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Lecture – 20

Gene concept, Lac & Trp operan

by

Dr. Praveen Kumar

*Asst. Prof. **GPB***

MSSSoA, CUTM, Odisha



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- The fine structure of gene deals with mapping of individual gene locus
- **Benzer** (1955) divided the gene into
- **Recon**- units of recombination
- **Muton** - units of recombination and
- **Cistron** -units of function within a gene



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REGULATION OF GENE EXPRESSION

- **Housekeeping genes or constitutive genes:** Genes that encode a product required in the maintenance of basic cellular processes or cell architecture
- **Constructive gene-** is an unregulated gene, whose expression is uninterrupted, in contrast to the regulated expression of a gene.
- **Regulator gene** – All gene not only specify the structure of enzyme but some of them also regulate expression of other genes



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Gene regulation in eukaryotes

1. Chromatin structure – Histones, CpG methylation
2. Transcription initiation – Promoters, Enhancers
3. Transcript processing and modification
4. RNA transport
5. Translation initiation and protein modification
6. Protein transport



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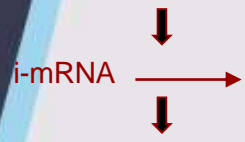
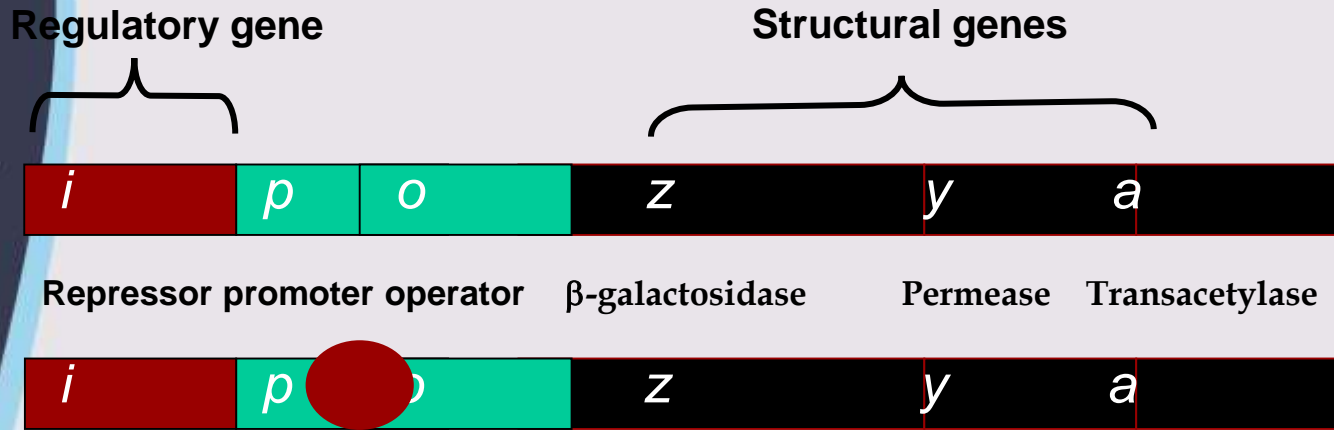
F. Jacob and J. Monod (1961) proposed **Operon concept**

- Gene regulation in prokaryotes and bacteriophages involves
- **Structural genes**
- **Operator**
- **Promoter**
- **Regulator genes**
- **Repressor proteins and**
- **Inducer**

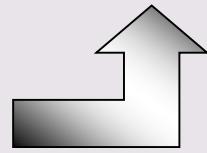


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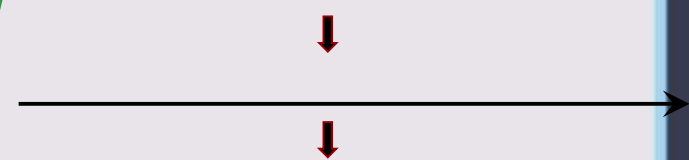
lac Operon model



Repressor

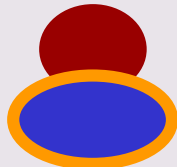
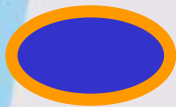


mRNA



β -galactosidase Permease Transacetylase

Inducer



Inducer-repressor complex
Cannot bind to operator



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Lac Operon of *E. coli*

- An operon refers to a group of closely linked genes which act together and code for various enzymes required for a particular biochemical pathway
- Lac operon consists of several components



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Structural genes

- structural genes
- ***z*** - codes for an enzyme β -galactosidase, converts lactose into glucose and galactose
- ***y*** - codes for an enzyme permease which facilitates the entry of lactose into the cell and
- ***a*** - specifies the enzyme thiogalactoside trans acetylase, which transfers an acetyl group from acetyl co-A to β -galactoside



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Four situations are possible

1. When glucose is **present** and lactose is **absent** the E. coli does **not** produce β -galactosidase.
2. When glucose is **present** and lactose is **present** the E. coli does **not** produce β -galactosidase.
3. When glucose is **absent** and lactose is **absent** the E. coli does **not** produce β -galactosidase.
4. When glucose is **absent** and lactose is **present** the E. coli **does** produce β -galactosidase.

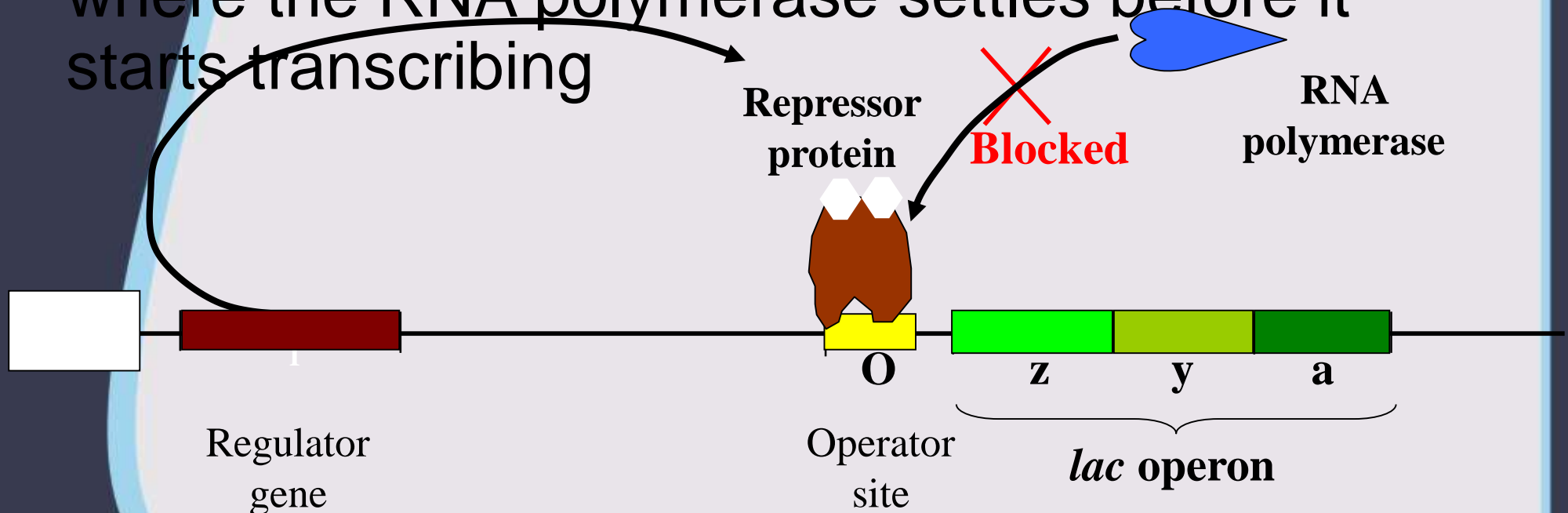


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1. When lactose is absent

- A repressor protein is continuously synthesised. It sits on a sequence of DNA just in front of the *lac* operon, the **Operator site**
- The **repressor protein** blocks the **Promoter site** where the RNA polymerase settles before it starts transcribing



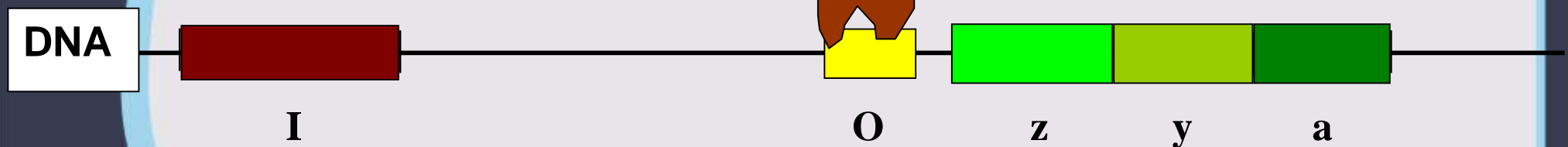


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2. When lactose is present

- A small amount of a sugar allolactose is formed within the bacterial cell. This fits onto the repressor protein at another active site (**allosteric site**)
- This causes the repressor protein to change its shape (a **conformational change**). It can no longer sit on the operator site. RNA polymerase can now reach its promoter site



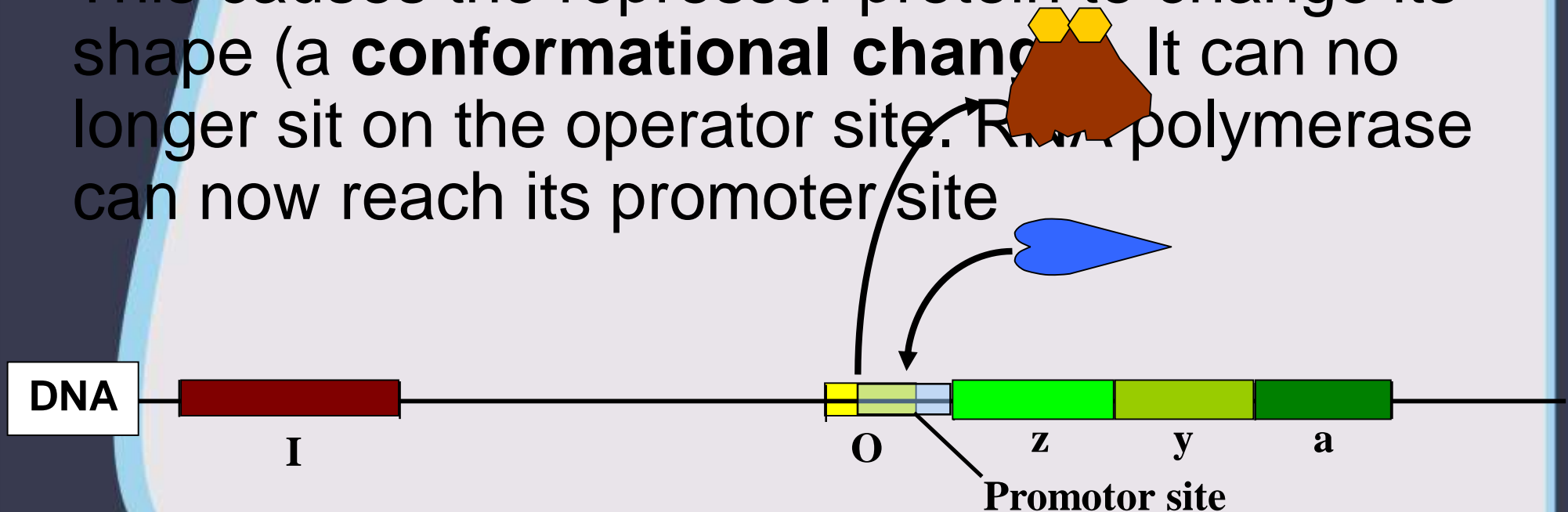


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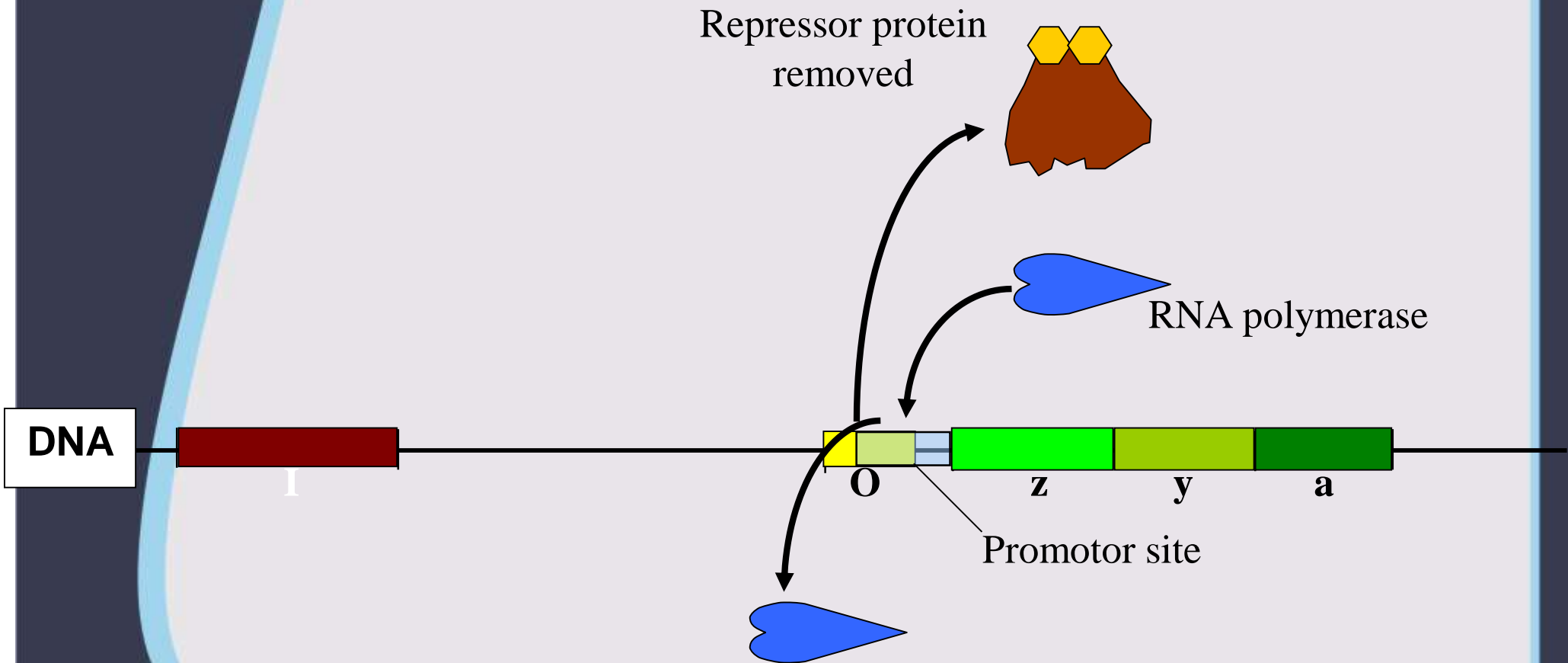
3. When both glucose and lactose are present

- This explains how the *lac* operon is transcribed only when lactose is present
- BUT..... this does **not** explain why the operon is not transcribed when **both** glucose and lactose are present.



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- When glucose and lactose are present RNA polymerase can sit on the promoter site but it is unstable and it keeps falling off





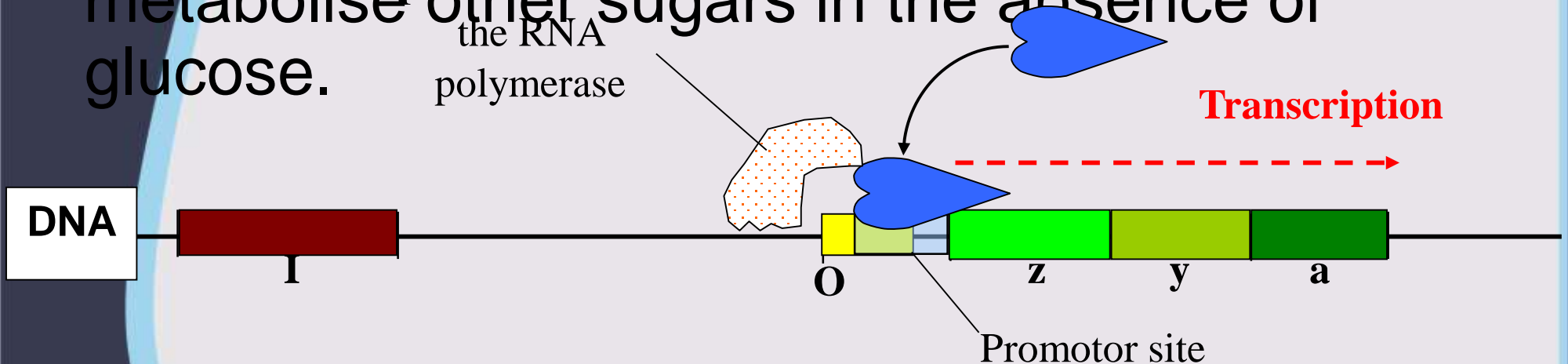
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4. When glucose is absent and lactose is present

- Another protein is needed, an **activator protein**. This stabilises RNA polymerase.
- The activator protein only works when glucose is absent
- In this way *E. coli* only makes enzymes to metabolise other sugars in the absence of glucose.

Activator protein stabilises the RNA polymerase





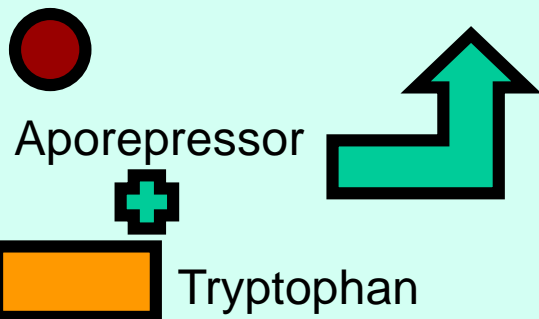
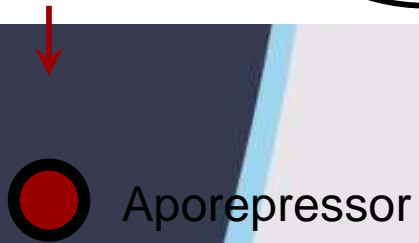
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Summary

Carbohydrates	Activator protein	Repressor protein	RNA polymerase	<i>lac</i> Operon
+ GLUCOSE + LACTOSE	Not bound to DNA	Lifted off operator site	Keeps falling off promoter site	No transcription
+ GLUCOSE - LACTOSE	Not bound to DNA	Bound to operator site	Blocked by the repressor	No transcription
- GLUCOSE - LACTOSE	Bound to DNA	Bound to operator site	Blocked by the repressor	No transcription
- GLUCOSE + LACTOSE	Bound to DNA	Lifted off operator site	Sits on the promoter site	Transcription



trp operon model



No Transcription

Attenuation!

Induction	Repression
1. It turns the operon on.	1. It turns the operon off.
2. It starts transcription and translation.	2. It stops transcription and translation.
3. It is caused by a new metabolite, which needs enzymes to get metabolised.	3. It is caused by an excess of existing metabolite.
4. It operates in a catabolic pathway.	4. It operates in an anabolic pathway.
5. Repressor is prevented by the inducer from joining the operator gene.	5. Aporepressor is enabled by a co-repressor to join the operator gene.

eg:- **Lac operon** ;
inducer:- **lactose**;

eg:- **try operon**;
co-repressor:- **tryptophan**



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THANK YOU