lac Operon

"The lac operon is an operon required for the transport and metabolism of lactose ... It consists of three adjacent structural genes, a promoter, a terminator, and an operator. The lac operon is regulated by several factors including the availability of glucose and of lactose."

–Wikipedia

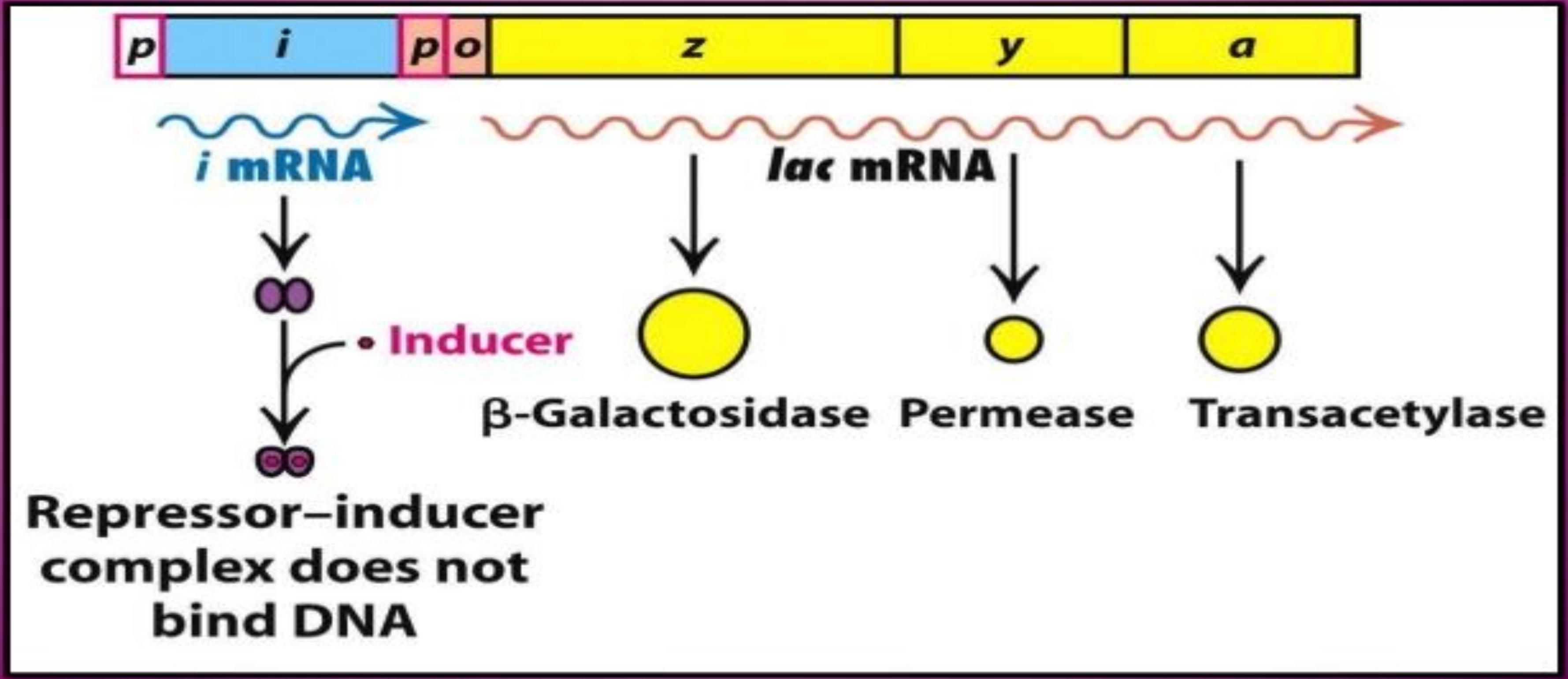
INTRODUCTION

- *Operon* is operating units which can be defined as the cluster of genes located together on the chromosomes & transcribed together.

- It is group of closely linked *structure genes* & associated *control gene* which regulate the metabolic activity.

- All the genes of an operon are coordinately controlled by a mechanism 1st described in *1961* by *Francois Jacob & Jaques Monod* of the Pasture institute of Paris.

Operon model



Designation of gene	Codes for enzyme	Function of the enzyme
lac Z	β-galactosidase	Breaks down lactose into glucose & galactose.
lac y	galactose permease	This protein, found in the E.coli cytoplasmic membrane, actively transports lactose into the cells
lac a	Thio-galactoside trans acetylase	The function of this enzyme is not known. It is coded for by the gene lacA.

Element	**Purpose**
Operator (lacO)	Binding site for repressor
Promoter (lacP)	Binding site for RNA Polymerase
Repressor	Gene encoding the lac repressor protein. Binds to DNA at the operator & blocks binding of RNA Polymerase at the promoter.
lacI	Controls production of the repressor protein

FUNCTIONING OF *LAC* OPERON

- In the absence of lactose(inducer), the regulator gene produce a repressor protein which bind to the operator site & prevent the transcription as a result, the structural gene do not produce mRNA & the proteins are not formed.

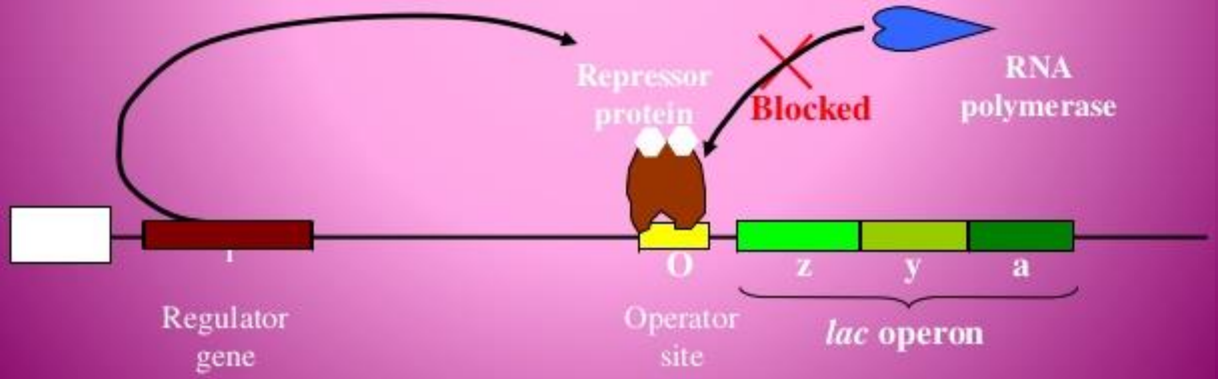
- When lactose(inducer), introduce in the medium, binds to the repressor the repressor now fails to binds to the operator.

- Therefore the operoter is made free & induces the RNA polymerase to bind to the initiation site on promoter which results in the synthesis of *lac* mRNA.

- This mRNA codes for three enzyme necessary for lactose catabolism.

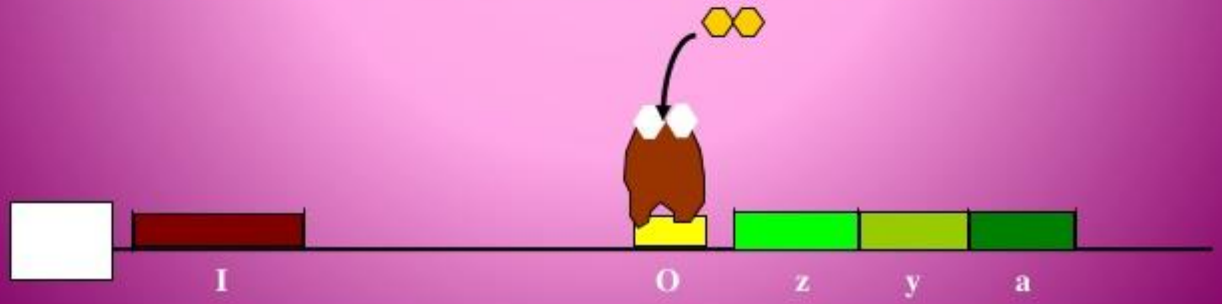
1. When lactose is absent

- A repressor protein is continuously synthesised. It sits on a sequence of DNA just in front of the *lac* operon, the **Operator site**
- The **repressor protein** blocks the **Promoter site** where the RNA polymerase settles before it starts transcribing



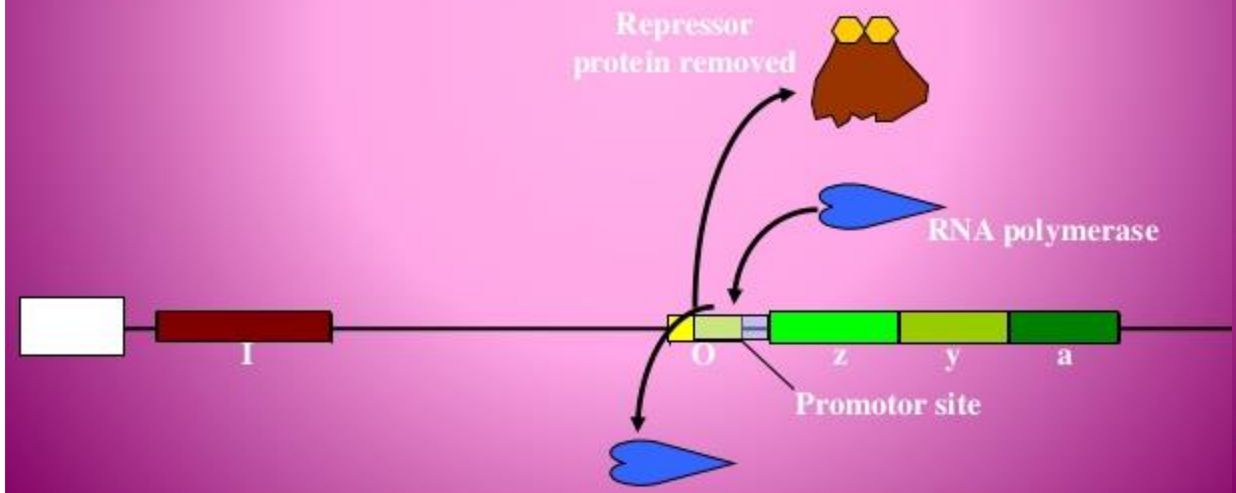
2. When lactose is present

- A small amount of a sugar allolactose is formed within the bacterial cell. This fits onto the repressor protein at another active site (**allosteric site**)
- This causes the repressor protein to change its shape (a **conformational change**). It can no longer sit on the operator site. RNA polymerase can now reach its promoter site



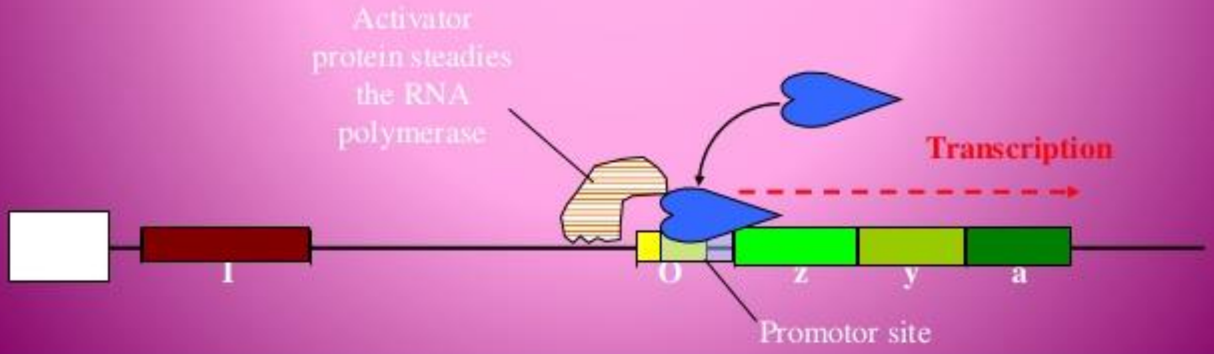
3. When both glucose and lactose are present

- When glucose and lactose are present RNA polymerase can sit on the promoter site but it is unstable and it keeps falling off.



4. When glucose is absent and lactose is present

- Another protein is needed, an **activator protein**. This stabilises RNA polymerase.
- The activator protein only works when glucose is absent
- In this way *E. coli* only makes enzymes to metabolise other sugars in the absence of glucose



Summary

Carbohydrates	Activator protein	Repressor protein	RNA polymerase	lac Operon
+ GLUCOSE + LACTOSE	Not bound to DNA	Lifted off operator site	Keeps falling off promoter site	No transcription
+ GLUCOSE - LACTOSE	Not bound to DNA	Bound to operator site	Blocked by the repressor	No transcription
- GLUCOSE - LACTOSE	Bound to DNA	Bound to operator site	Blocked by the repressor	No transcription
- GLUCOSE + LACTOSE	Bound to DNA	Lifted off operator site	Sits on the promoter site	**Transcription**