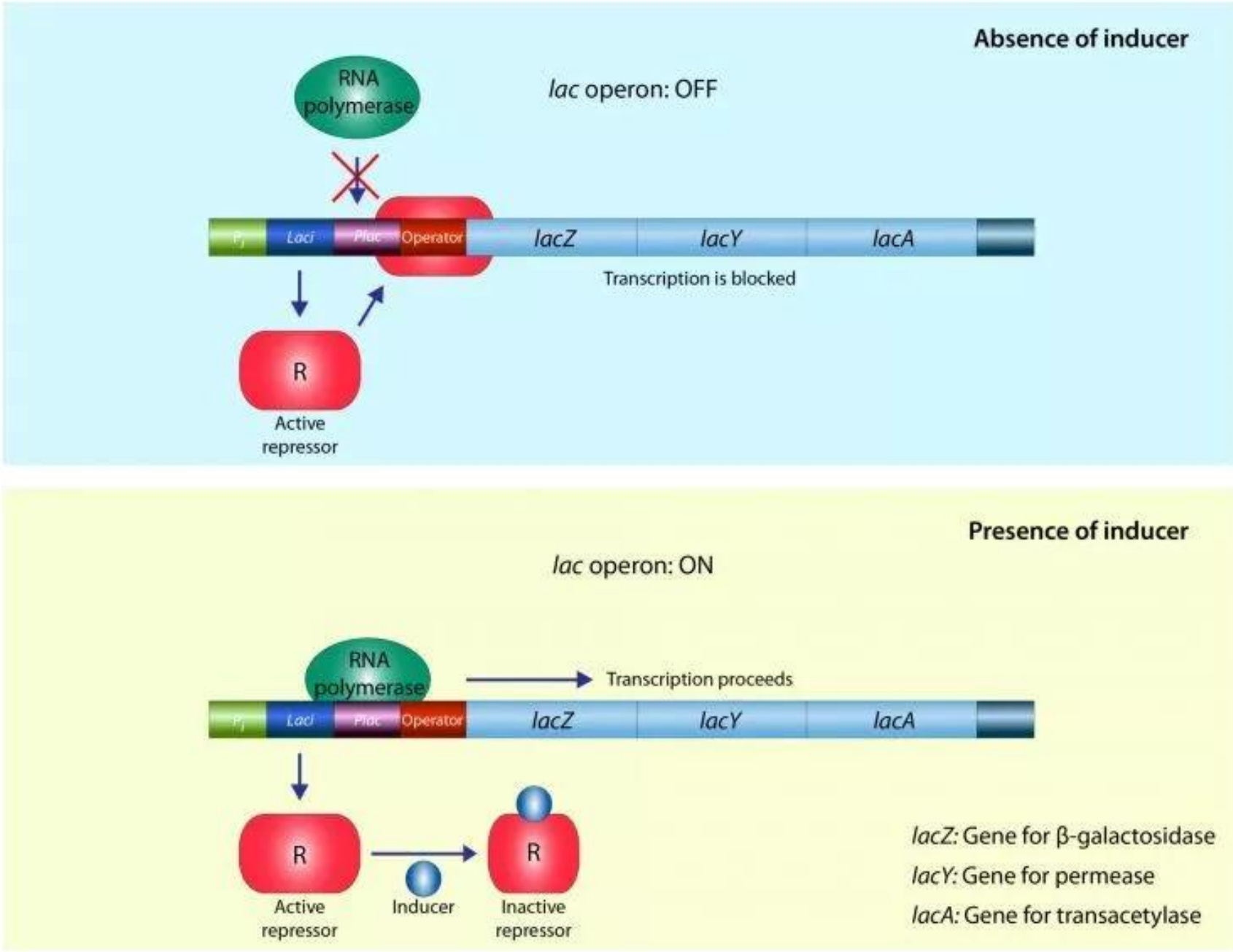


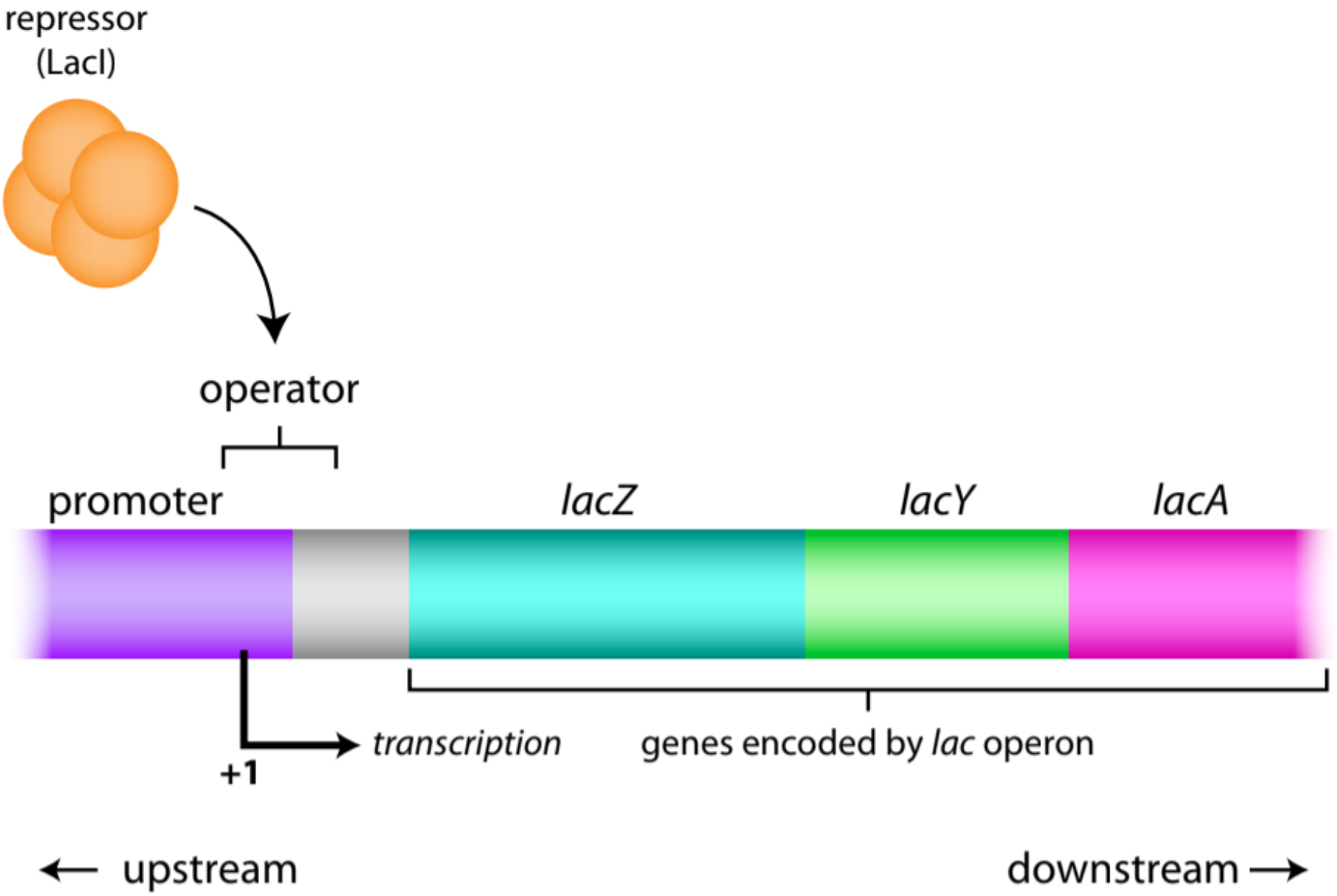
Glucose when present is metabolised, in preference to other, less efficient energy sources

Lac operon (Negetive control)




RNA polymerase
lac repressor
structural genes
DNA
promoter
operator
lacZ
lacY
lacA
RNA polymerase
lac repressor
lactose
structural genes
DNA
promoter
operator
lacZ
lacY
lacA
no transcription
RNA polymerase
lac repressor inactivated
structural genes
DNA
promoter
operator
lacZ
lacY
lacA
transcription


Absence of inducer
RNA polymerase
lac operon: OFF
Laci
Plac
Operator
lacZ
lacY
lacA
Transcription is blocked
R
Active repressor
Presence of inducer
lac operon: ON
RNA polymerase
Transcription proceeds
Laci
Plac
Operator
lacZ
lacY
lacA
R
Active repressor
Inducer
R
Inactive repressor
lacZ: Gene for β-galactosidase
lacY: Gene for permease
lacA: Gene for transacetylase


repressor
(LacI)
operator
promoter
lacZ
lacY
lacA
transcription
+1
genes encoded by lac operon
upstream
downstream

Positive Regulation of Lac Operon

Positive and negative regulation