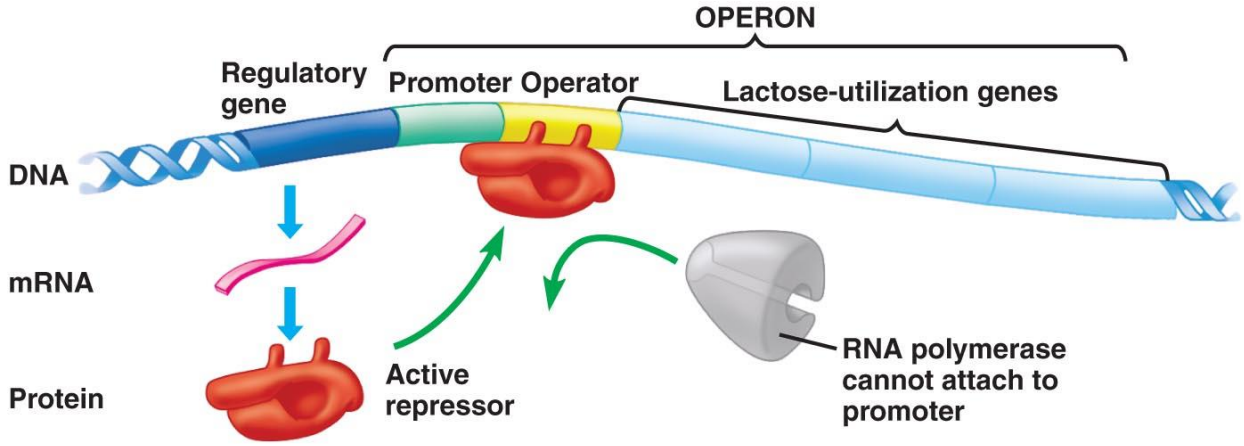
Gene Expression Part III: Operons

The regulation of gene expression at the level of DNA transcription is important for both the promotion and cessation of expressing particular genes. An **operon** is a sequence of the genetic code wherein a number of structural genes are grouped into an expressible unit with an operator/ promoter region for regulation of gene expression. When the gene is transcribed only in the presence of a particular substance, it is called an **inducible operon.**

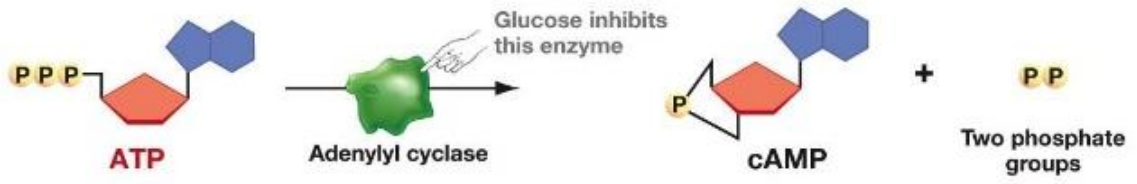
In the bacterium *E. coli*, three enzymes are responsible for the breakdown of lactose, a disaccharide, into usable monosaccharides of glucose and galactose for energy metabolism. These enzymes are β-galactosidase, β-galactoside permease, and β-galactoside transacetylase, which must all be operational in order to fully digest the lactose sugar. Because any single mutation that prevents the function of these enzymes will result in the uninterrupted over-production of the gene product, these are considered constitutive mutants.



Operon turned off (lactose absent)

The **lac operon** is controlled as low levels of glucose result in higher concentrations of cAMP (the metabolite which accumulates during energetic expenditure), which initiate the transcription process by binding to the promoter site of the operon and promoting RNA Polymerase activity. cAMP is referred to as the **effector molecule** in this system, because it concentration regulates the ability of gene expression to occur. Therefore, as glucose metabolism increases to support increased energy use, the lower concentration of glucose results in a higher concentration of cAMP, and more lactose must be broken down to refuel the glucose store. It is a self-regulating, inducible system.

Image credit: slideshare.net



In a **repressible operon**, the effector molecule is considered a co-preprocessor, binding to the repressor protein so that it can bind the operator and prevent RNA polymerase activity, essentially blocking the process of transcription.

In the **trp operon**, normal gene expression produces three enzymes (anthranilate synthetase, glycerolphosphate synthetase, and tryptophan synthetase) that are required for the synthesis of tryptophan from precursors within the cell. The effector molecule in this example is tryptophan itself, and its binding results in the attenuation/ cessation of gene expression. When tryptophan levels are adequate, there is no need for endogenous synthesis (referring to the amino acid's ability to be produced by the body). Tryptophan, therefore, is considered a non-essential amino acid in terms of human nutrition needs.

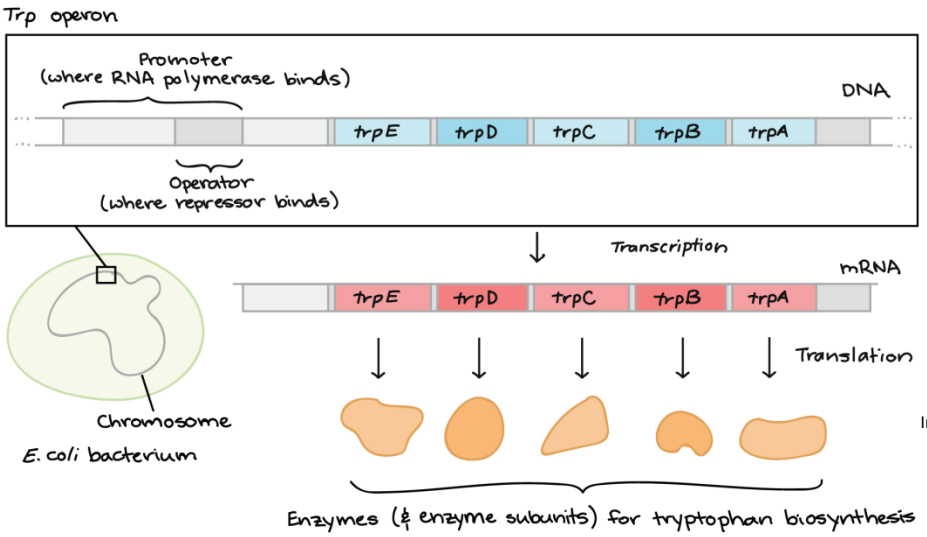


Image credit: Khan Academy

This pathway is also an example of **feedback inhibition**, whereby the final product of a metabolic pathway is used to attenuate the pathway at its outset.

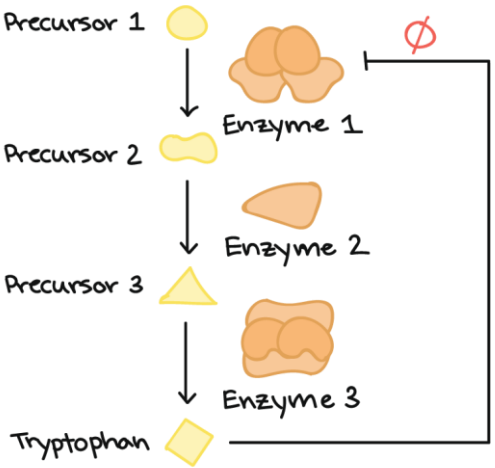


Image credit: Khan Academy