

Regulation of Gene Expression And Protein Function

How do cells/organisms regulate which genes are expressed and under what conditions?

How is regulation imposed at the level of protein function?

Gene Regulation in Bacteria

- Organisms only express a subset of their genes at any given time.
- Constitutive Enzymes: enzymes made over a wide variety of growth conditions. House keeping genes
- Repressible enzyme systems: enzymes normally expressed over a wide variety of conditions, but can be turned off.
- Inducible Enzyme: enzyme made in response to specific environmental signals

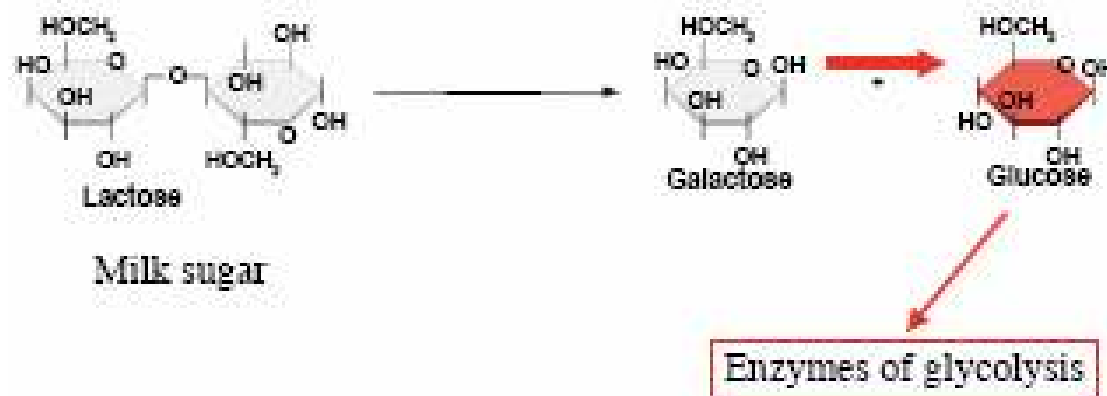
Where can regulation be imposed?

The Lactose Operon

An inducible enzyme system that is responsible for lactose catabolism

Operon: a cluster of genes that are functionally related and coordinately expressed, and are under the control of a single promoter/operator (regulatory) region.

Jacob and Monod- 1940's



Mutant Classes

Normal gene

lacZ⁺ (β -galactosidase)

lacY⁺ (permease)

lacI⁺ (Lac repressor)

O⁺ (operator)

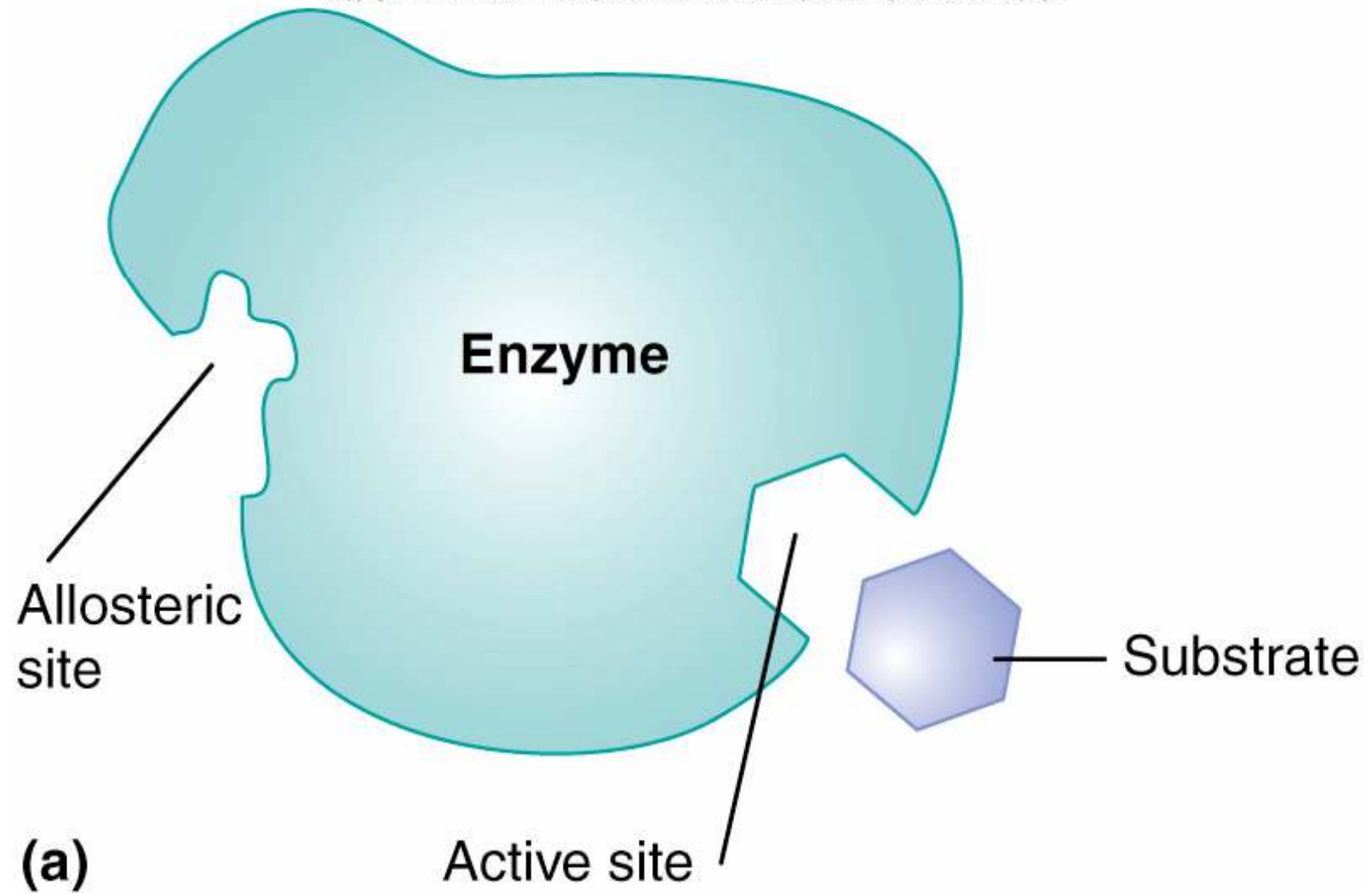
Mutant gene

lacZ⁻

lacY⁻

lacI⁻ (constitutive mutants)

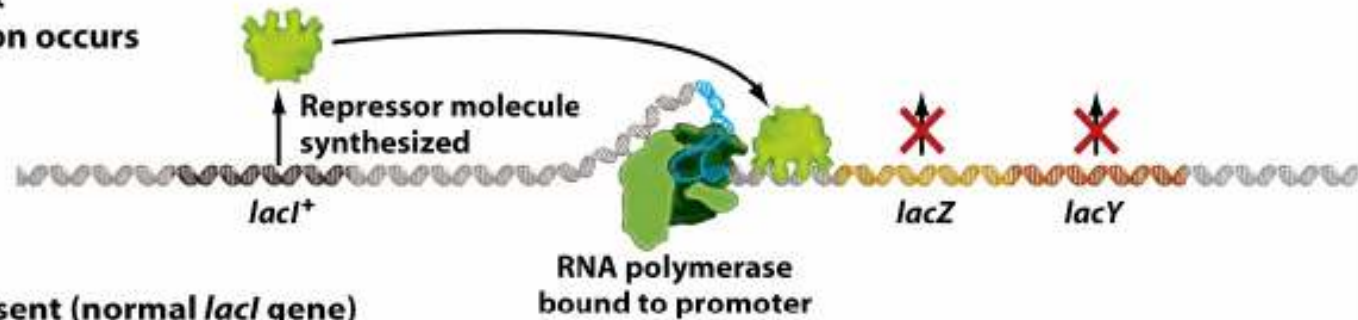
O^c (constitutive mutants)



(a) Repressor present (normal *lacI* gene)

Lactose absent

No transcription occurs

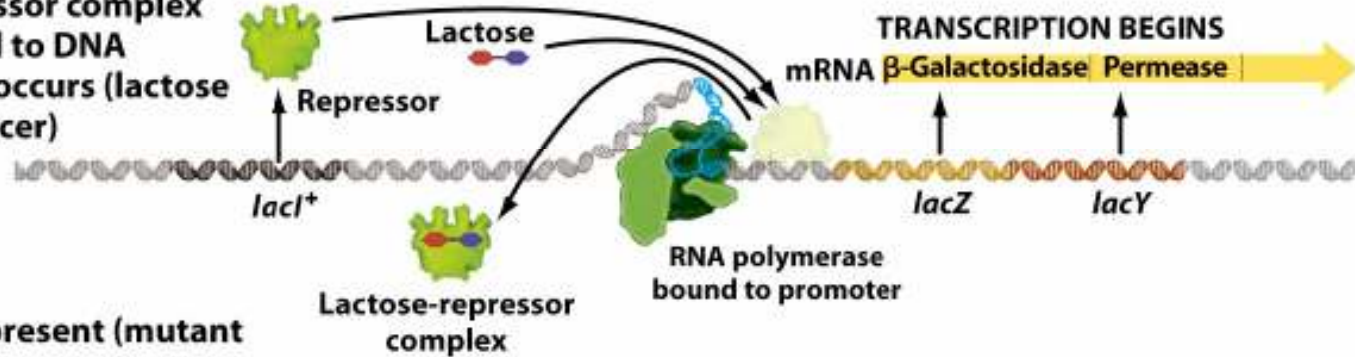


(b) Repressor present (normal *lacI* gene)

Lactose present; binds to repressor

Lactose-repressor complex cannot bind to DNA

Transcription occurs (lactose acts as inducer)



(c) No repressor present (mutant *lacI* gene)

Lactose present or absent

Transcription occurs

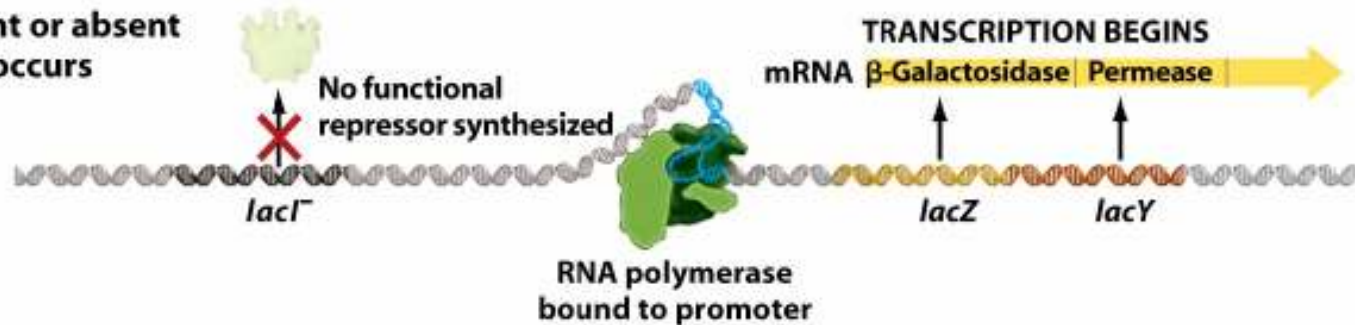


Figure 17-5 Biological Science, 2/e

Lactose Operon is also under Positive Control

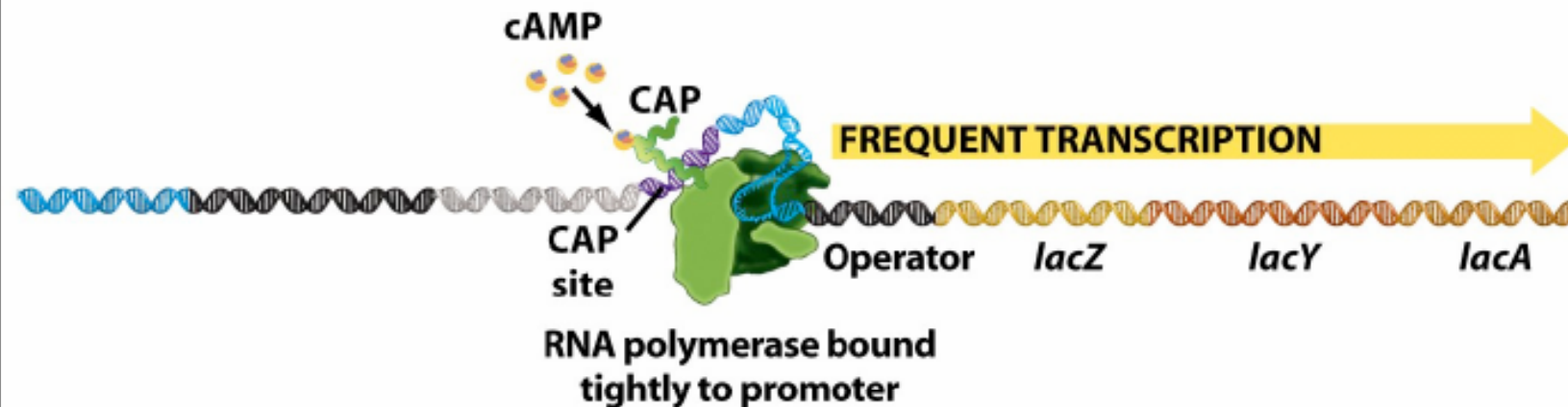
CAP: Catabolite Activator Protein

CAP binding site is part of lac promoter

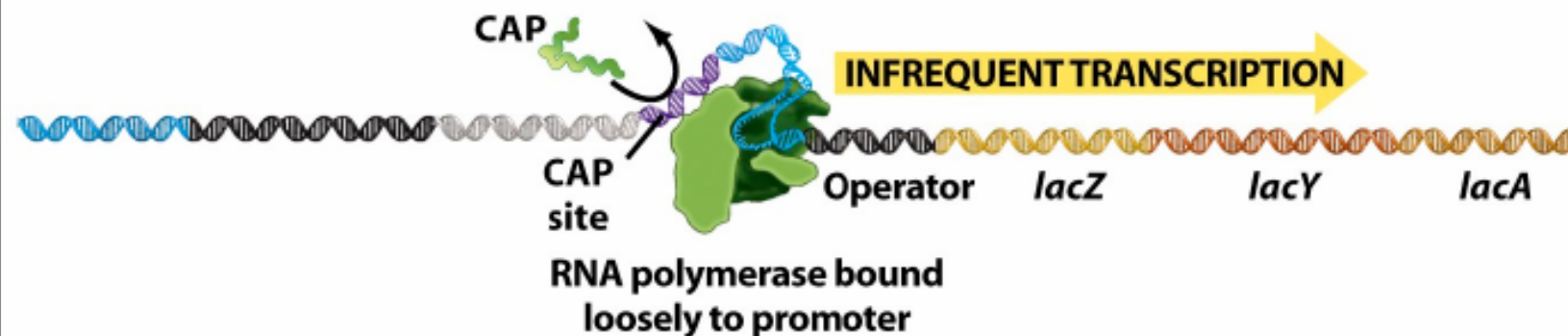
cAMP: Cyclic AMP

cAMP allosterically regulates CAP

- (a) When cAMP is present, it binds to CAP. The cAMP-CAP complex binds to DNA at the CAP site and increases binding of RNA polymerase to promoter. Transcription occurs frequently.



- (b) When cAMP is absent, CAP does not bind to DNA. RNA polymerase does not bind the promoter efficiently, and transcription occurs rarely.



Glucose inhibits the activity of the enzyme adenylyl cyclase, which produces cAMP from ATP.

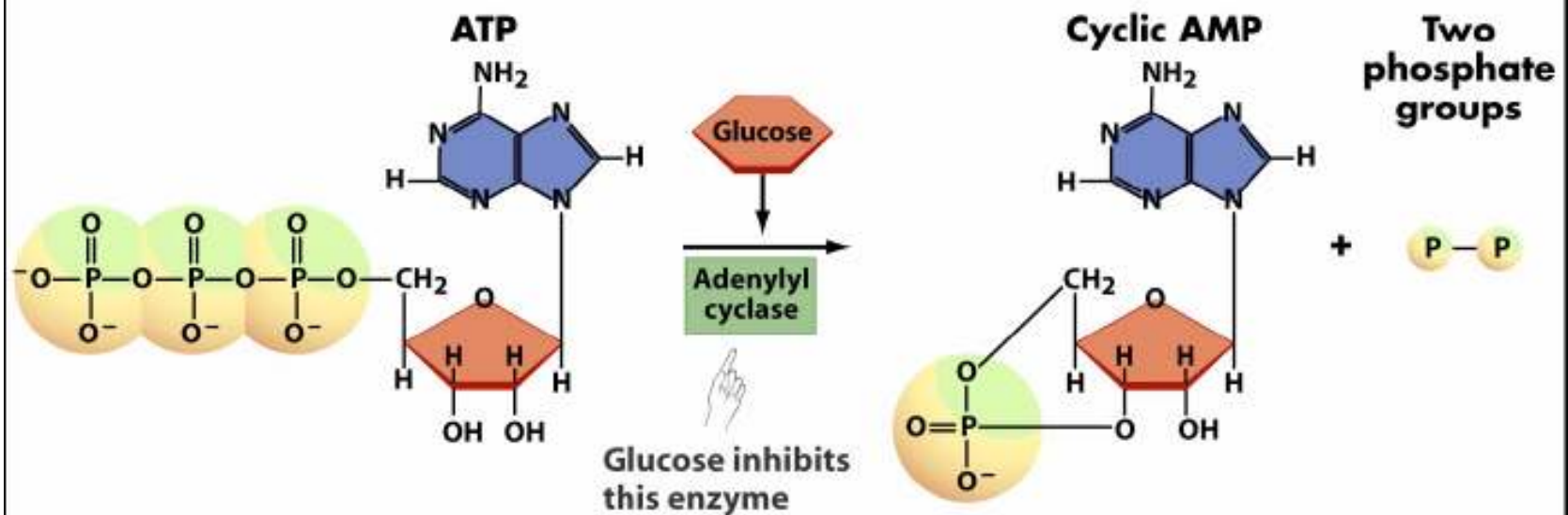


Figure 17-9a Biological Science, 2/e

The amount of cAMP and the rate of transcription of *lac* operon are inversely related to the concentration of glucose.

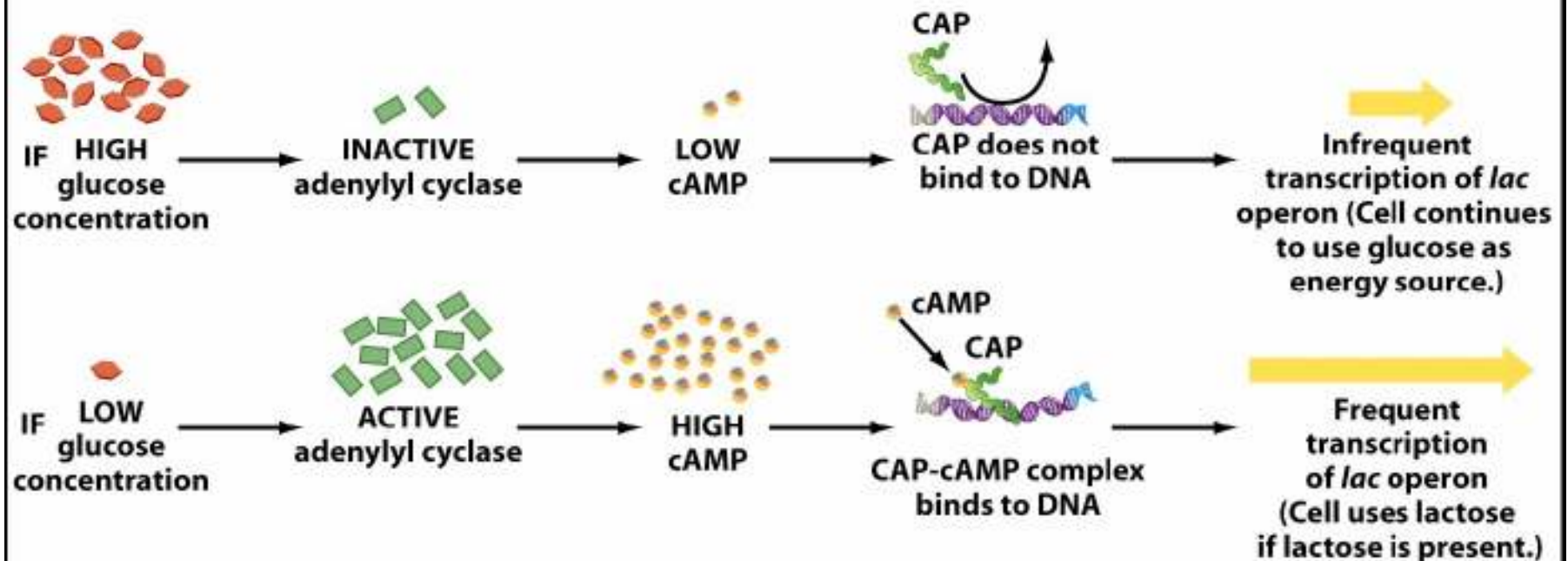


Figure 17-9b Biological Science, 2/e

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Draw out the lac operon and state the level of transcription under the following conditions:

- A) Low lactose, high glucose**
- B) Low lactose, high glucose in a *lacI*- background**
- C) Low lactose, low glucose**
- D) Low lactose, low glucose in a *lacI*- background**
- E) High lactose, low glucose with a mutation in CAP binding site (CAP protein cannot bind)**