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Genetics BIOL 294
Prof. Rinehart-Kim
Lac Operon
Due Date: 27MAR2023

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).*

In the absence of lactose the Lac Operon would be "off" as the there is no need for the gene to be made or turned "on".

The cell senses there is no lactose present. The cell gene LacI produces a *Trans* repressor that binds to the operator area of the gene and prevents RNA polymerase from binding to the promotor. Preventing RNA polymerase from transcribing DNA to mRNA and the cell from making the three enzymes for lactose utilization.

This is an example of negative or repressor. E. coli's lactose sensor sense there is no lactose for the gene to be turned "on" and a repressor protein would bind to the operator on DNA. Preventing the lactose enzymes to be made.

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

The lactose operon would be turned "on" as the cell sense there is lactose present. The presence of lactose would signal the cell to make a *Cis* inducer (allotactose) which binds to the repressor. Changing the shape of the repressor so it can no longer bind to the operator. The repressor removed, RNA polymerase can bind to the promoter and move down the DNA to make mRNA for the genes that code for the lactose enzymes.

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

If glucose is not present, this would increase the availability of adenylate cyclase, this increases the conversion of ATP to cyclic AMP (cAMP) will bind to cAMP Receptor Protein (CRP) also called Catabolite Activator Protein (CAP). This cAMP-CRP complex will bind to the CAP site on the gene. This causes the RNA polymerase to bind to the promotor and move down the DNA to make mRNA for the genes that code for the lactose enzymes.

This is an example of positive regulation as cAMP-CRP complex allows for the physical contact of RNA polymerase and to the promoter.

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

In the absence of glucose and the presence of lactose, the cAMP-CRP complex is formed and binds to the CAP site near the promoter region, and the lactose inducer binds to lactase repressor, releasing the repressor. Allowing RNA polymerase to bind and move down the DNA to make mRNA for the genes that code for the lactose enzymes.

The combination of these two events cAMP CRP complex binding to CAP site and the release of the repressor results in an even higher level of expression of the lactose genes than just the release of the repressor by the inducer.

Summary of Lac Operon Responses

Glucose: present or absence	Binding of CAP	Lactose: present or absence	Binding of Repressor	Level of Transcription
Present	Neg	Absence	Yes	No Transcription
Present	Neg	Present	Neg	Low Level transcription
Absence	Yes	Absence	Yes	No Transcription
Absence	Yes	Present	Neg	High level of Transcription

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

This process would occur at the transcription level. As DNA is being transcribed to RNA to be sent to the ribosomes to be translated into protein.

Lactase Enzymes

Structural Gene	Enzyme	Function
LacZ	Beta-galactosidase	Transforms the lactose into allolactose and also catalyzes the conversion of lactose to glucose and galactose
LacY	Permease	Membrane channel protein required to uptake lactose from the environment
LacA	Thiogalactoside transacetylase	Rids the cell of toxic thioglactosides that also get transported by LacY

1) absence of Lactose

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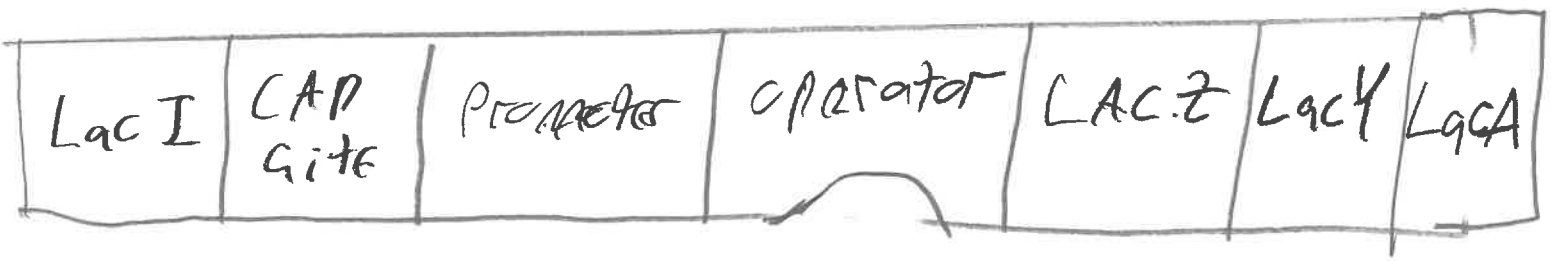
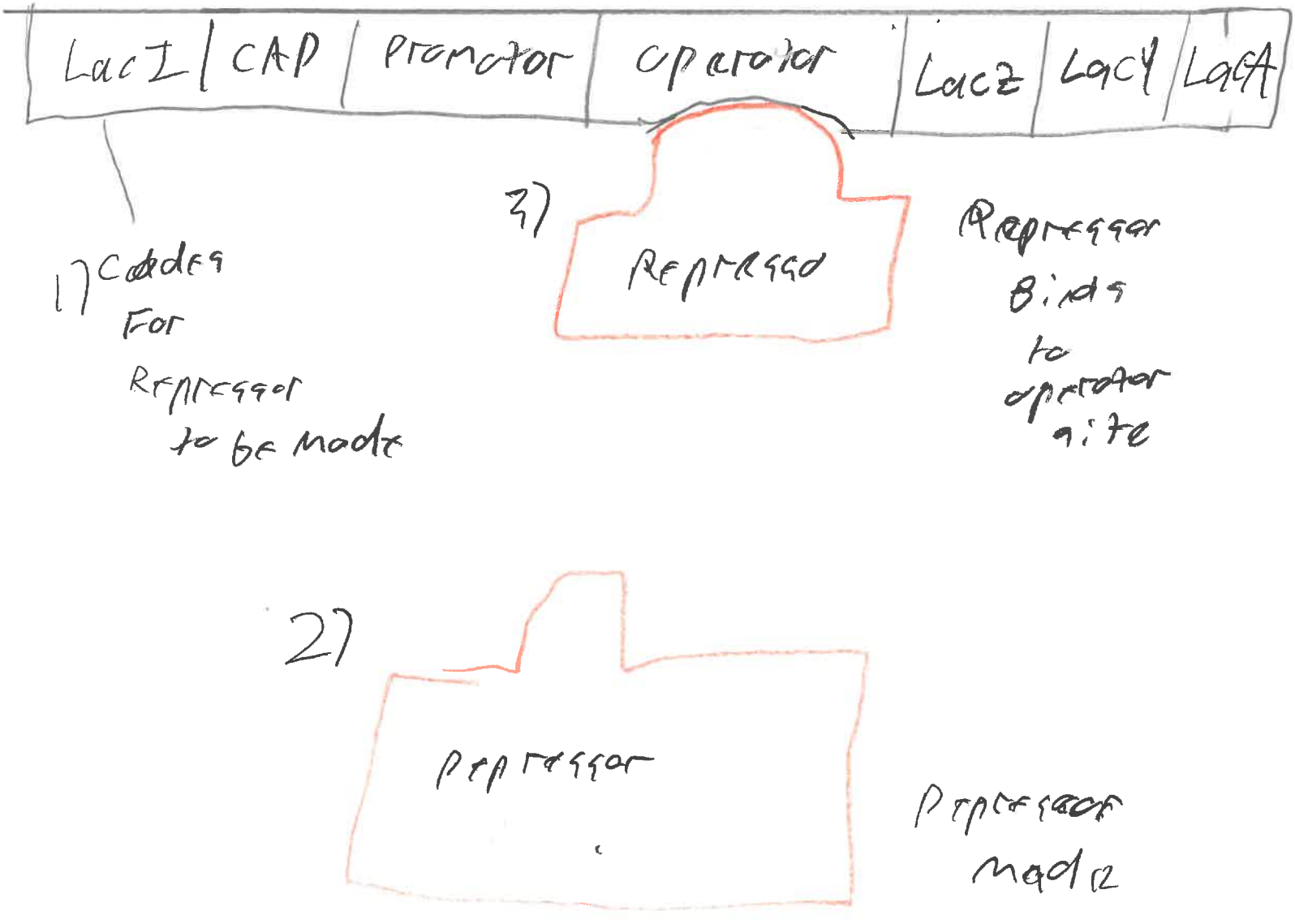
la

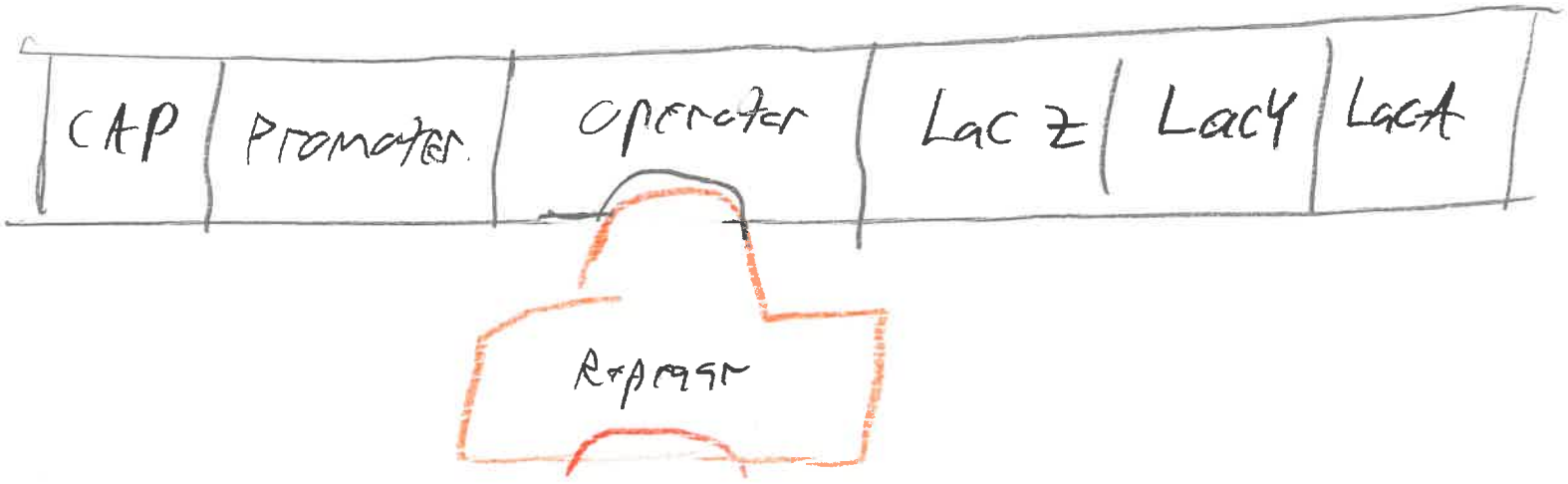


1) absence of Lactose

1b

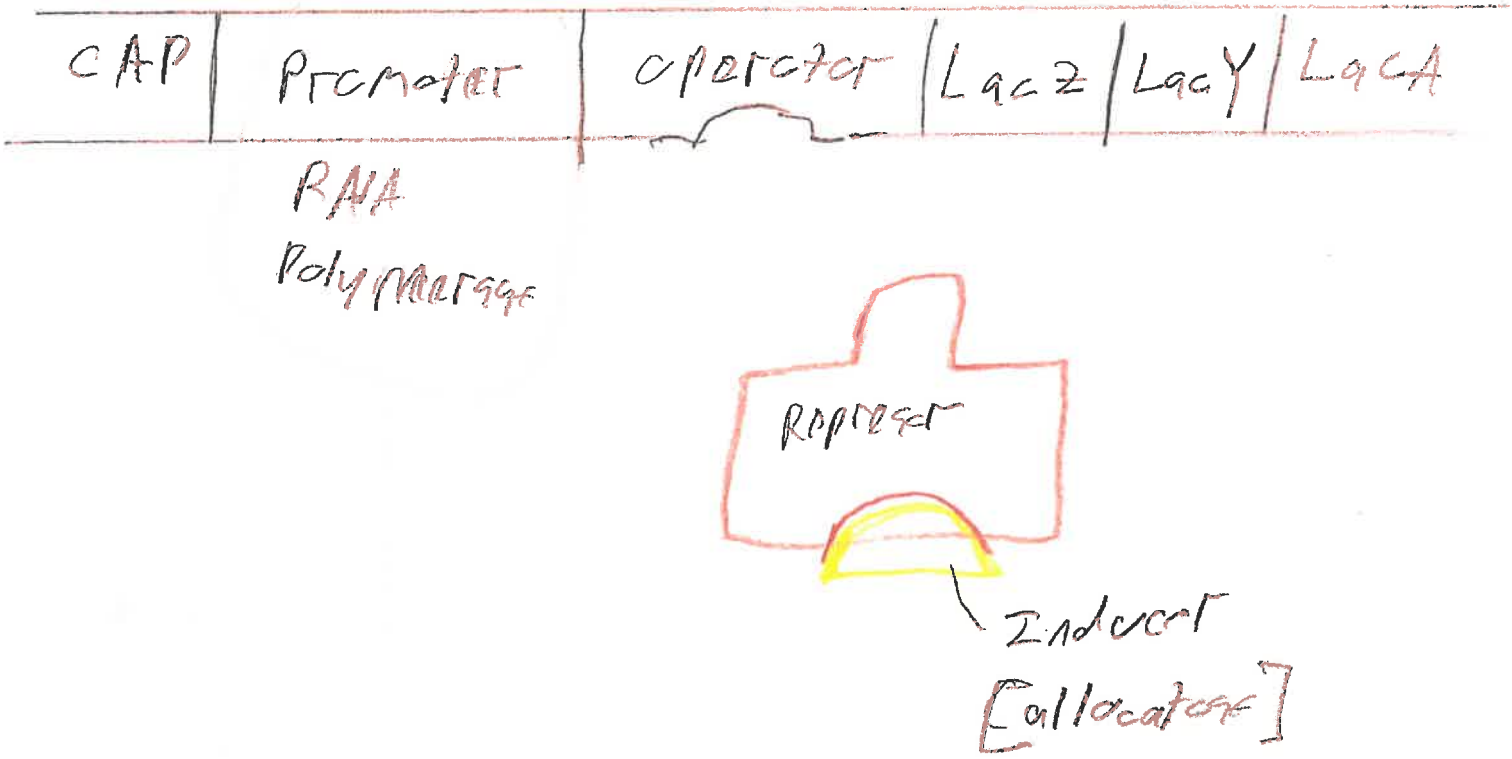


2A) Region of lactose



Presence of lactose

2B



1) The Inducer [allocatose] binds to Repressor.

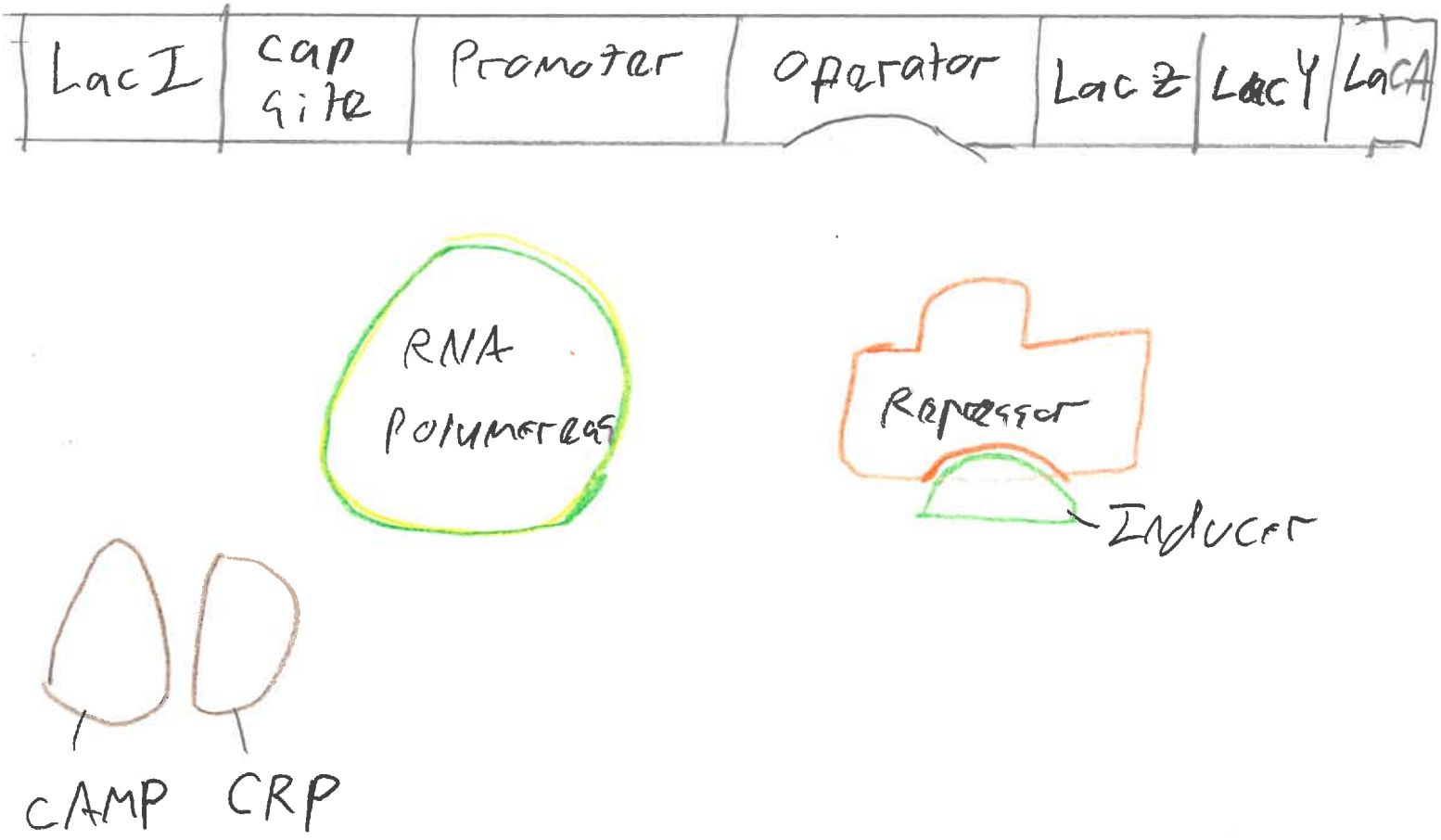
2) the repressor no longer fits in operator.

3) The repressor Release

4) As the Repressor is Released RNA polymerase is able to bind to the Promoter

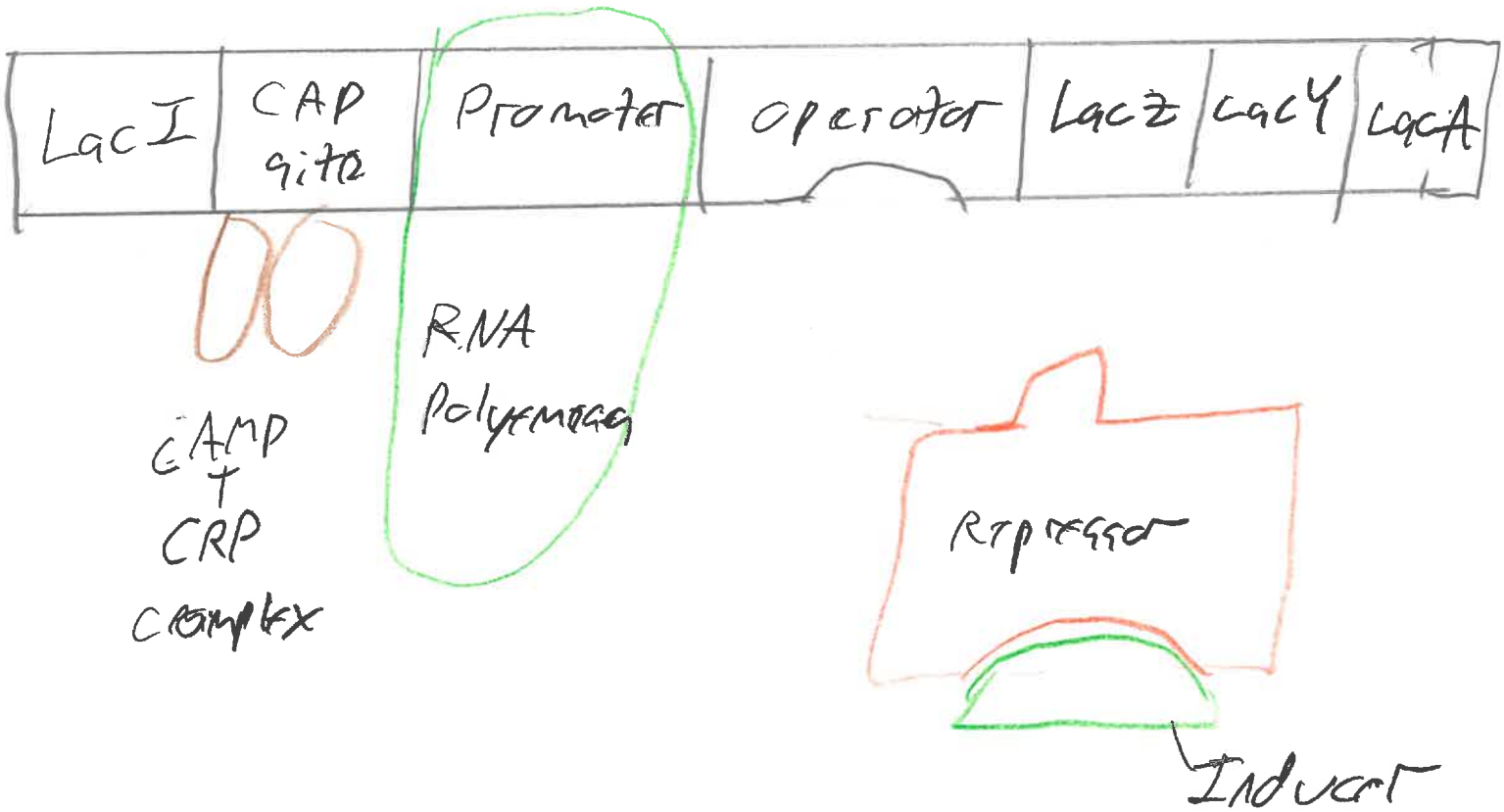
3) Presence of Glucose, Disregard of lactose

3a

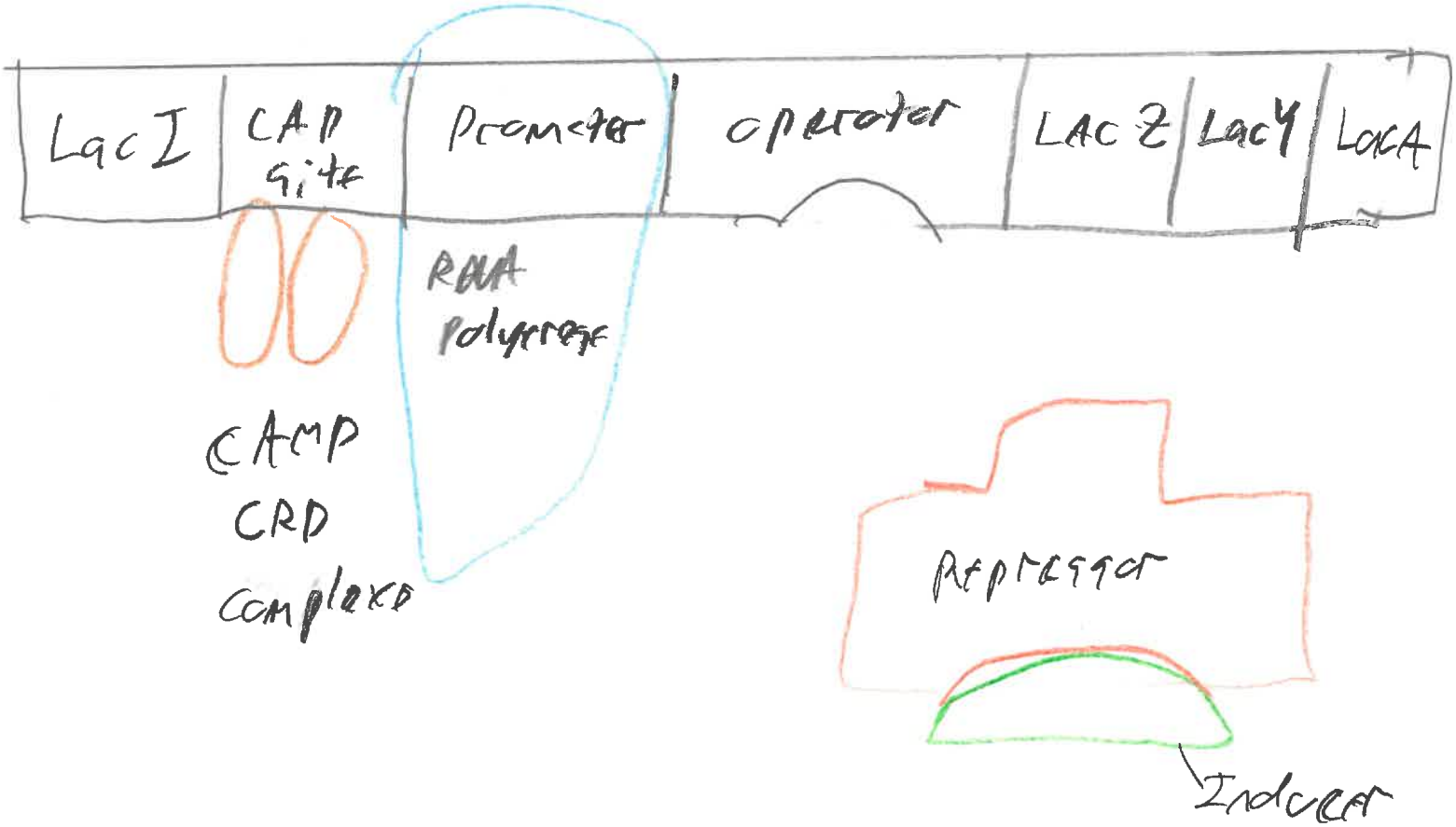


3 Presence of Glucose, Disregard of lactose

3b



4) Absence of Glucose Presence of lactose



Strange expression of lactose gene in the absence of glucose and presence of Lactose

References

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