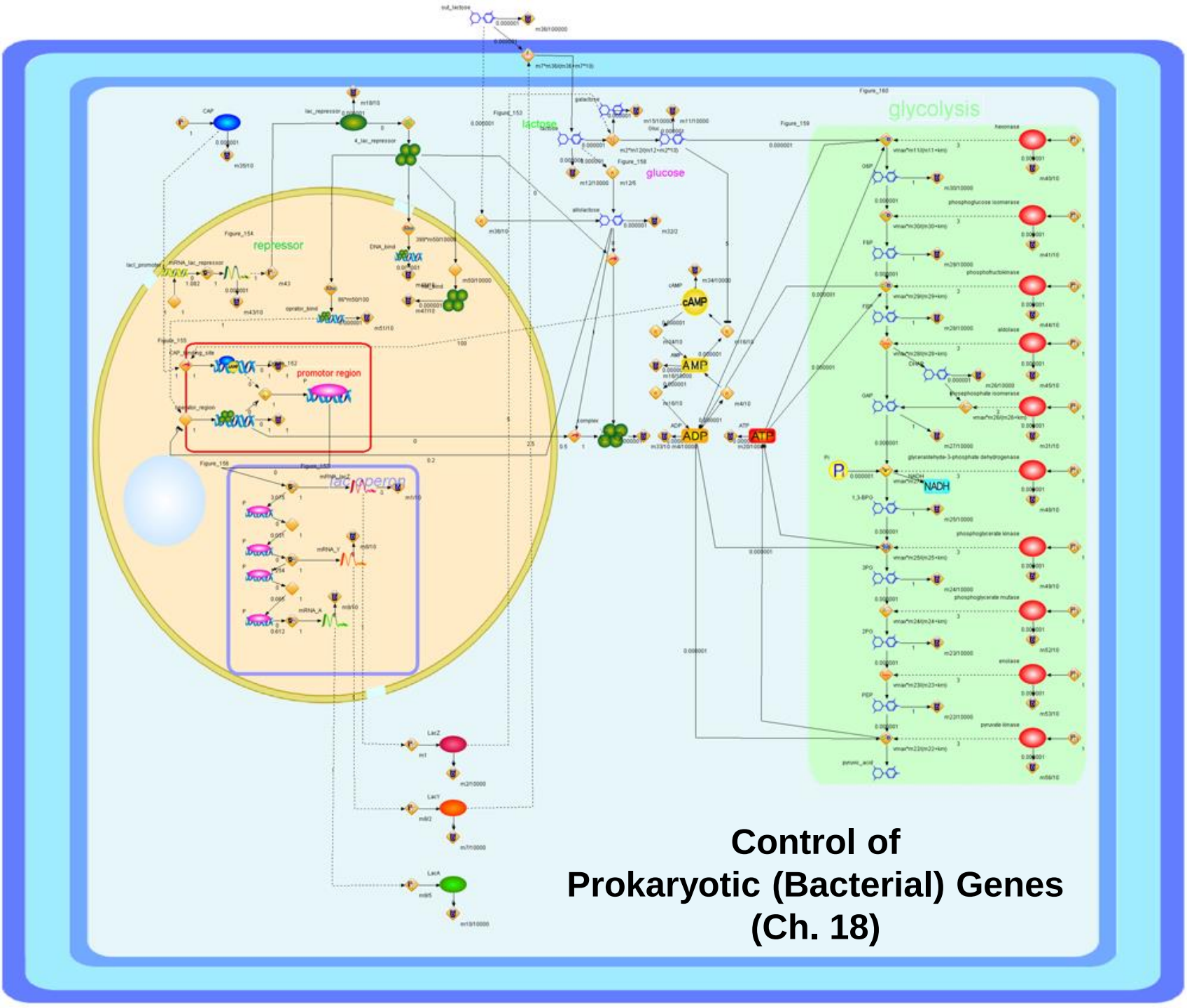
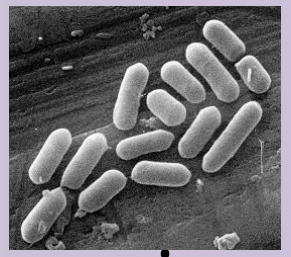


Control of Prokaryotic (Bacterial) Genes (Ch. 18)

Bacterial metabolism



- Bacteria need to respond quickly to changes in their environment
  - if they have enough of a product, need to stop production

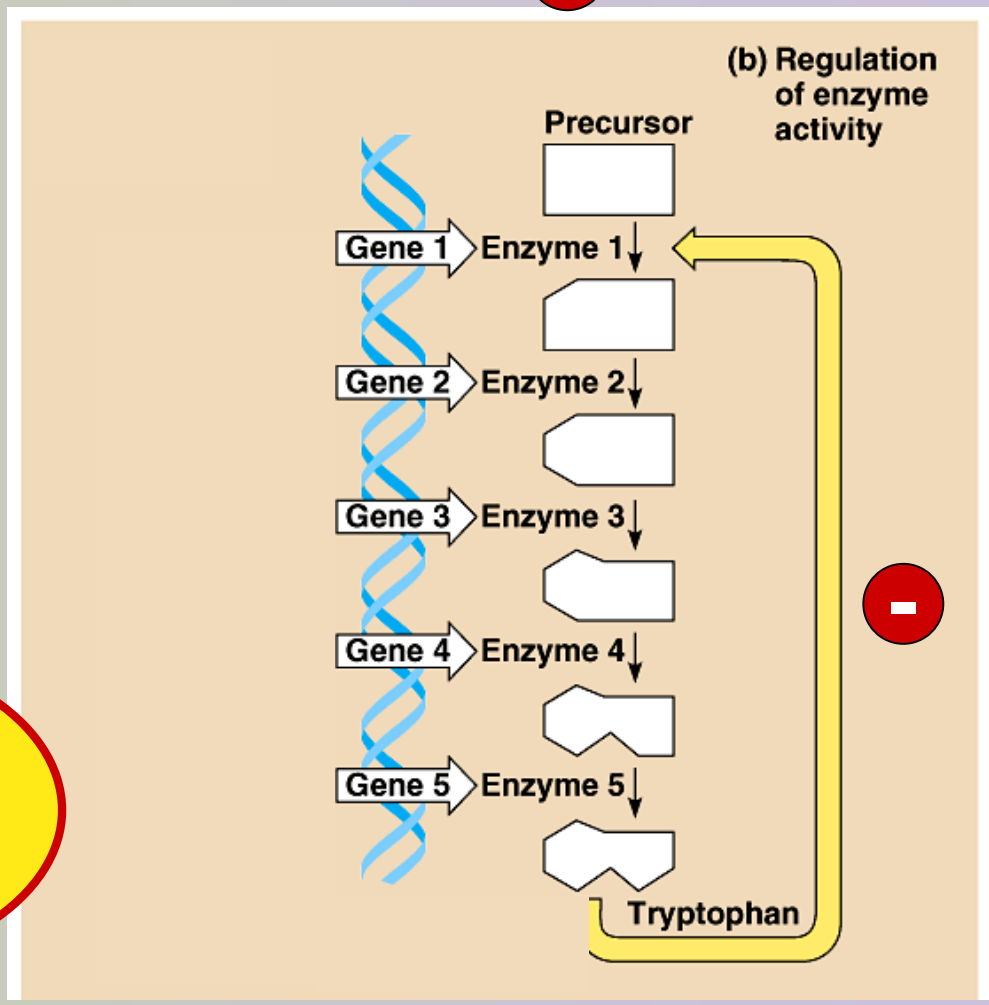
    - why? waste of energy to produce more
    - how? stop production of enzymes for synthesis
  - if they find new food/energy source, need to utilize it quickly

    - why? metabolism, growth, reproduction
    - how? start production of enzymes for digestion

How to Regulate Metabolism?

- Feedback inhibition
  - The product acts as an allosteric inhibitor of the 1st enzyme in tryptophan pathway
  - *but this is wasteful production of enzymes*

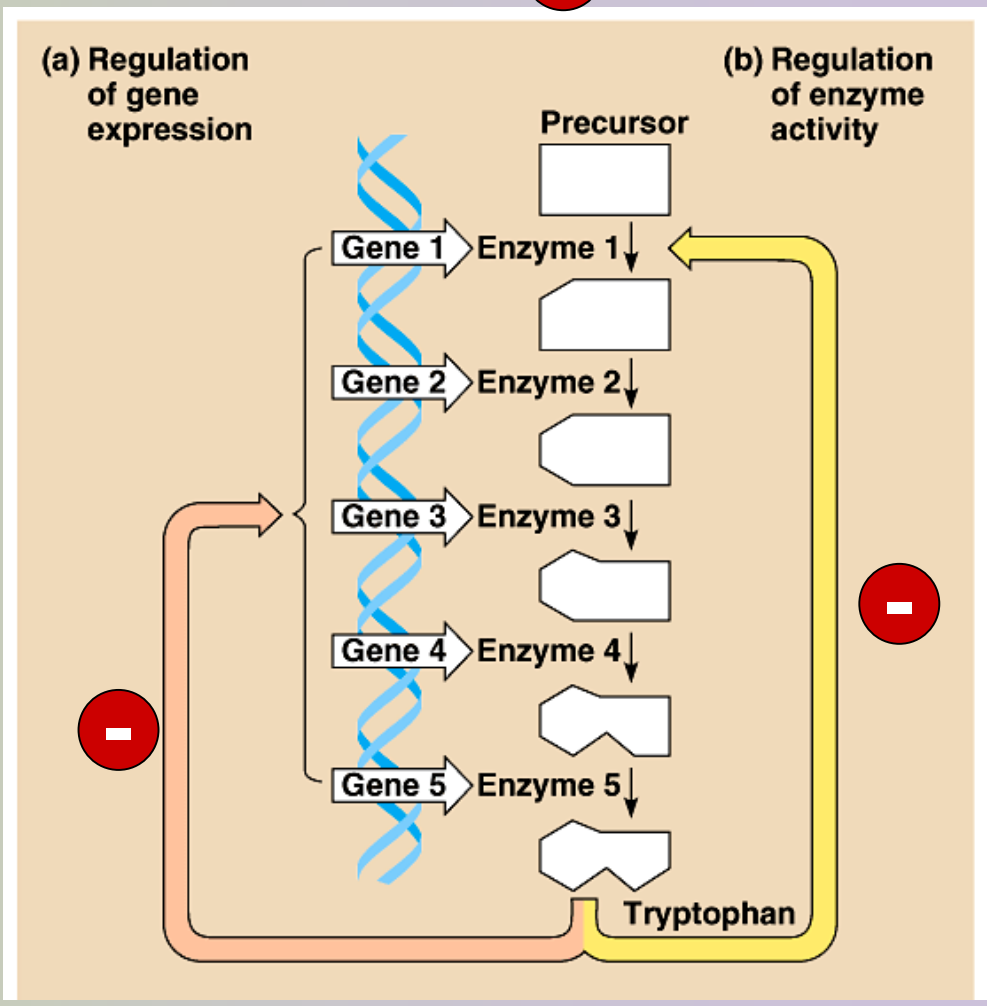
What kind of feedback do we have here?



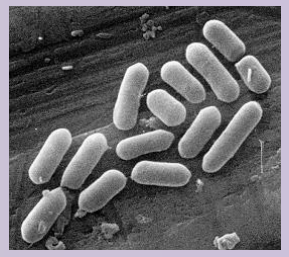
A Different way to Regulate Metabolism

- Gene regulation
  - Don't block the enzyme's function, block transcription of genes for all enzymes in tryptophan pathway
    - saves energy by not wasting it on unnecessary protein synthesis

Now, that's a good idea from a lowly bacterium!



Gene regulation in bacteria



- Cells vary amount of specific enzymes by regulating gene transcription
  - turn genes on or turn genes off
    - turn genes OFF example

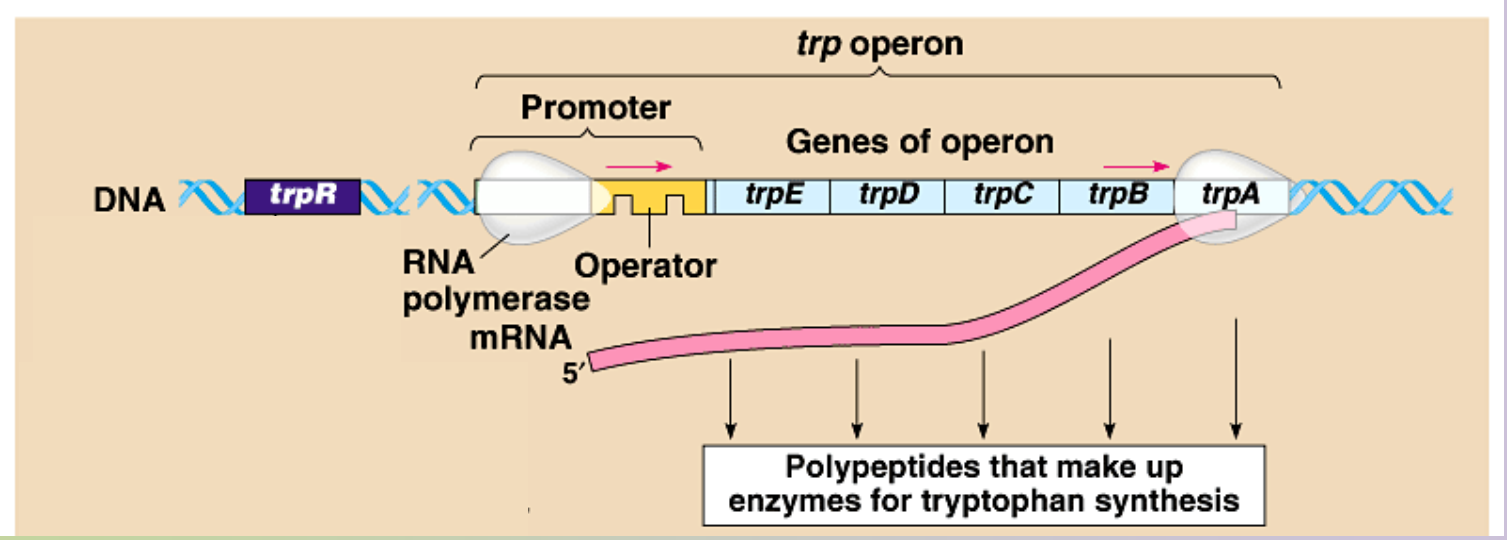
if bacterium has enough tryptophan then it doesn't need to make enzymes used to build tryptophan

    - turn genes ON example

if bacterium encounters new sugar (energy source), like lactose, then it needs to start making enzymes used to digest lactose

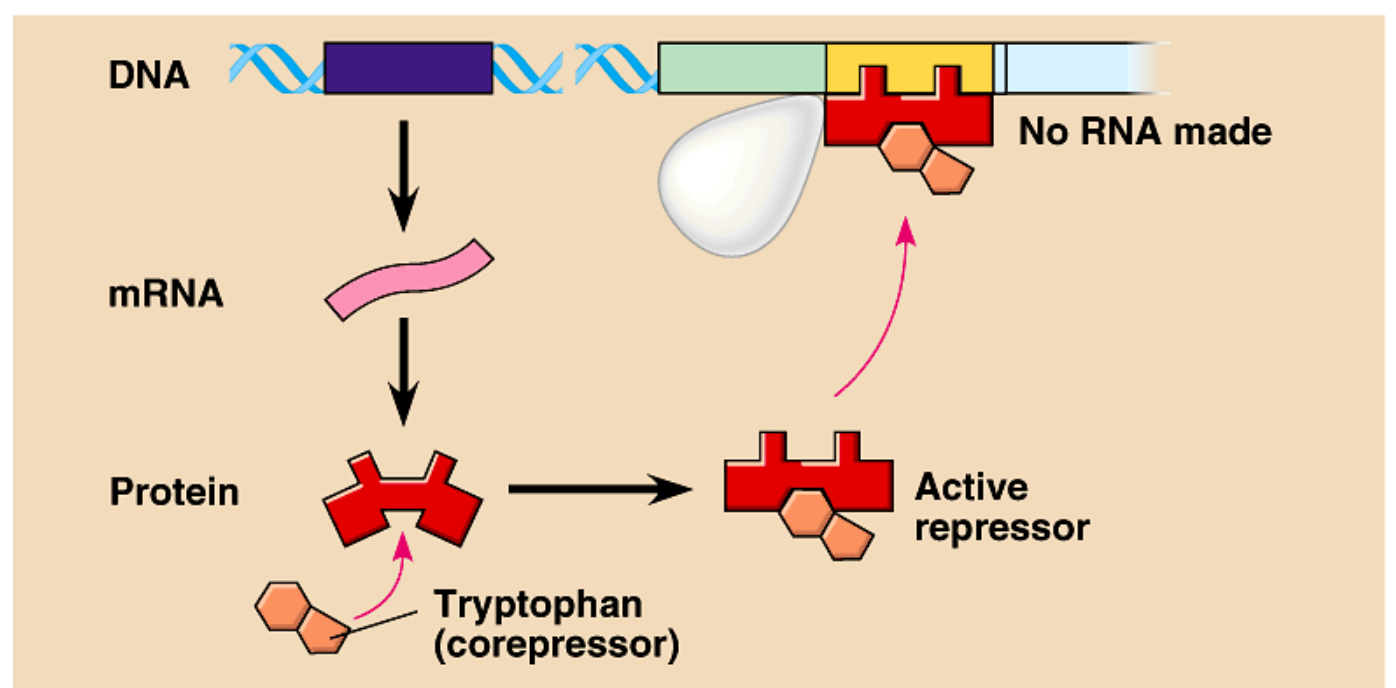
Bacteria group genes together

- Operon
  - genes grouped together with related functions
  - promoter = RNA polymerase binding site
    - single promoter controls transcription of all genes in operon
    - transcribed as one unit & a single mRNA is made
  - operator = DNA binding site of repressor protein



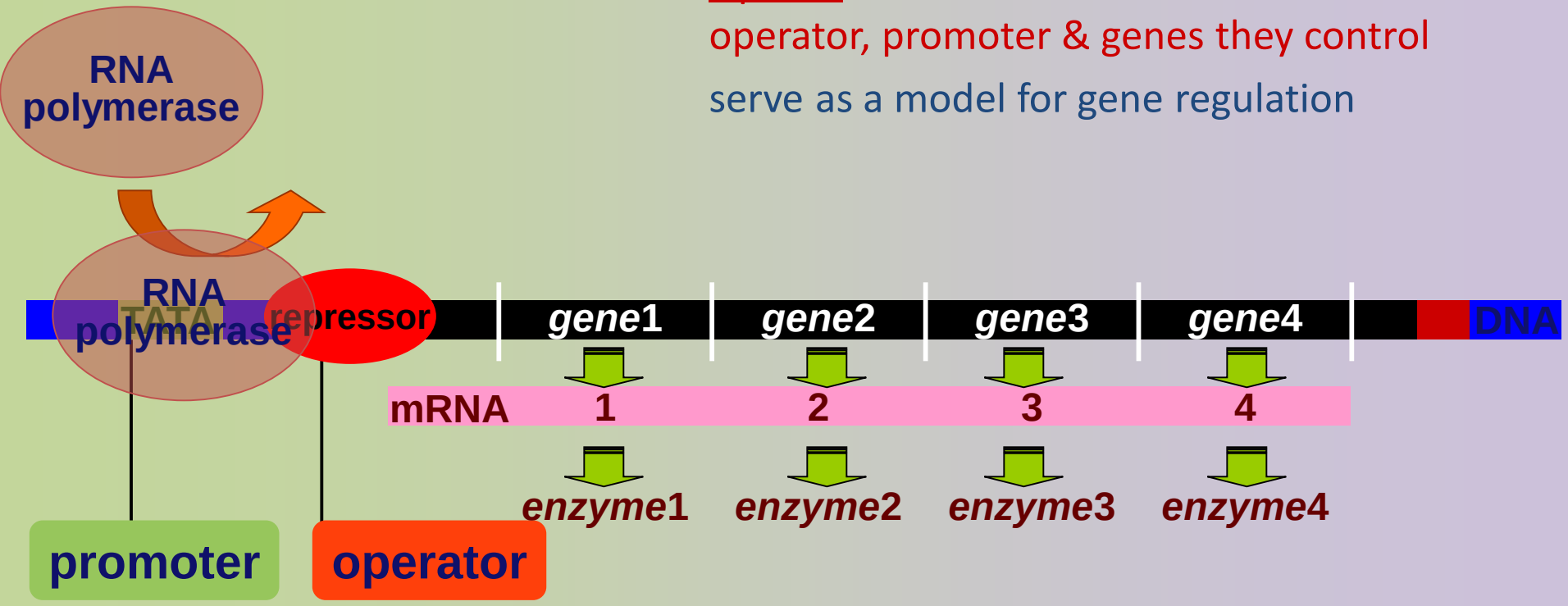
So how can these genes be turned off?

- Repressor protein
  - binds to DNA at operator site
  - blocking RNA polymerase
  - blocks transcription



Operon model

Operon:
operator, promoter & genes they control
serve as a model for gene regulation



Repressor protein turns off gene by blocking RNA polymerase binding site.

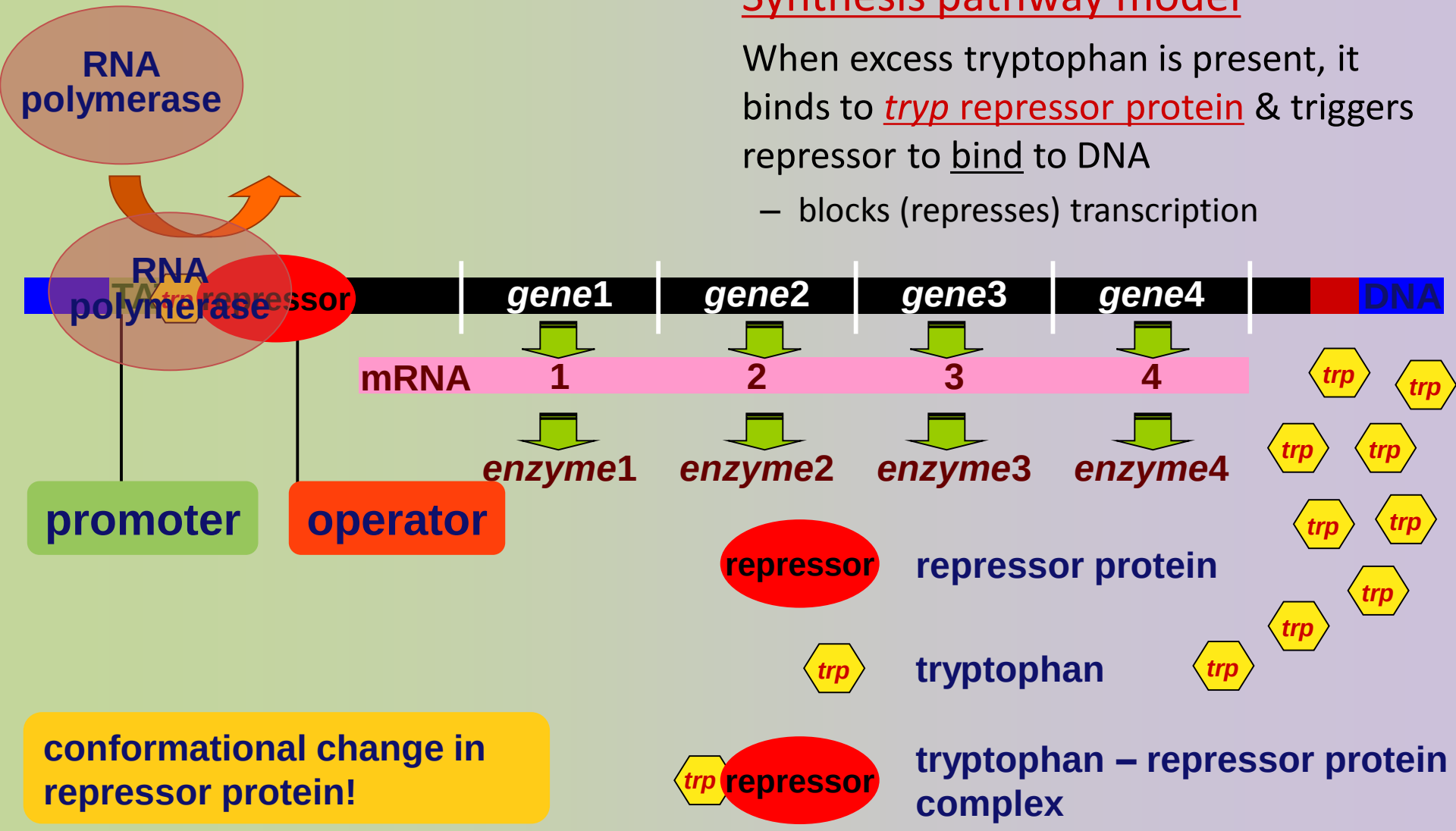
repressor = repressor protein

Repressible operon: tryptophan

Synthesis pathway model

When excess tryptophan is present, it binds to *tryp* repressor protein & triggers repressor to bind to DNA

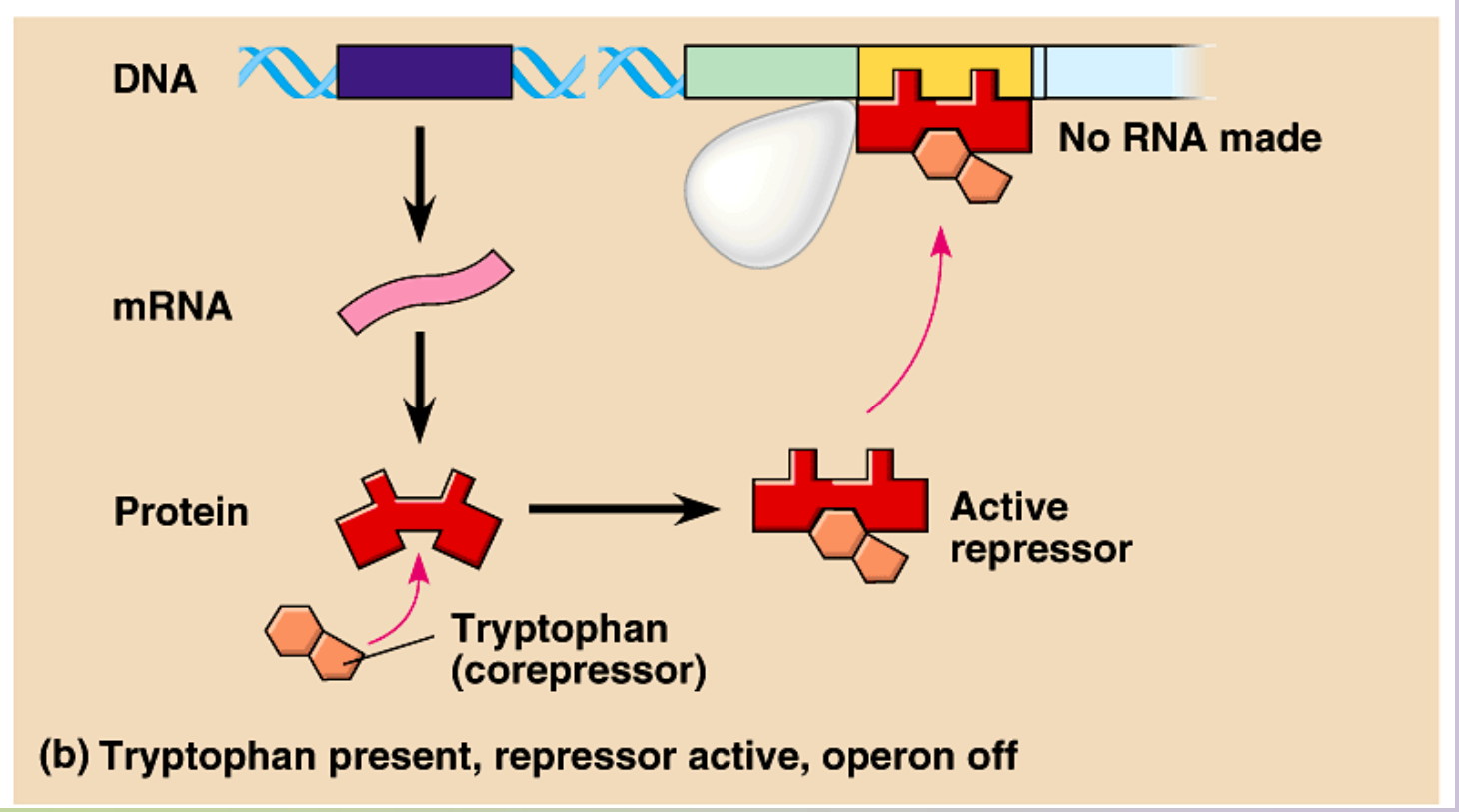
- blocks (represses) transcription



Tryptophan operon

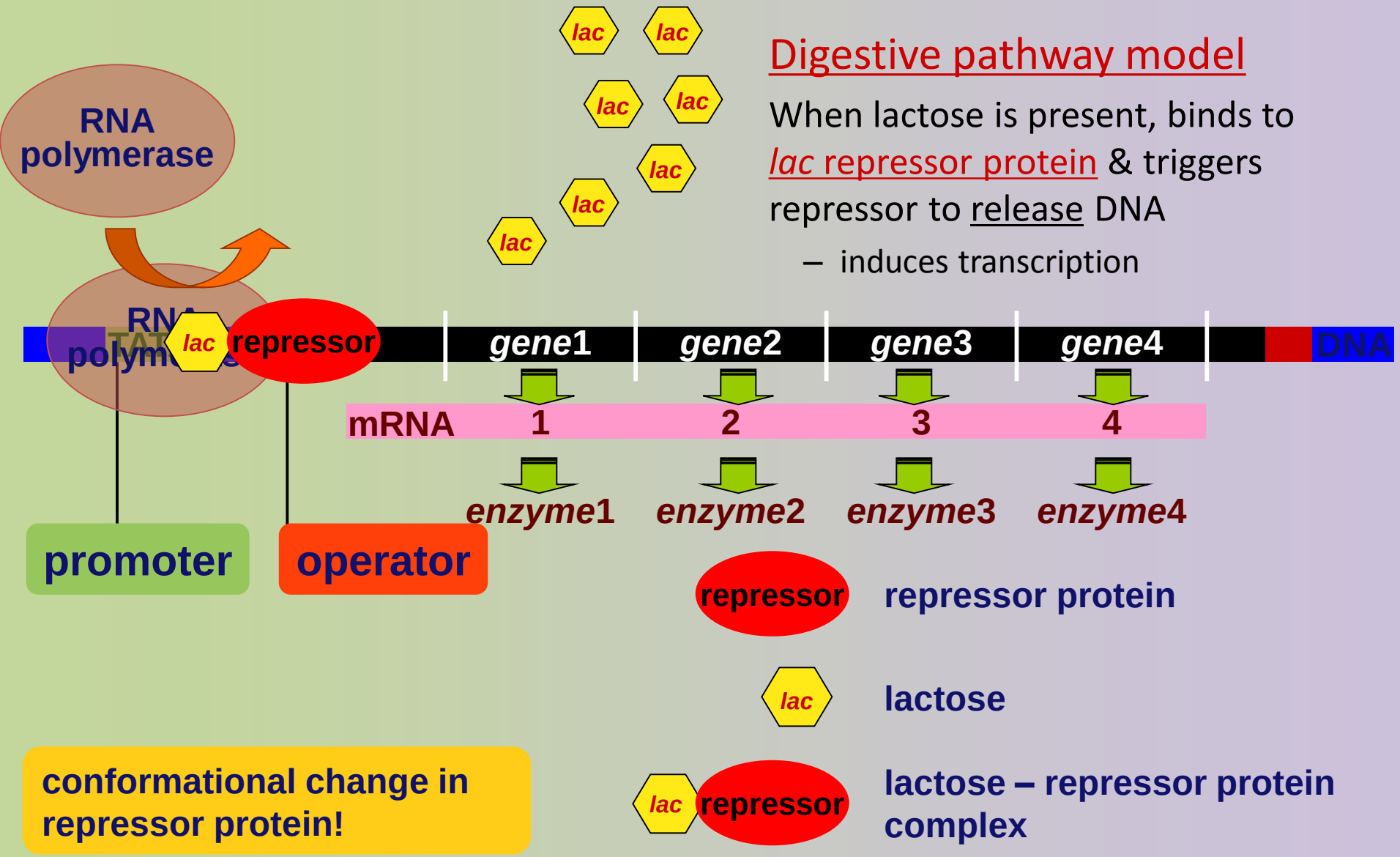
What happens when tryptophan is present?

Don't need to make tryptophan-building enzymes



Tryptophan is allosteric regulator of repressor protein

Inducible operon: lactose



Digestive pathway model

When lactose is present, binds to *lac* repressor protein & triggers repressor to release DNA

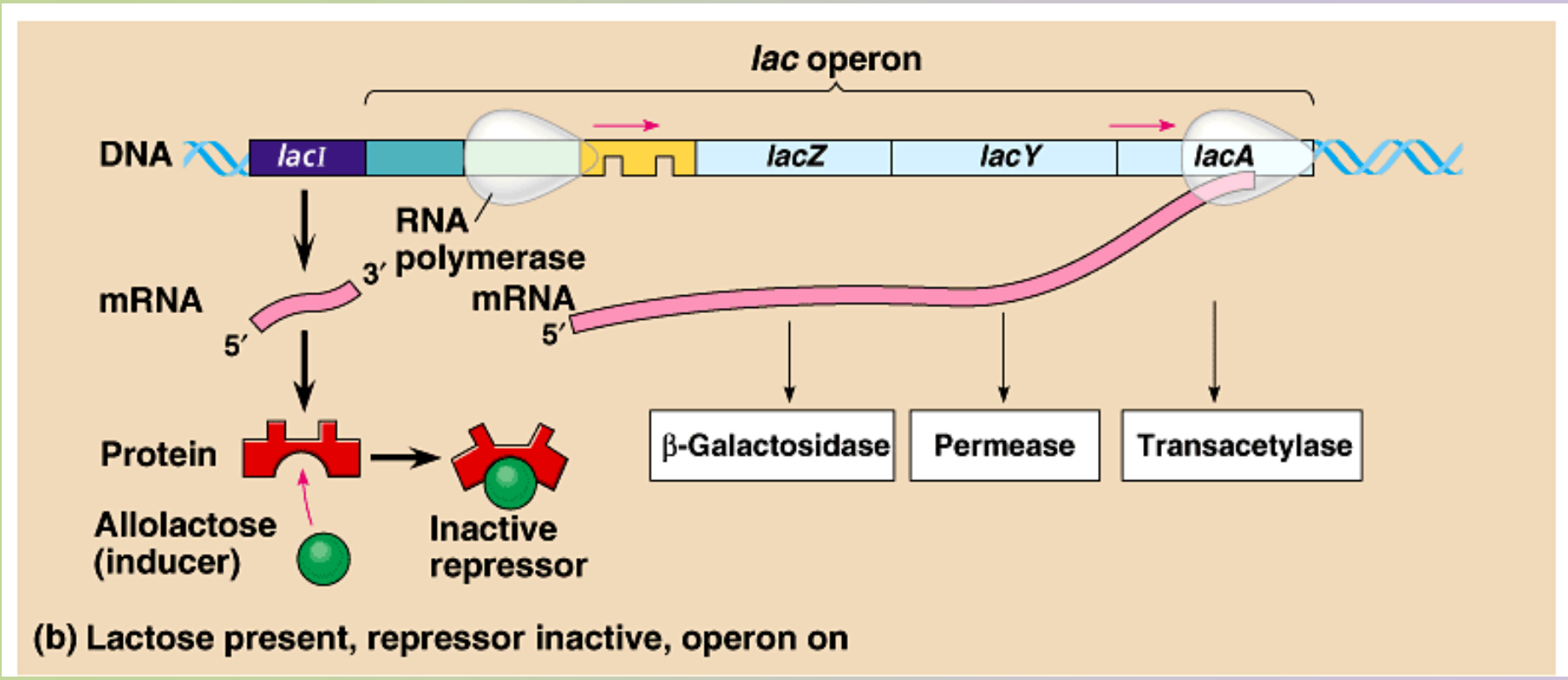
- induces transcription

conformational change in repressor protein!

Lactose operon

What happens when lactose is present?

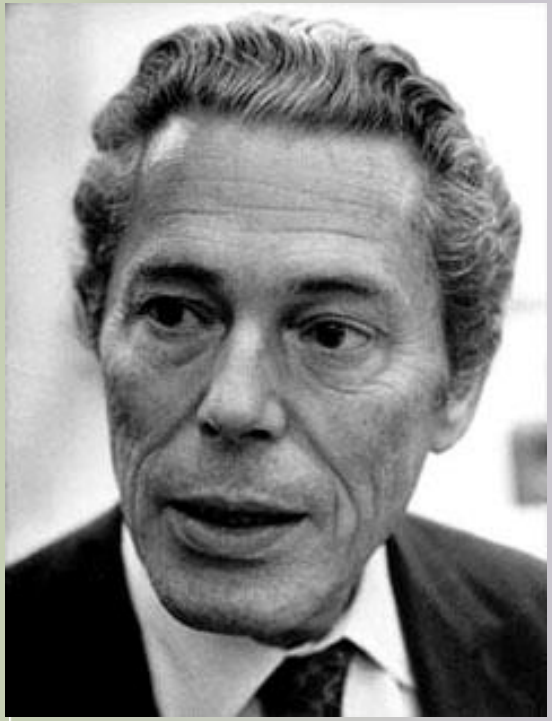
Need to make lactose-digesting enzymes



Lactose is allosteric regulator of repressor protein

Jacob & Monod: *lac* Operon 1961 | 1965

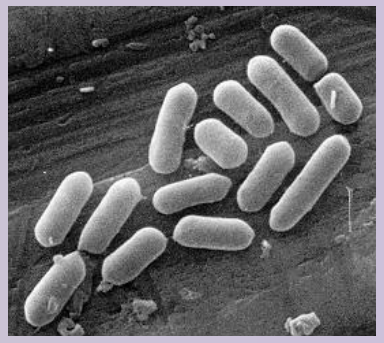
- Francois Jacob & Jacques Monod
  - first to describe operon system
  - coined the phrase “operon”



Jacques Monod

Francois Jacob

Operon summary



- Repressible operon
  - usually functions in anabolic (‘building’) pathways
    - synthesizing end products
  - when end product is present in excess, cell allocates resources to other uses
- Inducible operon
  - usually functions in catabolic (‘destroying’) pathways,
    - digesting nutrients to simpler molecules
  - produce enzymes only when nutrient is available
    - cell avoids making proteins that have nothing to do, cell allocates resources to other uses

Don’t be repressed*!*

How can I induce you to ask Questions?

Review Questions

1. A mutation that inactivates the regulator gene of a repressible operon in an *E. coli* cell would result in
   A. continuous transcription of the structural gene controlled by that regulator.
   B. complete inhibition of transcription of the structural gene controlled by that regulator.
   C. irreversible binding of the repressor to the operator.
   D. inactivation of RNA polymerase.
   E. both B and C.

2. A mutation that makes the regulatory gene of an inducible operon nonfunctional would result in
   A. continuous transcription of the operon's genes.
   B. reduced transcription of the operon's genes.
   C. accumulation of large quantities of a substrate for the catabolic pathway controlled by the operon.
   D. irreversible binding of the repressor to the promoter.
   E. overproduction of cAMP receptor protein.

3. A mutation that renders nonfunctional the product of a regulatory gene for an inducible operon would result in *

   A. continuous transcription of the genes of the operon.
   B. complete blocking of the attachment of RNA polymerase to the promoter.
   C. irreversible binding of the repressor to the operator.
   D. no difference in transcription rate when an activator protein was present.
   E. negative control of transcription.