Regulation of Gene Expression: Gene expression is the mechanism at the molecular level by which a gene is able to express itself in the phenotype of an organism, that consists of synthesis of specific RNAs, polypeptides, structural proteins, proteinaceous biochemicals or enzymes, which control the structure or functioning of specific traits. The formation of RNAs from genes is called transcription. Certain genes form rRNAs, tRNAs & other small RNAs. Other genes transcribe mRNAs which contain coded information for synthesis of polypeptides. mRNAs carries the information to the ribosomes & translates it into amino acid sequence of a polypeptide with the help of tRNAs. The polypeptide expresses the gene by forming a (a) structural protein, (b) proteinaceous biochemical or (c) Enzyme.

The control over the functioning of genes is called regulation of gene expression, which can be exerted at four levels:-

(i) Transcriptional level during formation of primary transcript
(ii) Processing like splicing, terminal additions or modifications.
(iii) Transport of RNAs from nucleus to cytoplasm, &
(iv) Translation level.

Regulation takes place under negative or positive control besid

(I) Inducible — It is a regulation when the genes are switched on in response to the presence of a chemical substance or inducer which is required for the functioning of the product of gene activity.

② Constitutive — A regulation is absent. The genes & hence the enzymes remain operational throughout.

③ Repressible — It is regulation in which the product of gene activity, if already present, inhibits or represses the activity of the said gene.

Regulation can be under Negative control, when the product of gene activity shuts off the expression of genes under its control.
Regulation can be under positive control, when the product of regulatory gene activates expression of genes under its control.
Thus gene expression is regulated.

Lac Operon : An operon is a part of genetic material or DNA, which acts as a single regulated unit having one or more structural genes, an operator gene, a promoter gene, a regulator gene, a repressor & an inducer. Operator, promoter & regulator genes constitute the regulatory region. Operon systems are common in prokaryotes. Lac Operon is the first operon, discovered by Jacob and Monad in 1961.
Lac Operon is an inducible operon system, that is a regulated unit of genetic material which is switched on in response to the presence of a chemical, that consists of:

① Structural Genes — which actually synthesize mRNAs

that control metabolic activity of cytoplasm through the formation of protein or enzyme over the ribosomes.

The lactose or lac-operon of E. coli contains three structural genes — lac Z, lac Y & lac A, which transcribe a polycistronic mRNA molecule that helps in the synthesis of three enzymes — (i) β-galactosidase for hydrolysing lactose or galactoside

(ii) lactose or galactoside permease for allowing entry of lactose from outside

(iii) thiogalactoside acetylase or transacetylase for metabolising toxic thiogalactosides which are also allowed entry by lactose permease.

(b) Operator Gene — which directly controls the synthesis of mRNAs over the structural genes. It is switched off by the presence of a repressor. An inducer can take away the repressor & switch on the gene.

(c) Promoter Gene — acts as an initiation signal which functions as recognition centre for RNA-polymerase, provided the operator gene is switched on. When the operator gene is functional, the polymerase moves over it & reaches the structural genes to perform transcription.

(d) Regulator Gene — called as i-gene in lac-operon, because it produces an inhibitor or repressor, which binds to operator gene & stops the working of it. Thus the regulator gene exerts a negative control over the working of structural genes.

Inducer is a chemical, which after coming in contact

with the repressor, changes the latter into non-DNA binding state so as to free the operator gene. The inducer for lac-operon of E. coli is lactose.

Catabolic activator protein (CAP) is an activator that exerts a positive control in lac-operon because in its absence RNA polymerase is unable to recognise promoter gene. CAP activates the lac genes only when glucose is absent.

RNA polymerase is recognised by promoter gene, that passes over the freed operator gene, & then catalyses transcription of mRNAs over the structural genes. The mRNAs pass into the cytoplasm & form particular proteins or enzymes. Out of the three enzymes produced by lac-operon, lactose-permease is meant for bringing lactose inside the cell. β-galactosidase or lactase breaks lactose into glucose and galactose.

The lac-operon will not remain operative indefinitely despite presence of lactose in the external environment. It will stop its activity with the accumulation of glucose and galactose in the cell beyond the capacity of the bacterium for their metabolism. Or when all lactose molecules are used up, inactive repressor turns active, attaches itself to operator & finally switches off the operon.