M.Sc. Botany, Part-II

Paper – X, Cytogenetics

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Lac Operon

Operon- Jacob and Monod were the first to propose the concept of Operon model in 1961. An operon is as several distinct genes situated in tandem all controlled by a common regulatory region .An operon consists of repressor, promoter, operator and structural gene. The message produced by an operon is polycistronic because the information of all the structural genes are present on the single molecule of mRNA.

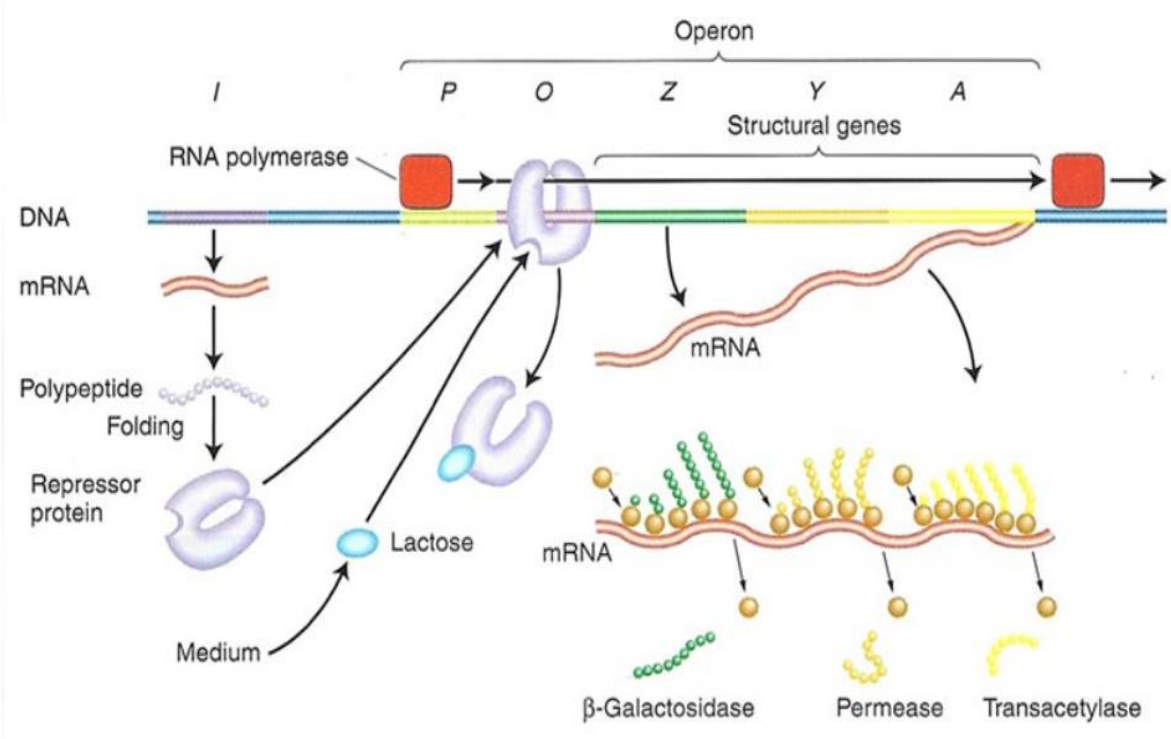
Lac Operon:-

The regulatory mechanism of Operon responsible for the utilisation of lactose as a carbon source is called the Lac Operon. Lactose is disaccharide which is composed of glucose and galactose.

The lactose utilizing system consist of two types of components, the structural genes(Lac Z, Lac Y and Lac A) the products of which are required for transport and metabolism of lactose and regulatory genes (the Lac I, the Lac O and the Lac P). These two components together comprises the Lac Operon.

Some important features of Operon-

- It provides a mechanism for the coordinate expression of structural genes controlled by regulatory genes.
- It shows polarity i.e. the genes Z, Y and A synthesise equal quantities of three enzymes β- galactosidase (by Lac Z), permease (by Lac Y) and acetylase(by Lac A).



Diagrammatic representation of Lac Operon.

The Structural Genes:-

The structural genes form one long polycistronic mRNA molecule. The number of structural gene corresponds to the number of proteins. Each structural gene is controlled independently, and transcribe mRNA molecules separately. This depends on substrates to be utilise. For example in Lac Operon three structural genes (Z, Y and A) are associated with lactose utilisation. B-galactose in the product of Lac Z that cleaves β-1, 4 linkage of lactose and release the free monosaccharides. His enzyme I a tetramer of 4 identical subunits. Ach with molecular weight of 1, 16, 400. The enzyme permease (a product of Lac Y) facilitates the lactose to enter inside the bacteria. Its molecular weight of 46,500. The enzyme transacetylase (3000 MW) is a product of Lac A.

The lac operon consists of a promoter(P) and an operator (O) together with the structural genes. The initiation codon of Lac Z is T, A, C that corresponds to AUG mRNA. It is situated 10 base pair away from the end of operator genes.

The Operator Genes:-

The operator genes is about 28 bp in length present adjacent to Lac Z genes. The operator overlaps the promoter region. The Lac repressor protein bind to the Lac operator and form an operator-repressor complex which in turn physically blocks the transcription of Z, Y, A genes by preventing the release of RNA polymerase to begin transcription.

The Promoter Genes:-

The promoter genes is about 100 nucleotides long and continuous with the operator gene. These nucleotide sequence of the control region of Lac Operon. The promoter gene lies between the operator gene and regulator gene. Like operators the promoter region consists of palindromic sequence of nucleotide.

These palindromic sequences are recognised by such protein that have symmetrically arrange subunit. This section of 2 fold symmetry is present on the CRP site that bind to a protein called CRP(cyclic AMP receptor protein). Its CRP bind to cAMP (cyclic AMP found in E. coli and other organism) molecule and form a CMP – CRP complex. This complex is required for transcription. It binds to promoter and enhances the attachment of RNA polymerase to the promoter. Therefore, it increases transcription and translation process.

The Repressor (Regulator) gene:-

Repressor gene determines the transcription of structural gene. It is of two types:-

1. Active repressor
2. Inactive repressor

It codes for amino acid of a defined repressor protein. After synthesis the repressor molecules are diffused from the ribosome and bind to the operator in the absence of inducer. Finally the path of RNA polymerase is blocked and mRNA is not transcribed. As a result no protein synthesis occurs. This type of mechanism occurs in the inducible system of active repressor.

Moreover when an inducer (Lactose) is present it binds to repressor protein and forms an inducer-repressor complex. This complex cannot bind to the operator. Due to formation of complex the repressor undergoes changes in confirmation of shape and become inactive. As a result the structural gee can synthesise the polycistronic mRNA and the later synthesises enzymes (protein). Apart from that, in the reversible system the regulator gene synthesise repressor protein that is inactive and therefore fails to bind two operator. As a result protein are synthesised by the structural gene. However, the Repressor proteins can be activated in the presence core repressor. The core repressor together with repressor protein forms the repressor-core repressor complex. This complex bind to operator gene and block protein synthesis.