An operon is a cluster of genes whose jobs are to carry out one specific role; the lac operon is a cluster of genes that regulate the metabolism of the sugar lactose. In the case of the bacterium *Escherichia coli*, the lac operon in the absence of lactose stitches "off." Cellular biology of most life is extremely efficient—the regulation of metabolism on the cellular, biochemical level is no different. When lactose is absent in the bacterium there is no need to carry out lactose metabolism, thus the bacterium will begin a cascade that prevents metabolism of lactose starting with a repressor protein. Lactose metabolism is regulated by gene expression, so when lactose, an inducer of the repressor protein, is absent the repressor protein is able to bind to the operator region of the lac operon. When the repressor protein is bound to the operator region, RNA polymerase is unable to bind to the promoter region of the lac operon region in bacterial DNA. When RNA polymerase is unable to bind to the promoter region, the lac operon is unable to transcribe the operon, therefore translation cannot occur. When the operon is unable to operate, lactose metabolism is deactivated. The lac operon is very efficient at carrying out its job when necessary, as well as efficient for not carrying out its sole job due to the bacterium shutting off the cellular processes that are carrying out the actual metabolism of lactose.

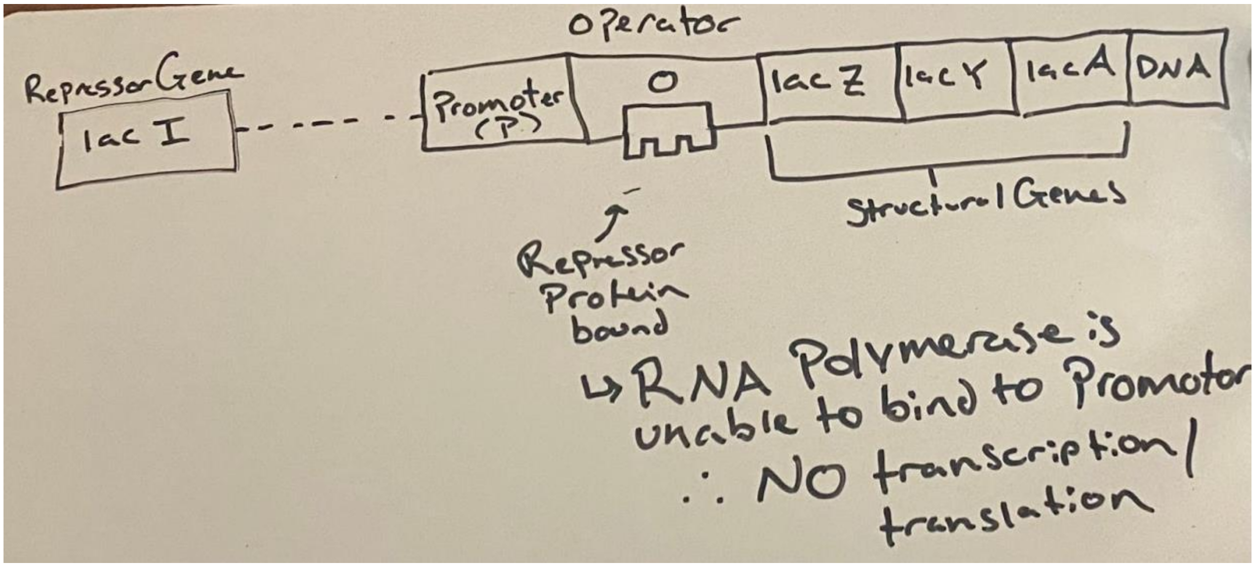
Now when lactose is present it is likely for the bacterium to want to metabolize and utilize the energy trapped within the bonds of the sugar. When lactose is present in the bacterium, lactose is able to bind to the repressor protein. Due to the repressor protein being an allosteric protein—a protein that changes shape when something is bound to it— the inducer, lactose, is able to deactivate the repressor. When the repressor changes shape it is unable to continue blocking RNA polymerase from binding to the promoter region. When the promoter region is open for RNA polymerase to bind, transcription of the lac operon is then initiated. The lac operon is an inducible operon. Lac I gene produces the repressor protein, the promoter region initiates transcription, the operator regulates gene expression of the lac operon, the lac Z produces permease, the lac Y encodes for β-galactosidase, and the lac A gene is not absolutely necessary for lactose metabolism. Lac Z, Y, and A are structural genes of the lac operon.

In the absence of glucose, gene regulation of the lac operon begins with adenylyl cyclase. Adenylyl cyclase's job is to break down ATP and convert it into cAMP. When cAMP levels are high in the bacterium, cAMP is able to bind to cAMP receptors (CRP). When cAMP is bound to CRP, CRP is structurally changed so CRP is now able to bind to the promoter region. When the CRP complex is bound to the promoter region of the lac operon, transcription of genes is enhanced for CRP enhances the activity of RNA polymerase.

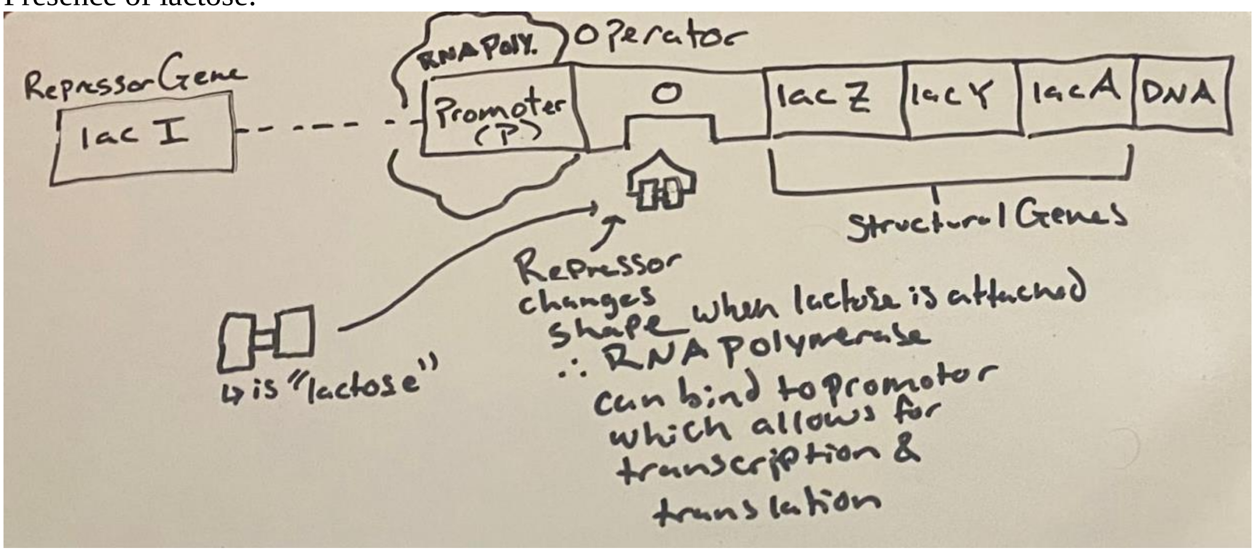
In the case when there is a presence of both glucose and a presence of lactose, the bacterium will prefer to metabolize glucose. The cellular level cascade is activated that will favor the metabolism of glucose rather than lactose. When glucose levels are high, adenylyl cyclase levels are reduced by the bacterium. When adenylyl cyclase levels are decreased, ATP is unable to be converted into cAMP. When there is no cAMP to bind to CRP, CRP is unable to change shape to be able to bind to the promoter region. When CRP is unable to bind to the promoter region, transcription of the lac operon genes is not enhanced. Thus, high glucose levels, despite the presence of lactose, lactose metabolism is not enhanced and instead the process of glycolysis takes over, for the cell prefers the more accessible energy source—glucose.

Gene expression of the lac operon regulation takes place at the transcriptional level. At every instance—absence of lactose, in the presence of lactose, in the absence of glucose, and finally presence of glucose and the presence of lactose—regulation involves regulating the genes of the bacteria's DNA. The central dogma of biology is a concept that grasps the idea that DNA is converted into RNA by transcription and that RNA is converted into polypeptides via translation. Most cellular processes of organisms are extremely efficient; thus, regulation of biomolecules/metabolism would occur from which they originate from—deoxyribose nucleic acid—which in turn regulates every other subsequent step in the central dogma after DNA.

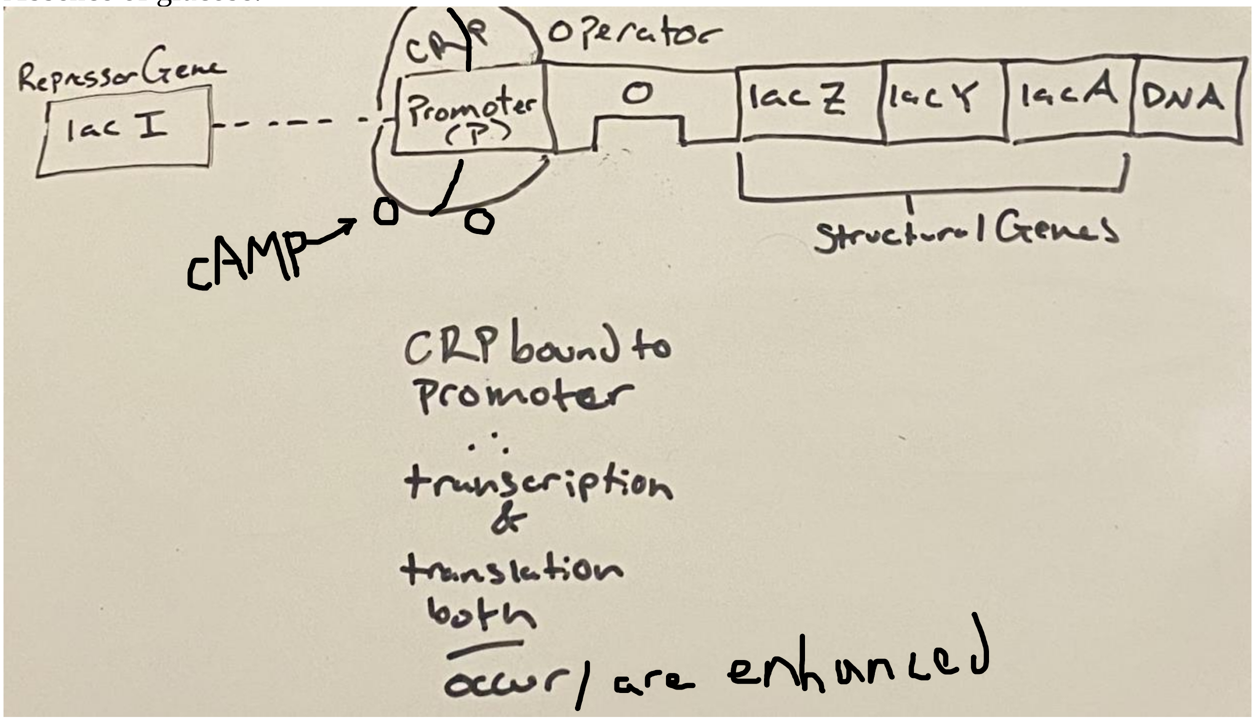
Absence of lactose:



Presence of lactose:



Absence of glucose:



Presence of glucose and the presence of lactose