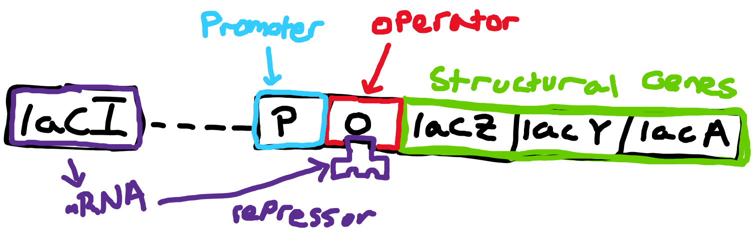
Old Dominion University/BIOL294-Genetics/Rinehart-Kim/Module 6/Lac Operon Regulation

Draw and describe the regulation of the *Escherichia coli* lac operon in the following situations:

1. **In the absence of lactose (disregard presence or absence of glucose).**

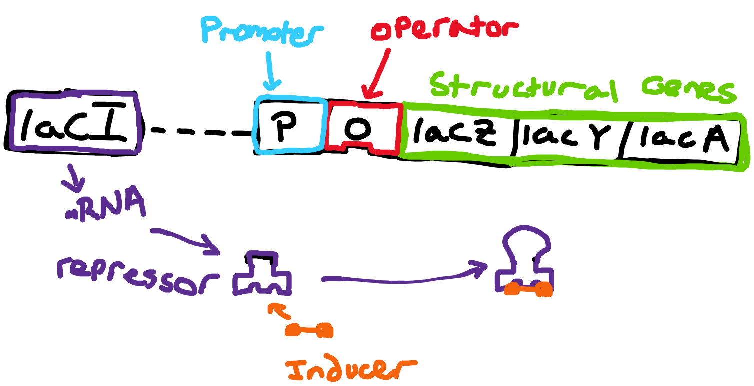


lac I is the repressor gene, which gets transcribed into mRNA and translated into a repressor protein. This is an example of a trans factor–something that can move through the cytoplasm to inhibit the expression of a gene. Without the presence of lactose, the repressor protein is bound to the operator and the structural genes (lac Z, lac Y, and lac A) cannot be expressed to create lactase–the enzyme responsible for breaking down lactose.

The promoter region is where RNA polymerase binds to transcribe the lac gene into a lac mRNA molecule. Since there is a repressor protein, that was coded by lac I, bound to the operator (O region of the gene) RNA polymerase is not able to access the structural genes and lactase is not produced. As the cell asks itself, why create a protein to breakdown a molecule (lactose) that isn't there?

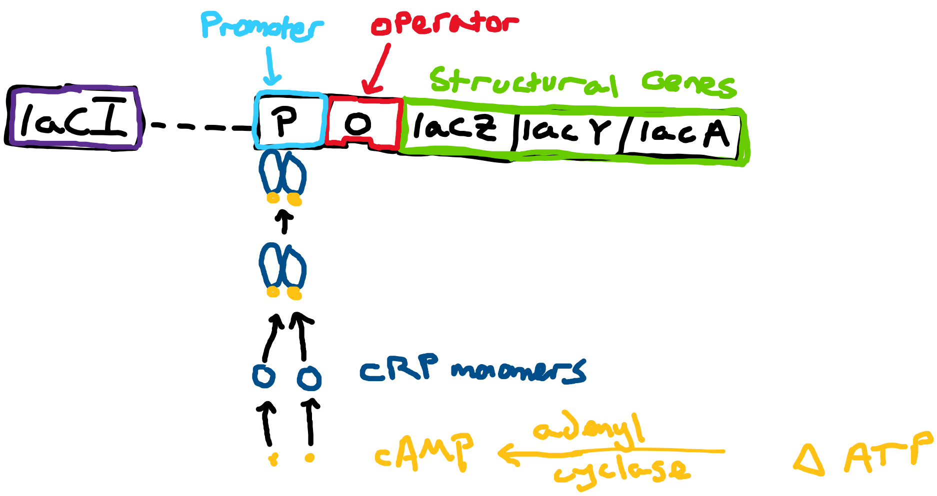
Ultimately, when there is no lactose in the cell, lac I is transcribed into mRNA that is translated into a repressor protein that stops RNA polymerase from accessing the structural genes that code for lactase, which is used to break down lactose into glucose and galactose.

2. **In the presence of lactose (disregard presence or absence of glucose).**



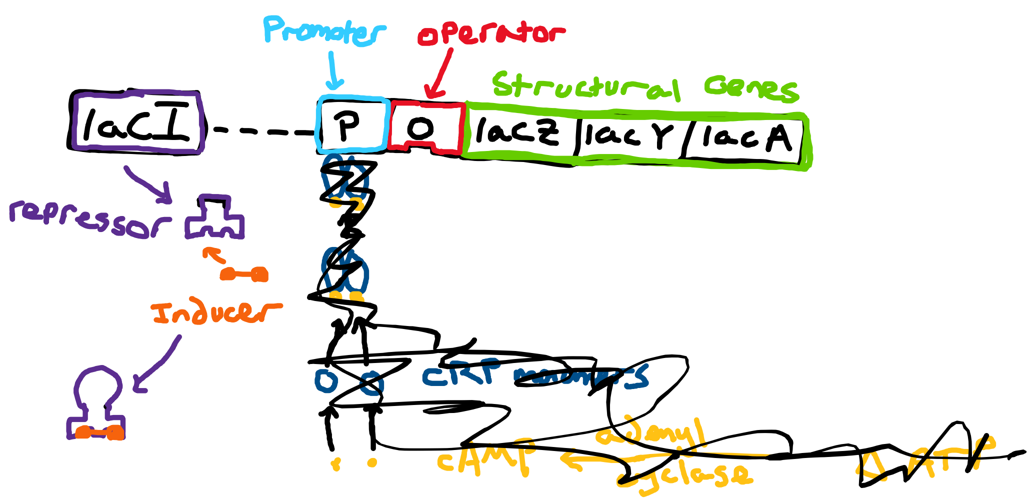
When lactose is present in the cell, it acts as an inducer that prevents the repressor protein from binding to the operator gene. This allows the RNA polymerase to transcribe the lac gene to form the lac mRNA. The lac mRNA is responsible for coding different proteins: lac Z codes for the ß-galactosidase, lac Y creates permease, and lac A codes for transacetylase. The purpose of the inducer is to allosterically attach to the repressor protein and alter its shape. This prevents the repressor protein from binding to the operator and RNA polymerase is able to express the structural genes of the lac gene.

3. **In the absence of glucose (disregard the presence or absence of lactose).**



In the absence of glucose, adenyl cyclase turns adenosine triphosphate (ATP) into cyclic AMP (cAMP), which can bind to cAMP receptor protein (CRP) and bind to the promoter region of the lac operon and promote the expression of the lac gene by RNA polymerase. This is to get all hands-on deck to provide as much energy for the cell as possible.

4. **In the presence of glucose AND the presence of lactose.**



When there is an abundance of glucose and lactose, the cell prefers the easier method of metabolism–glycolysis. This regulation of the prokaryote is done by limiting the number of adenyl cyclase's present. Based off the drawing for number 3, if there is no adenyl cyclase, no cAMP can be produced to change the shape of CRP monomers, which then cannot bind to the promoter region of the lac operon to promote the activity of RNA polymerase. However, when the glucose levels decrease, the prokaryote hires more adenyl cyclase's to turn ATP into cAMP and resume the production of lac mRNA. With the presence of lactose, which is an inducer, the repressor protein changes shape and is not able to bind to the operator gene and RNA polymerase is able to transcribe the lac gene.

5. **Finally, describe where in the process of gene expression (transcription, post-transcription, translation, post-translation) this regulation takes place.**

The process of this gene expression is regulated at the transcription level and because of this, gene expression is regulated at all levels. As mentioned in the previous questions, if transcription is not allowed to occur, then post-transcription, translation, and post-translation are all impacted. It is the domino effect of gene expression. DNA is the fundamentally most important part of all living things because it is the very instruction that creates it. Without DNA, no living thing would be here today. Therefore, this lac operon is regulated at the transcription level, which has an impact on all other following levels of gene expression. For example, the lac I codes for a protein that inhibits the continuation of lac gene expression.