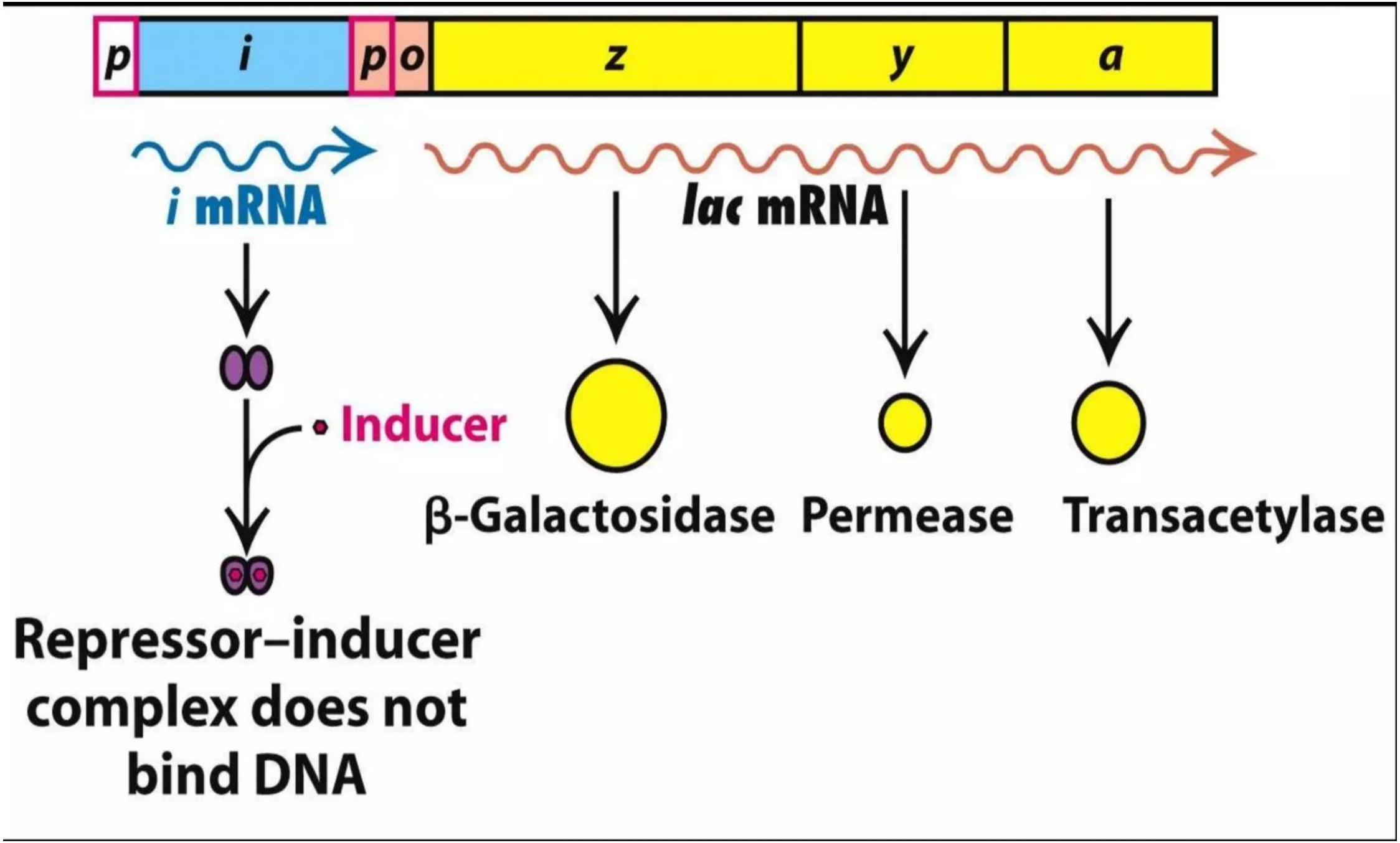
Gene Regulation: Operon concept

Introduction

1. 1961, Jacob and Monad studies the Metabolism of lactose by E.coil.
2. Operon = is a collection of Prokaryotic genes transcribed together on a single mRNA transcript(polycistronic) to serve a single purpose.
3. Composed of:
   a. An operator = "on-off" switch
   b. A promoter
   c. Gene for metabolic enzyme.
4. Can be switched off a repressor protein.
5. Corepressor is a small molecule that binds to a repressor to switch an operon off.


p
i
p
o
z
y
a
i mRNA
lac mRNA
Inducer
β-Galactosidase
Permease
Transacetylase
Repressor–inducer complex does not bind DNA

Operon are either REPRESSIBLE or INDUCIBLE.

Repressible

- Involves binding a Co-repressor(metabolite/end-product) to repress/ turn off Operon transcription.

Inducible

- Involves binding an inducer(metabolite/starting substrate) to induce/ turn on operon transcription.

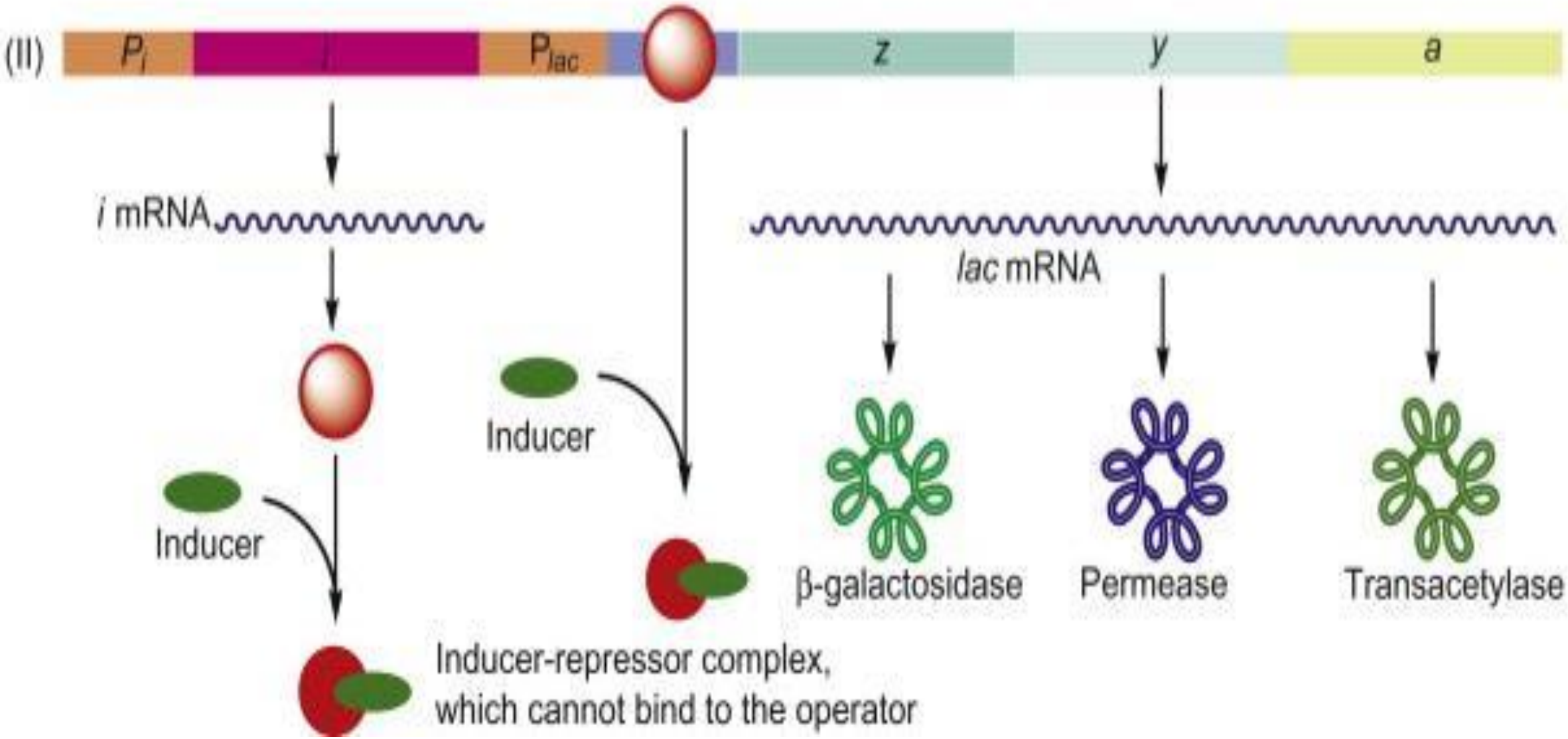
Type of operon	Presence of	Effect	Examples	
			Metabolite	Operon
Inducible	metabolite	ON	lactose	*lac*
Repressible	metabolite	OFF	Trp	*trp*

Components

That controls the transport and Metabolism of lactose.

Structure of Lac operon:

1. Structural genes
2. Regulatory genes


(II)
P_i
P_{lac}
z
y
a
i mRNA
lac mRNA
Inducer
Inducer
β-galactosidase
Permease
Transacetylase
Inducer-repressor complex,
which cannot bind to the operator

Structural genes

Three Structural genes : LacZ, LacY and LacA.

[Note. Transcribed together as a single polycistronic mRNA from a common promoter]

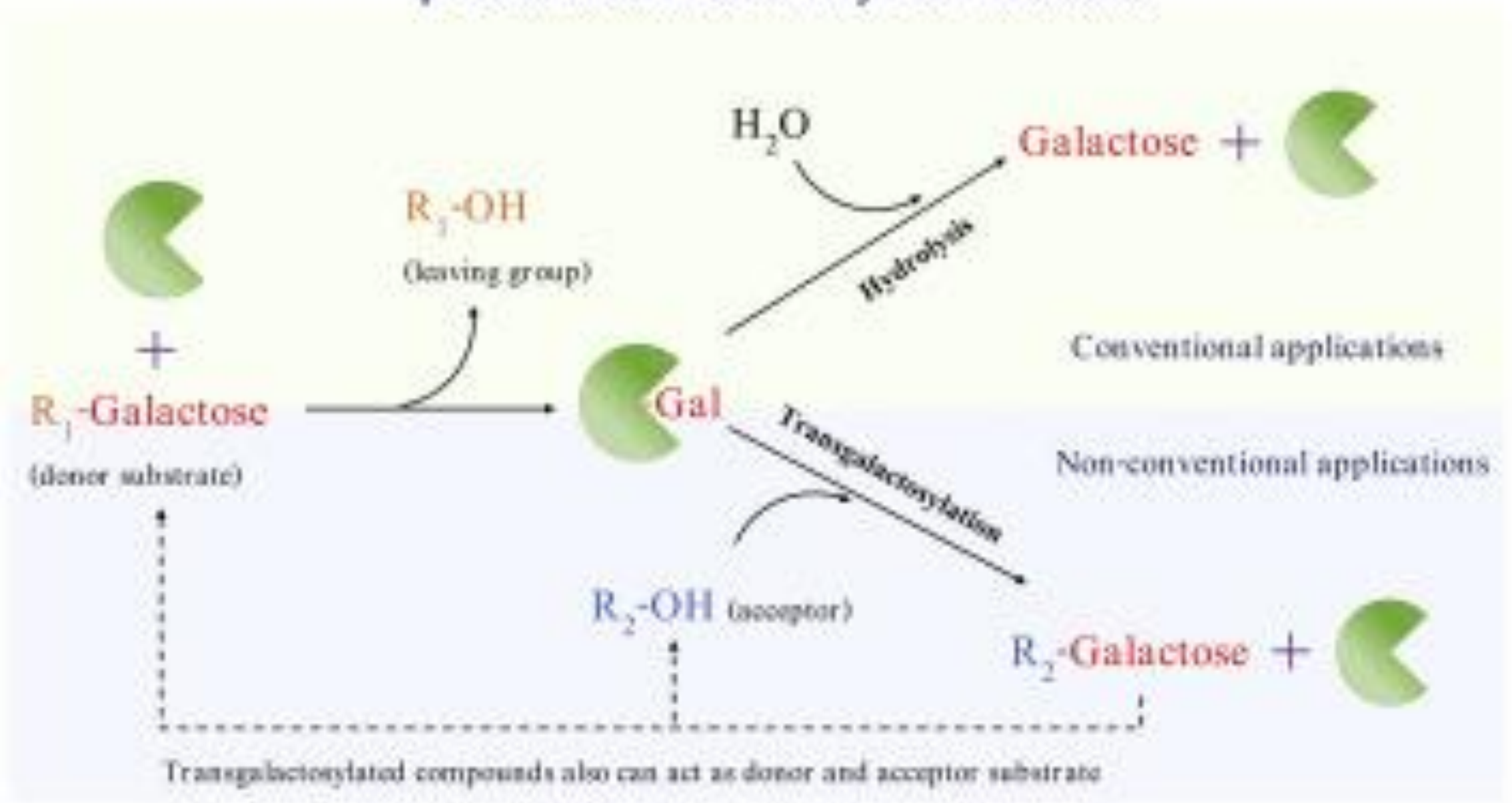
1. Lac Z

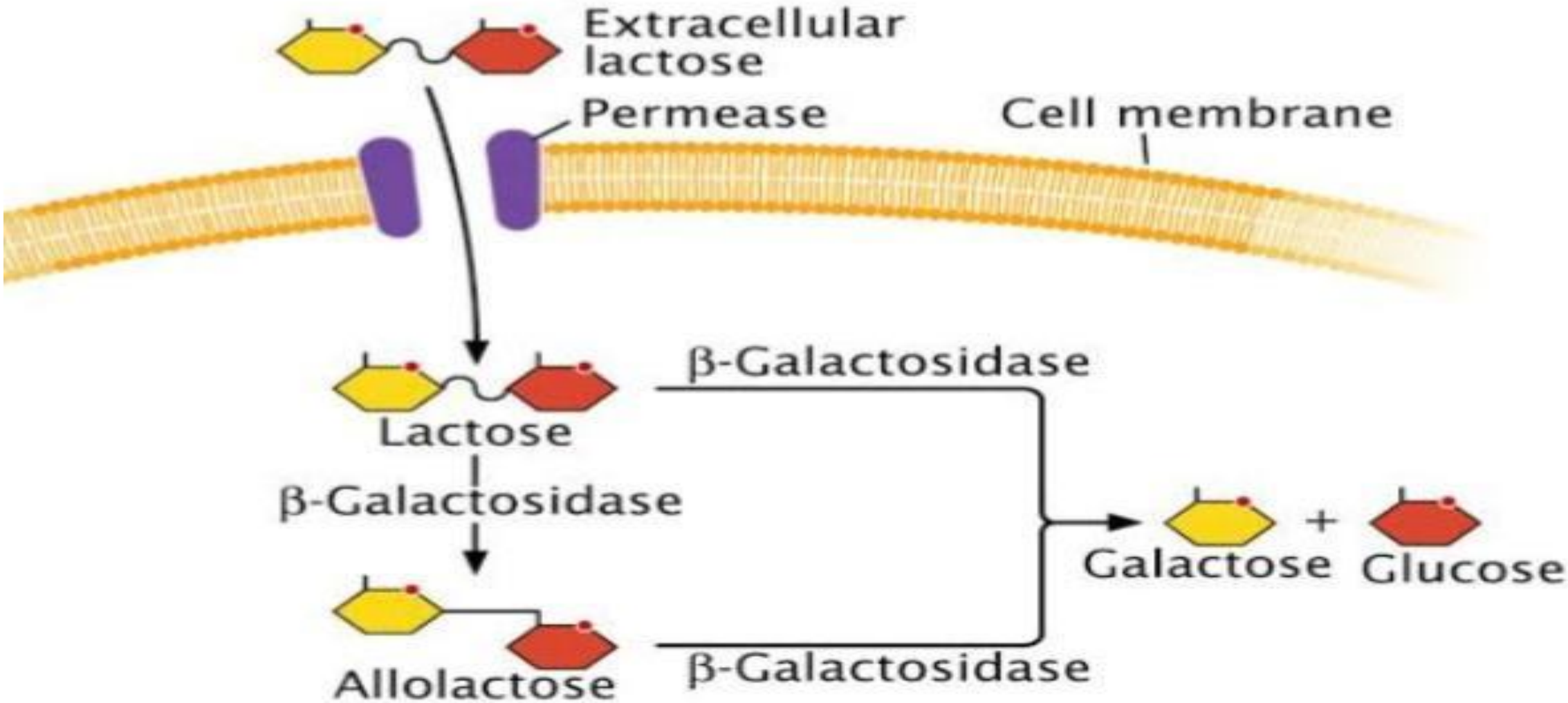
- Gene codes for the enzyme B(beta)- galactosidase (Tetramer) – 500kD
- Play a crucial role in Lactose Metabolism by breaking down B – galactosidease(including lacose).

  Lactose ----------> Allolactose

- With the help B – galactosidease
- Hydrolysed into glucose and galactose

β-Galactosidase catalyzed reactions




Extracellular lactose
Permease
Cell membrane
β-Galactosidase
Lactose
β-Galactosidase
Galactose
+
Glucose
Allolactose
β-Galactosidase

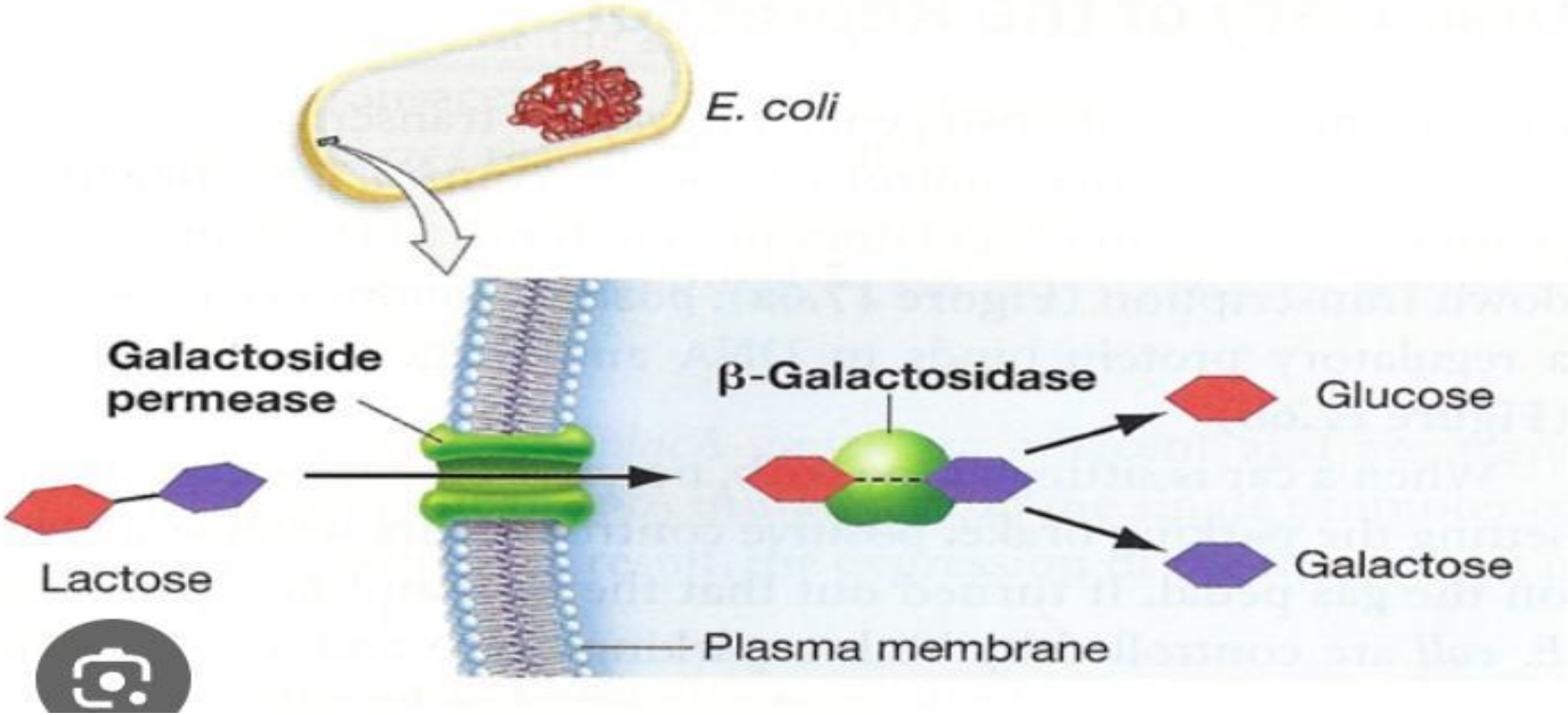
2. Lac Y

- Gene encodes the B – galactoside permease.
- Membrane – bound protein (MW = 30kD)

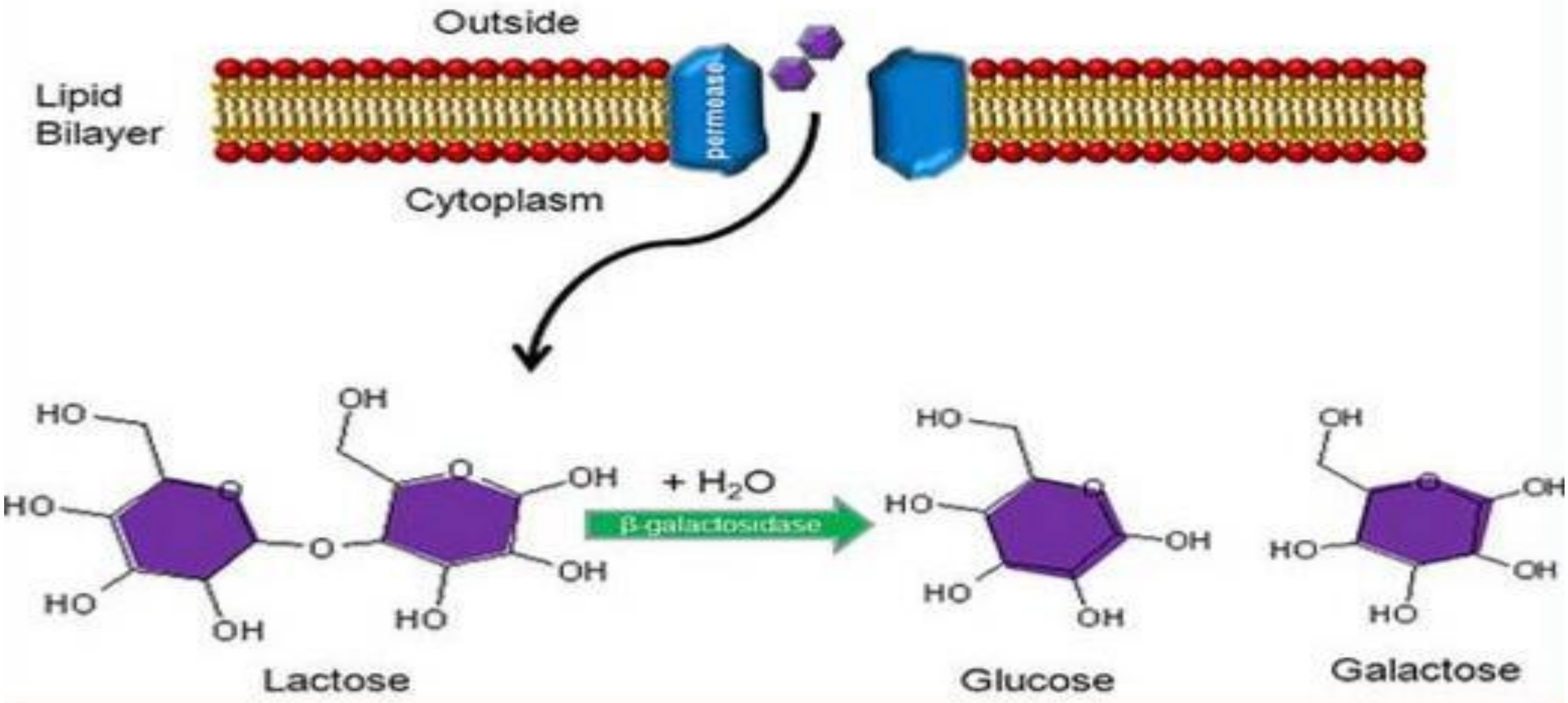
[note: facilitates the transport of B – galactosides (such as : lactose)]

- Uptake of lactose from the environment

Using lactose takes two proteins



Lactose metabolism in *E. coli*



3. Lac A

- Gene codes for B – galactoside permease(not fully understood)
- Transfers an acetyl group from acetyl Co-A to B – galactosides(specific function remain unclear)
- Help to clean up any toxic metablic byproduct of lactose Metabolism.

[Note: lac operon provides the necessary genes and enzymes for the uptake the Metabolism of lactose and other B – galactosides in bacteria like E.coil.

- Terminator: Represents the endpoint of the Lac operon gene segments.

Regulatory gene:

1. Promoter –

- Binding site of RNA polymerase(initiating Transcription).
- Located upstream(facilitates the Binding of RNA pol.

2. Operator –

- Negative regulatory site situated between P → structural gene
- Lac repressor protein binds to the operator, preventing RNA pol. From transcribing the structural gene.

3. Lac I (Repressor) Gene –

- Lac I gene codes for the Lac operon repressor protein(have their own promoter and operator).
- Has its own promoter and terminator.

a. Tetramer composed

b. 38 kD each

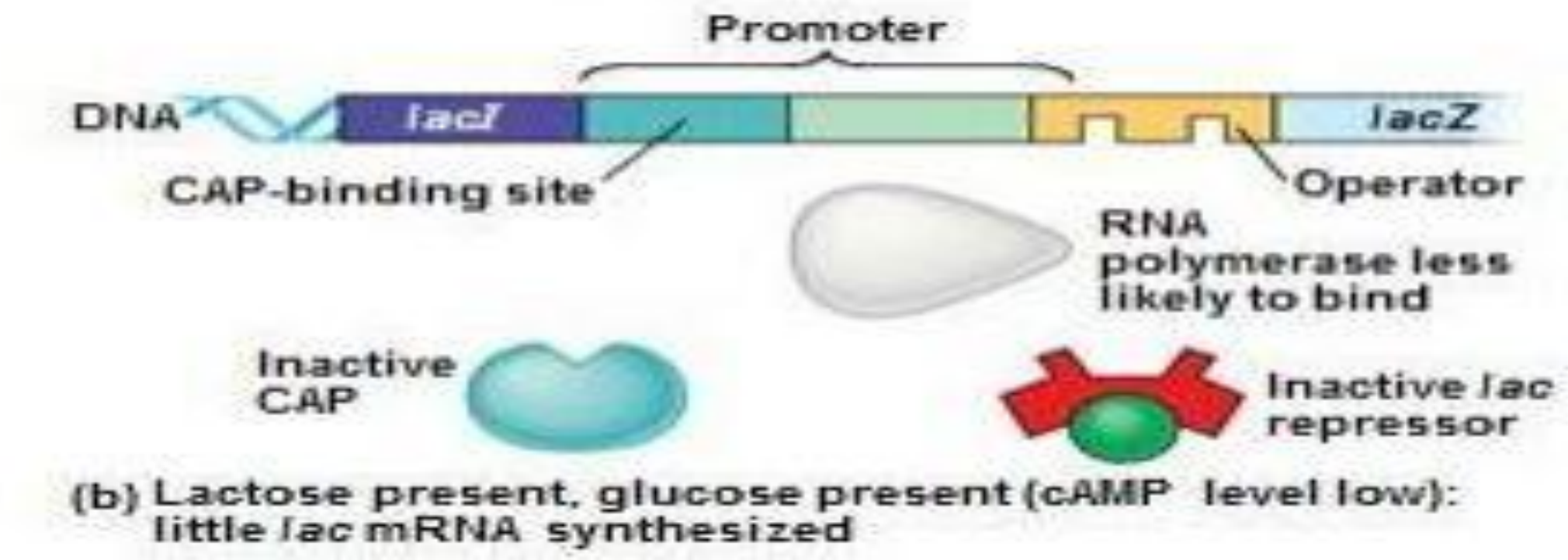
4. CAP(Catabolism Activator Protein Binding Site)

Note: acts as a glucose sensor

- CAP is Regulated by cyclic AMP(cAMP), a molecule signals low glucose levels.
- Glucose level drop, cAMP binds to the CAP changing it's shape(so it can bind to DNA and promote transcription.

Regulatory of Lac Operon:

1. Positive Regulation/Control:



2. Negative Regulation/Control: