THE *lac* OPERON

The control of gene expression

- Each cell in the human contains all the genetic material for the growth and development of a human
- Some of these genes will be need to be expressed all the time
- These are the genes that are involved in of vital biochemical processes such as respiration
- Other genes are not expressed all the time
- They are switched on an off at need

Operons

- An operon is a group of genes that are **transcribed at the same time**.
- They usually control an important biochemical process.
- They are **only found in prokaryotes**.

Jacob, Monod & Lwoff

The *lac* Operon

- The *lac* operon consists of **three genes** each involved in processing the sugar lactose
- One of them is the gene for the enzyme **β-galactosidase**
- This enzyme hydrolyses lactose into glucose and galactose

Adapting to the environment

- *E. coli* can use either glucose, which is a monosaccharide, or lactose, which is a disaccharide
- However, lactose needs to be hydrolysed (digested) first
- So the bacterium prefers to use glucose when it can

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.

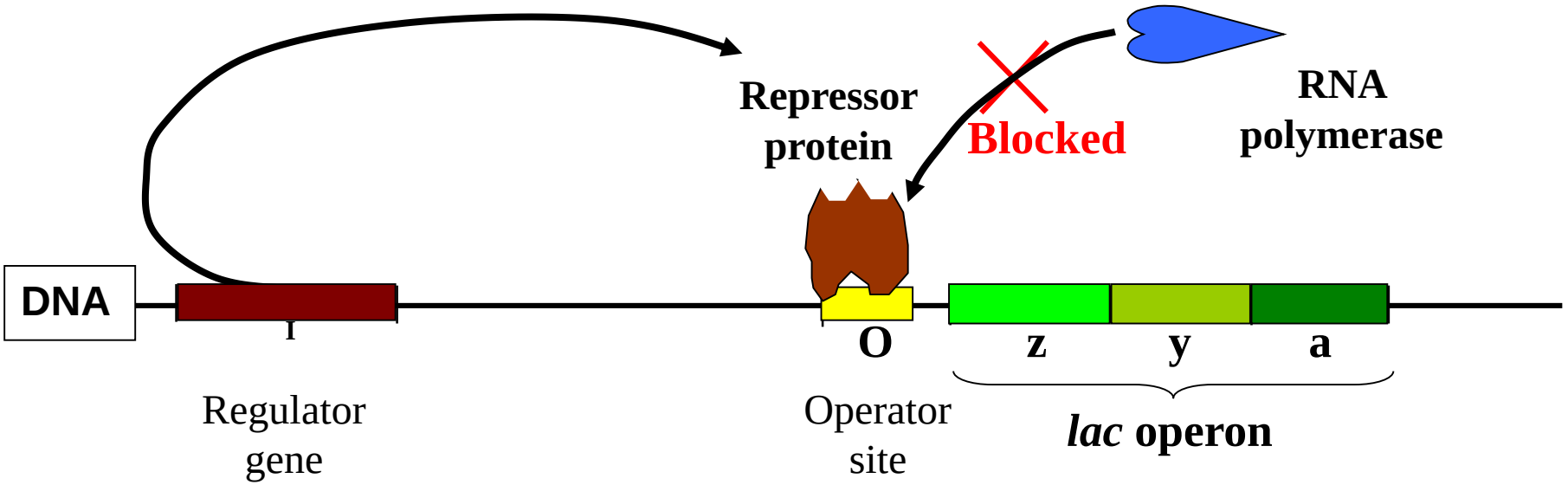
3. When glucose is **absent** and lactose is **absent** the E. coli does **not** produce β-galactosidase.

4. When glucose is **absent** and lactose is **present** the E. coli **does** produce β-galactosidase

The control of the *lac* operon

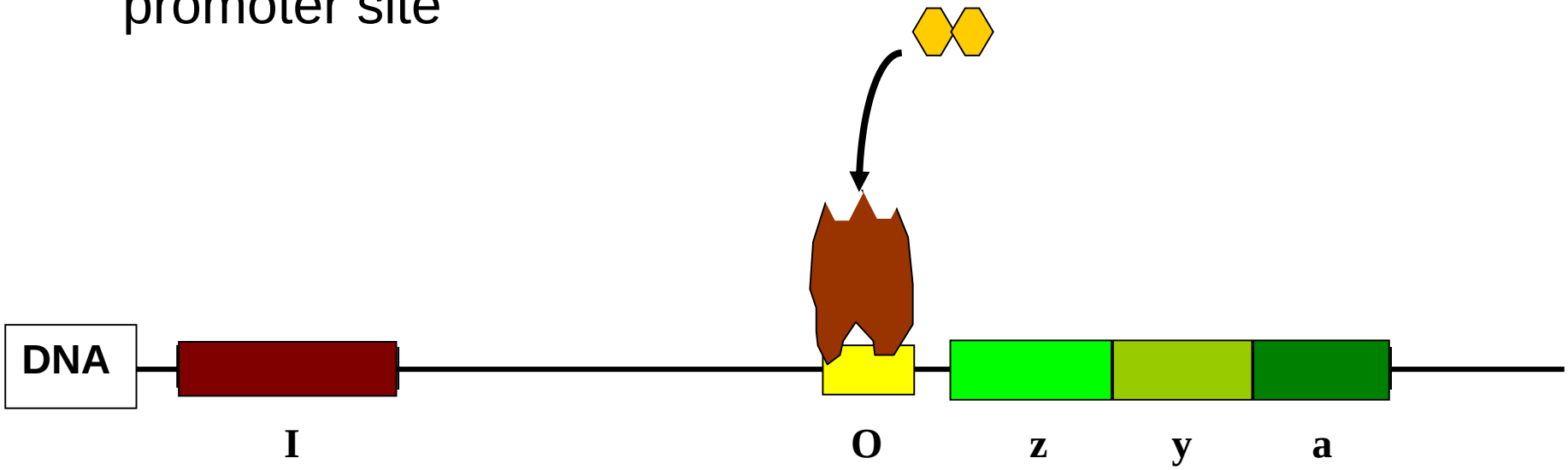
1. When lactose is absent

- 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



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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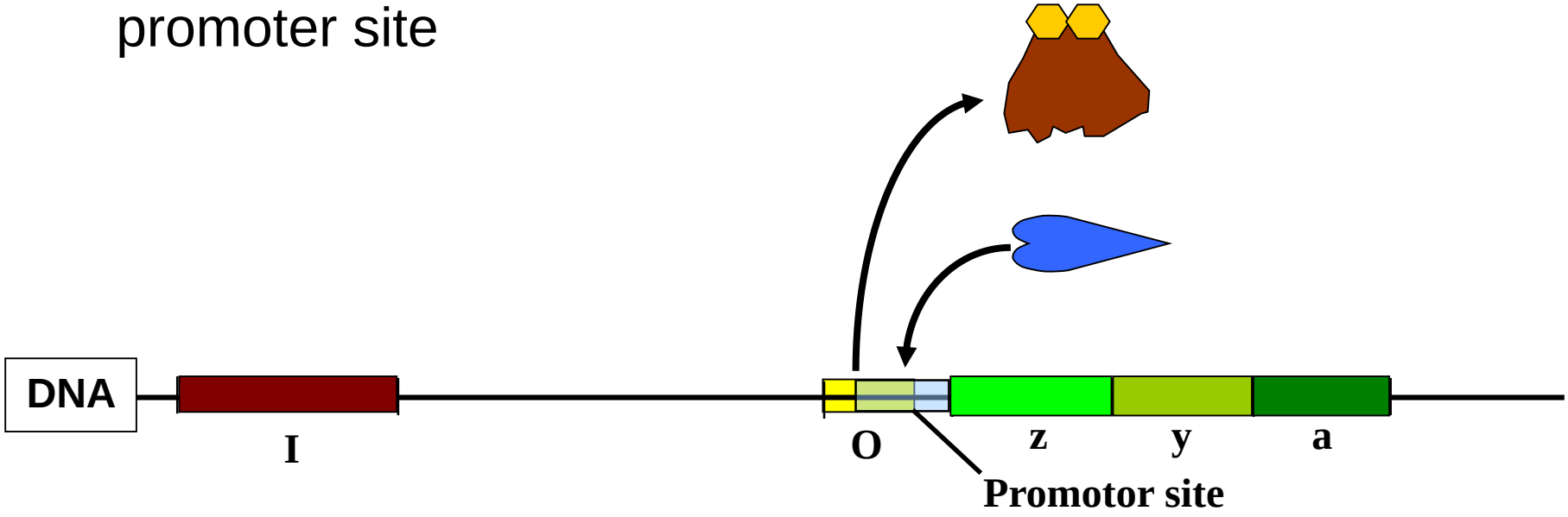
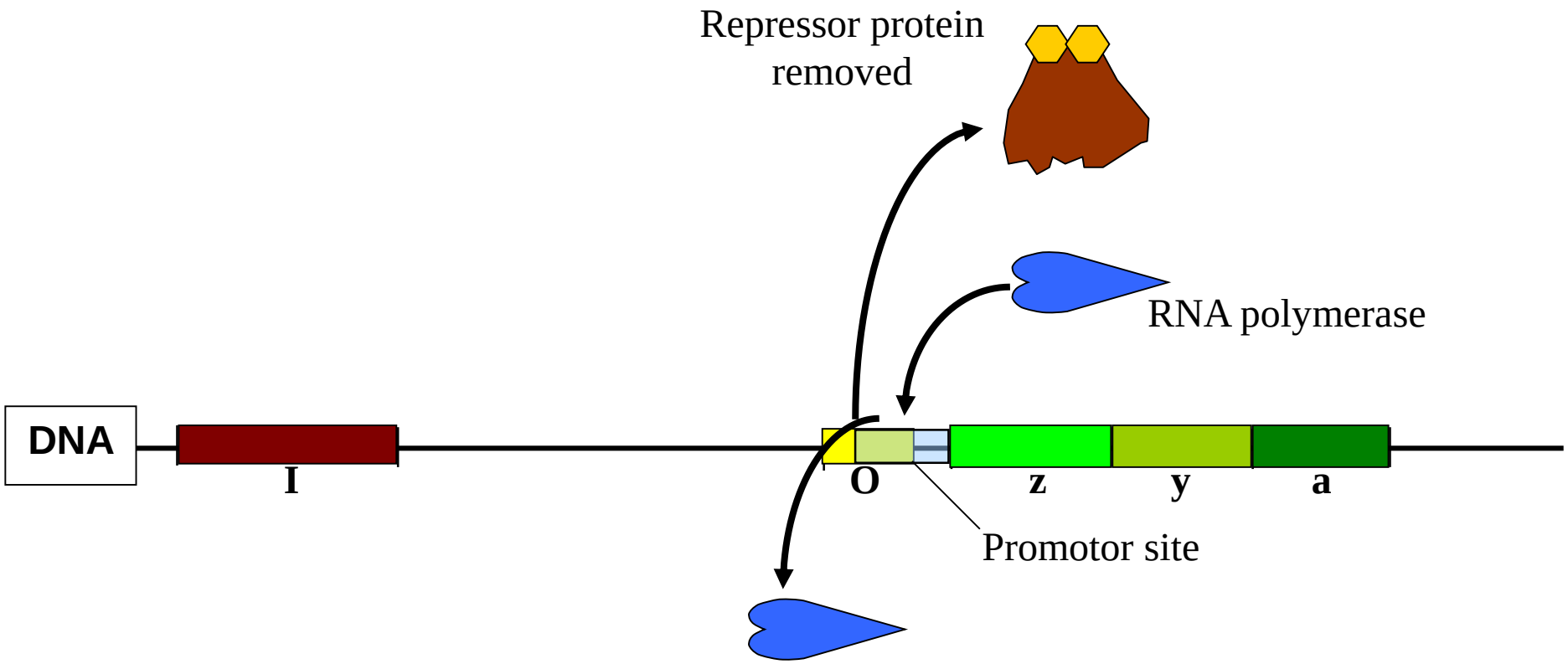


3. When both glucose and lactose are present

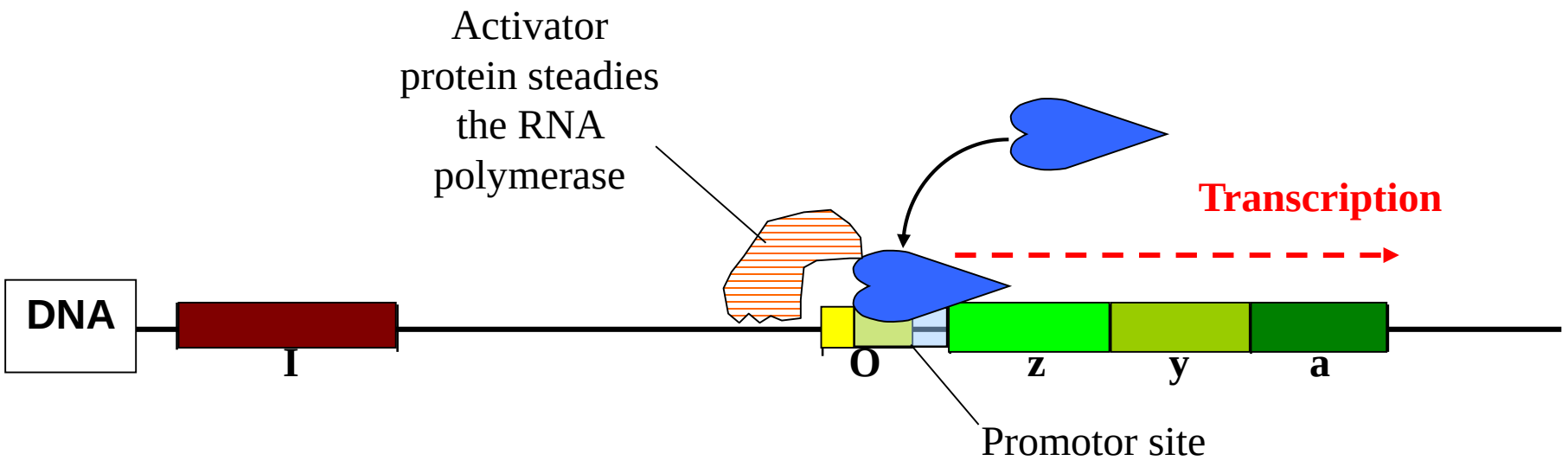
- This explains how the *lac* operon is transcribed only when lactose is present.
- BUT….. this does not explain why the operon is not transcribed when both glucose and lactose are present.

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



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



Summary

Carbohydrates	Activator protein	Repressor protein	RNA polymerase	*lac* 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**