



# ***Genetics***

***Subject* : Genetics**

***Lec no* : 8(part 2)**

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وَقُلْ رَبِّ زِدْنِي عِلْمًا

# Termination:

تنتهي عملية replication عند الوصول إلى terminator  
ويبدأ أنتج RNA molecule

- RNA polymerase recognizes a termination signal at the end of the DNA sequence to be transcribed (termination sequence). Then RNA polymerase stop transcription and releases RNA molecule.

- There are two mechanisms for transcription termination: Rho factor (تحتاج ATP) termination

1-Rho factor dependent termination (ATP dependent)

2-Rho factor independent termination (intrinsic termination)

لا تحتاج Rho factor

# 1-Rho-dependent termination:

- It uses a **termination factor called ρ factor** (rho factor) which is a protein that binds at a **rho utilization site** (*rut*) on the nascent RNA strand (cytosine-rich sequence ) and runs along the mRNA towards the RNAP (in a 5'-3' direction).

*(The rut serves as a mRNA loading site and as an activator for Rho)*

- The rho protein is an **ATP dependent RNA-DNA helicase**
- when ρ-factor reaches the RNAP, it causes RNAP to dissociate from the DNA, terminating transcription.

Rho factor ← يحسن الاقتران عند الازدياد  
rut region

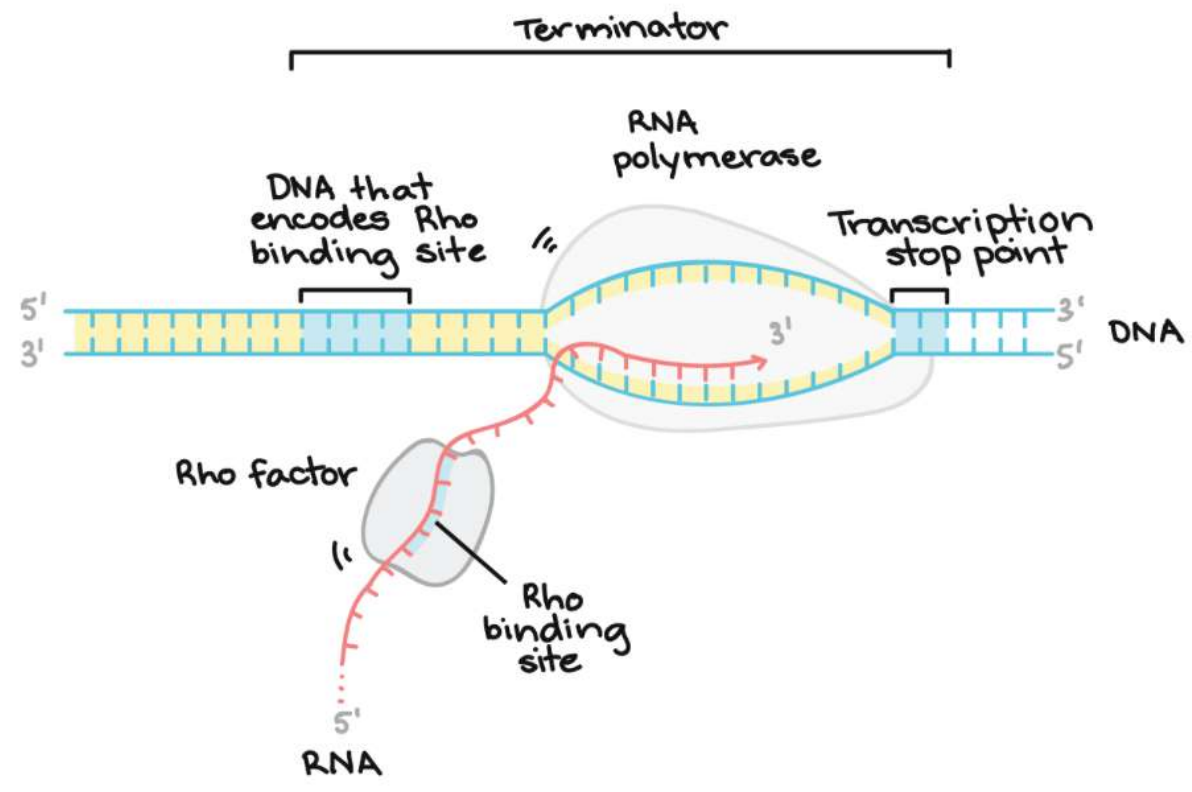
RNA polymerase ← يتوقف عن عملية transcription عند الوجود في Terminator

Rho factor ← يرتبط على RNA molecule على Rho utilization site ويغشي على RNA strand لكي ان يقابل RNA polymerase ويعمل فيه conformational changes لكي يكون قادر على الاقتران

Rho factor ← يمتلك helicase activity فيكسر hydrogen bond بين nucleotides بين RNA و DNA عن طريق ATP

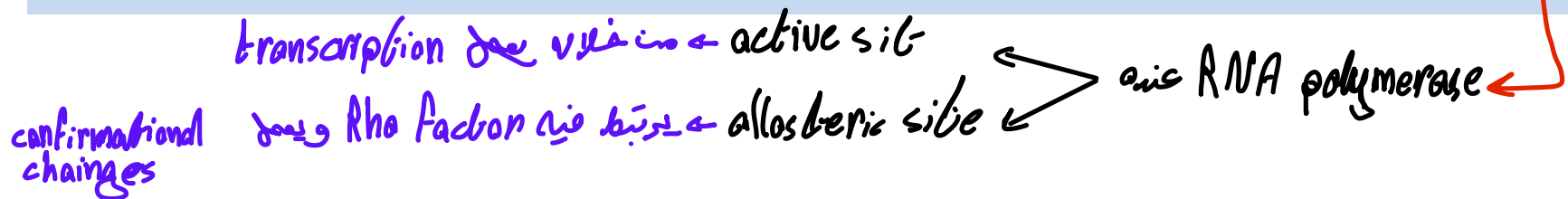
ATP dependant  
RNA-DNA helicase > Rho factor

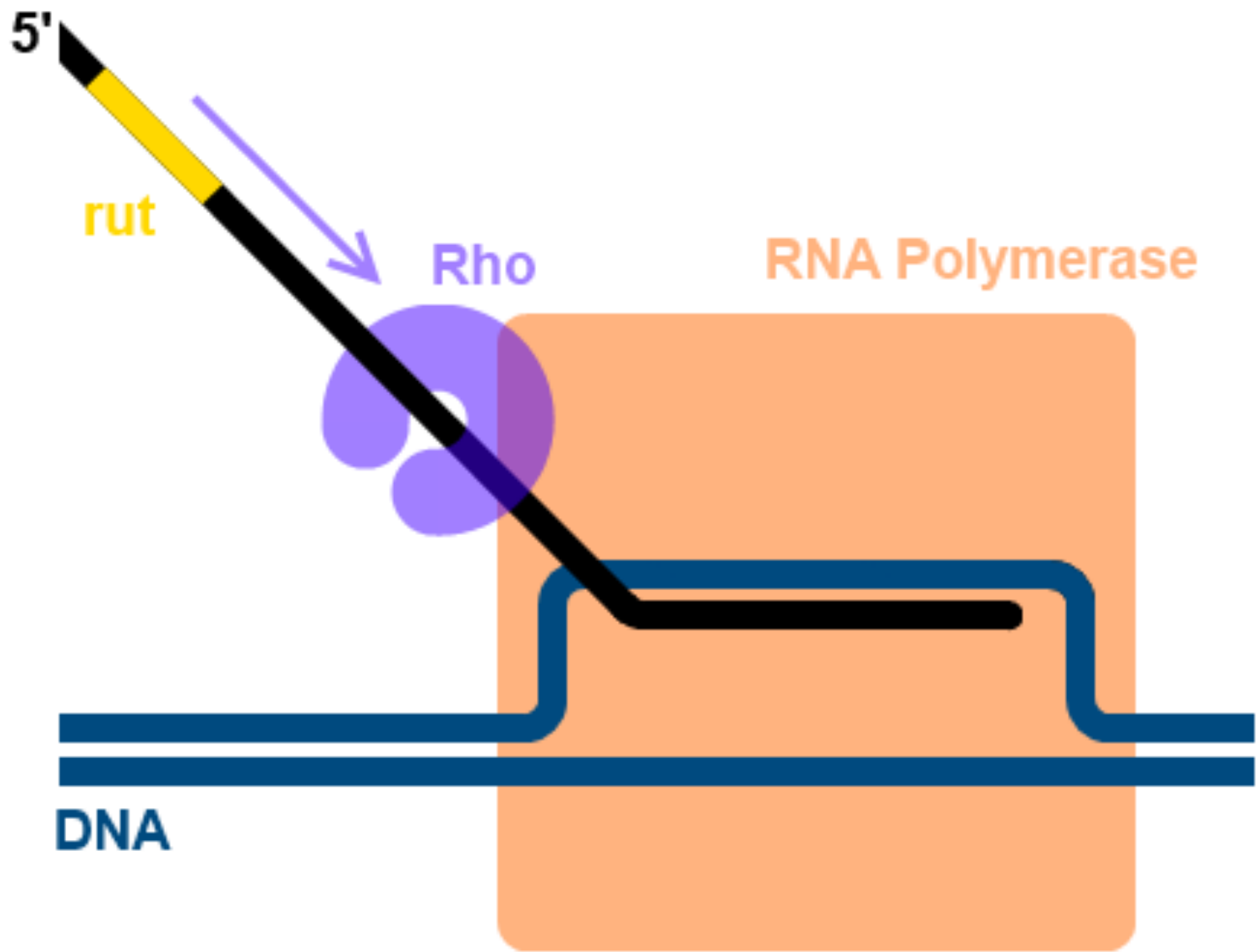
In Rho-dependent termination, the RNA contains a binding site for a protein called Rho factor. Rho factor binds to this sequence and starts "climbing" up the transcript towards RNA polymerase.



- Rho is able to catch up with the RNA polymerase. Contact between Rho and the RNA polymerase complex stimulates dissociation of the transcriptional complex through a mechanism involving allosteric effects of Rho on RNA polymerase.

transcription  $\rightarrow$  active site  
Rho Factor  $\rightarrow$  allosteric site  
confirmational changes  $\rightarrow$  RNA polymerase





## 2-Rho factor independent termination (intrinsic termination):

- The termination sequences is self-complementary sequences rich in GC that are present at the 3' end of mRNA. These complementary bases join each other forming hairpin loop like structure that leads to dissociation of RNA from the DNA and release the RNA polymerase enzyme.

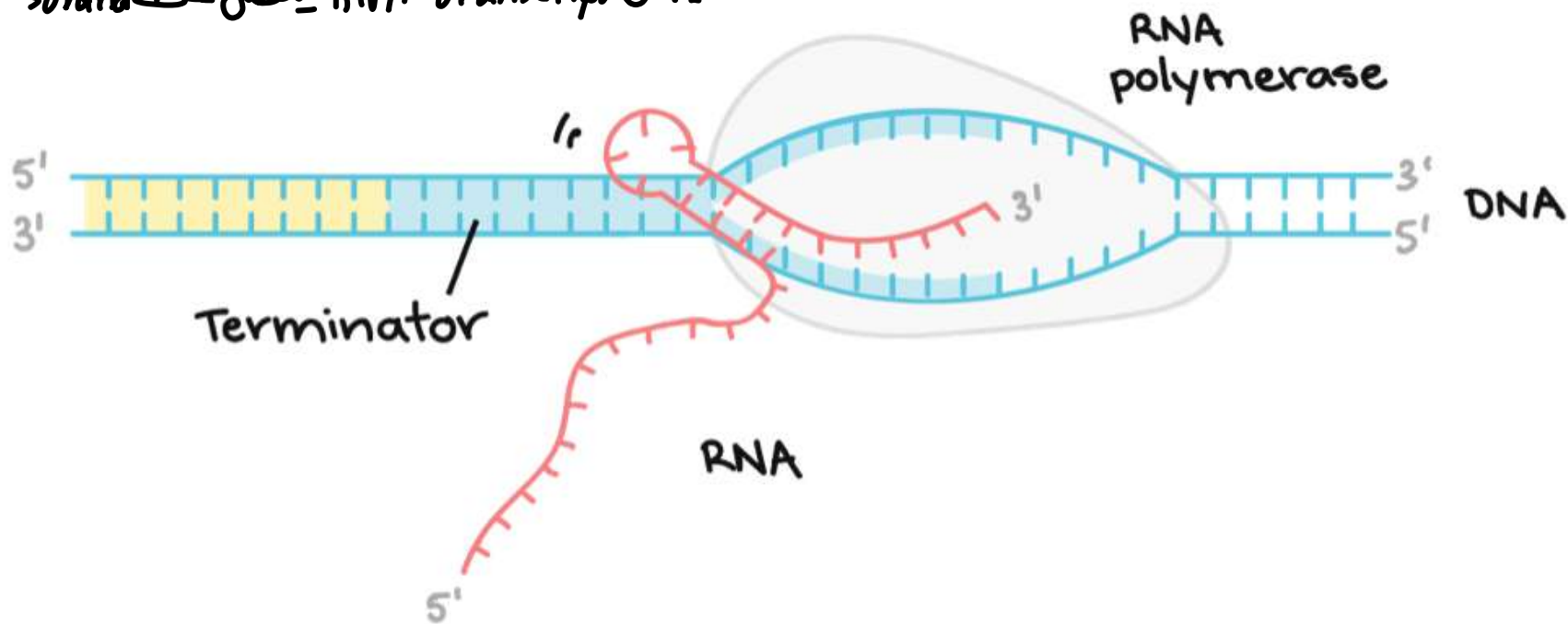
- The termination site is characterized by the presence of two regions that are separated by a few bases (4-6) in the form of a palindrome.
- DNA palindrome: A palindromic sequence is a nucleic acid sequence on double-stranded DNA wherein reading 5' to 3' forward on one strand matches the sequence reading 5' to 3' on the complementary strand with which it forms a double helix. (form symmetrical inverted repeat).
- When the RNA is created, the inverted repeats can loop back on themselves to form a hairpin loop, which acts as a termination signal.



المطوية مهمة للتخيل  
والكلام أهم 😊

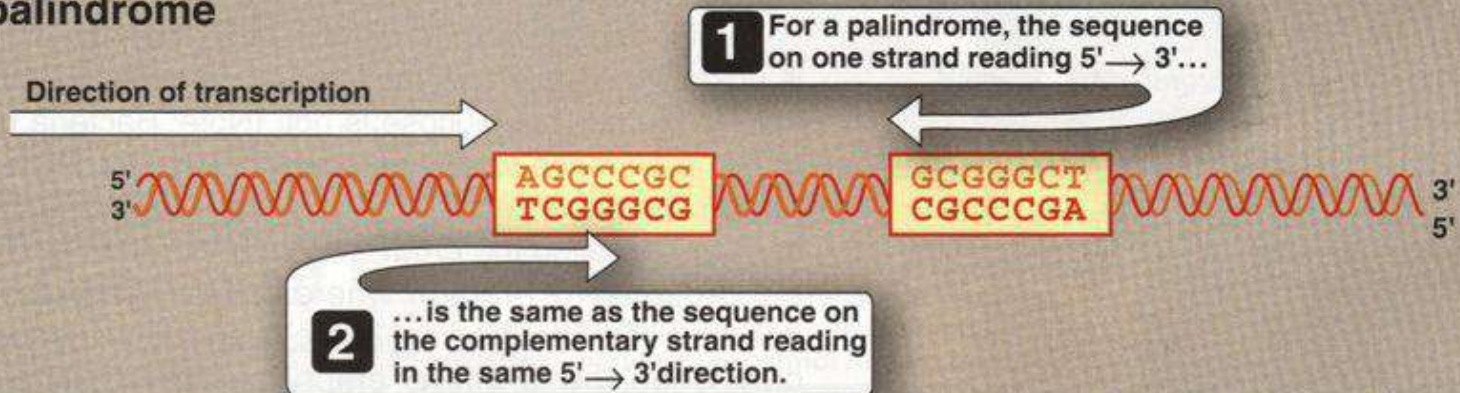
Rho-independent termination depends on specific sequences in the DNA template strand. As the RNA polymerase approaches the end of the gene being transcribed, it hits a region rich in C and G nucleotides. The RNA transcribed from this region folds back on itself, and the complementary C and G nucleotides bind together. The result is a stable hairpin that causes the polymerase to stall.

الآن، ربطاً بين complementary C and G nucleotides  
يُشكل RNA transcript من نفس strand template

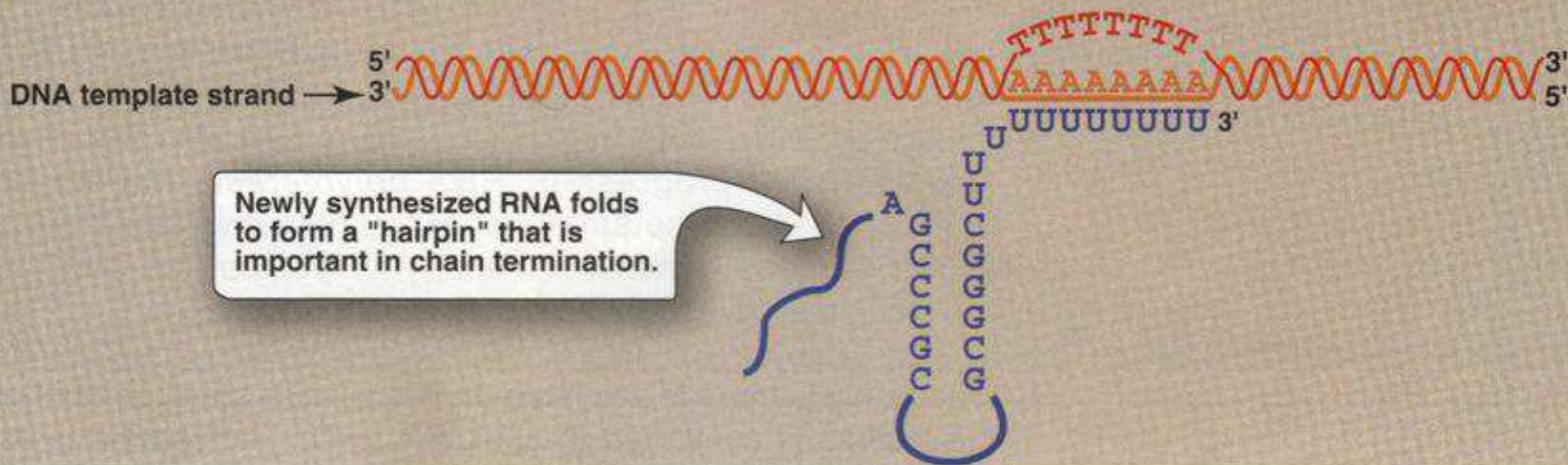


# Palindrome dependent Termination

## A DNA palindrome



## B Role of palindromes in the termination of RNA synthesis



**Figure 30.9**

Rho-independent termination of transcription. A. An example of a palindrome in double-stranded DNA. B. A transcribed DNA palindrome codes for RNA that can form a hairpin turn.

template strand \*  
 RNA strand  
 3 يقابلها 3  
 3 يقابلها 3

Two fold symmetry

coding strand



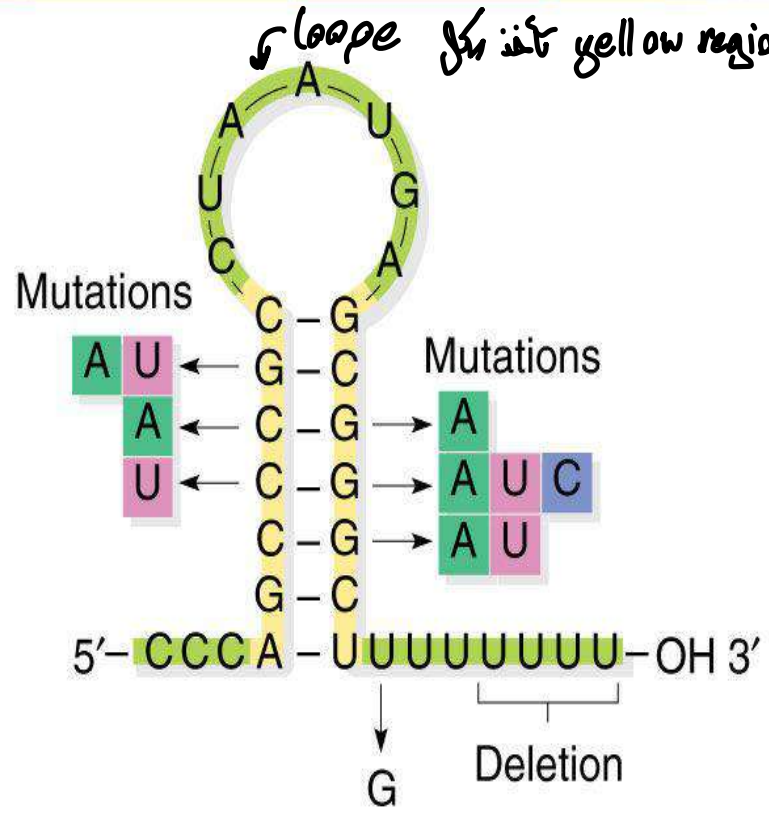
Template (DNA) 5' CCCAGCCCGCCTAATGAGCGGGCTTTTTTTTGAACAAA 3'  
 3' GGGTCGGGCGGATTACTCGCCCGAAAAAAAAACTTGT TTT 5'

Template strand

Transcript (RNA) 5' CCCAGCCCGCCUAAUGAGCGGGCUUUUUUUU-OH 3'

loop yellow regions  
 في بين green region

Transcript folded to form termination hairpin



← Two fold symmetry →



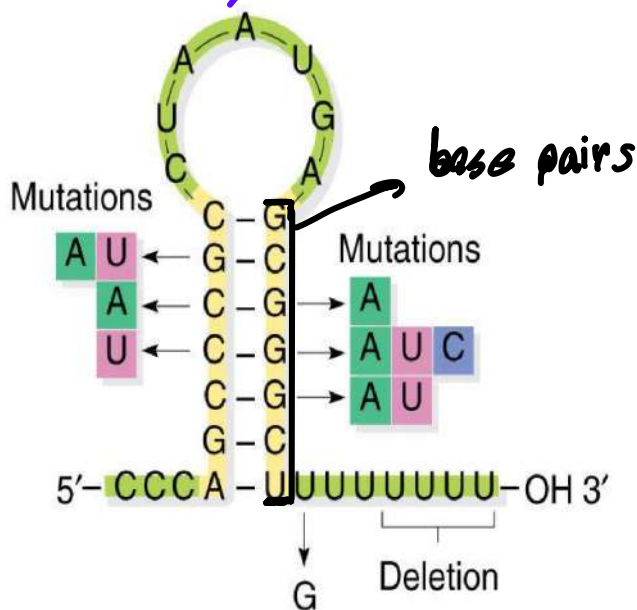
في المنطقتين (pink regions) ← القراءة من 3' → 5' في template strand في نفسنا من 3' → 5' في coding strand  
 palindromic sequences  
 symmetrical inverted repeat



(transcript ← U ← coding ← T) sequence of coding strand ← DNA transcript

complimentary بعض  
 hairpin structure  
 وهذا يجعل RNA ينفذ لوحده (بدون الريبوسايم)

yellow regions ← template strand في pink regions ←  
 غنية بـ G, C



# Regulation of prokaryotic gene expression

❖ *There are two types of gene according to their expression:*

genes دائماً تصعب (ماين ليه يصعب لها)  
(turn of turn on) ↗

1-Constitutive genes: البروتينات الي بتنتجها ضرورية بدونها فان الخلية تموت

- These genes are not regulated,
- They code their protein products which are required for the basic cellular functions and so, they are continuously expressed at a low rate;
- They are also known as “housekeeping” genes.

basic cellular functions و proteins الي بتنتجها مهمة ↖

لن يحدث لها expression, الا اذا اعدت تعبير  
(to induce expression) ← inducer

## 2-Inducible genes:

- They express their protein product only in the presence of an inducer or derepressor.  
← يعني دائماً فيه repressor موقفه انتاجها و inducer يبع derepresor (يعني على derepressor)  
repressors تمنع repression  
للجينات فتعيق انتاج البروتينات.
- They are negatively regulated by specific proteins termed repressors.
- The inducer produces inactivation of the repressor.

genes تعطي enzymes التي تدخل في metabolic pathway

يكونوا متجمعتين في منطقة في الكروموسوم وجانبهم في هذه المنطقة

expression of structural genes تتكلم في

regulatory genes تعمل هذه الجينات

- In bacteria, the structural genes that code for the enzymes of a metabolic pathway are often found grouped together on the chromosome together with the regulatory genes that determine their transcription as a single long piece of mRNA.

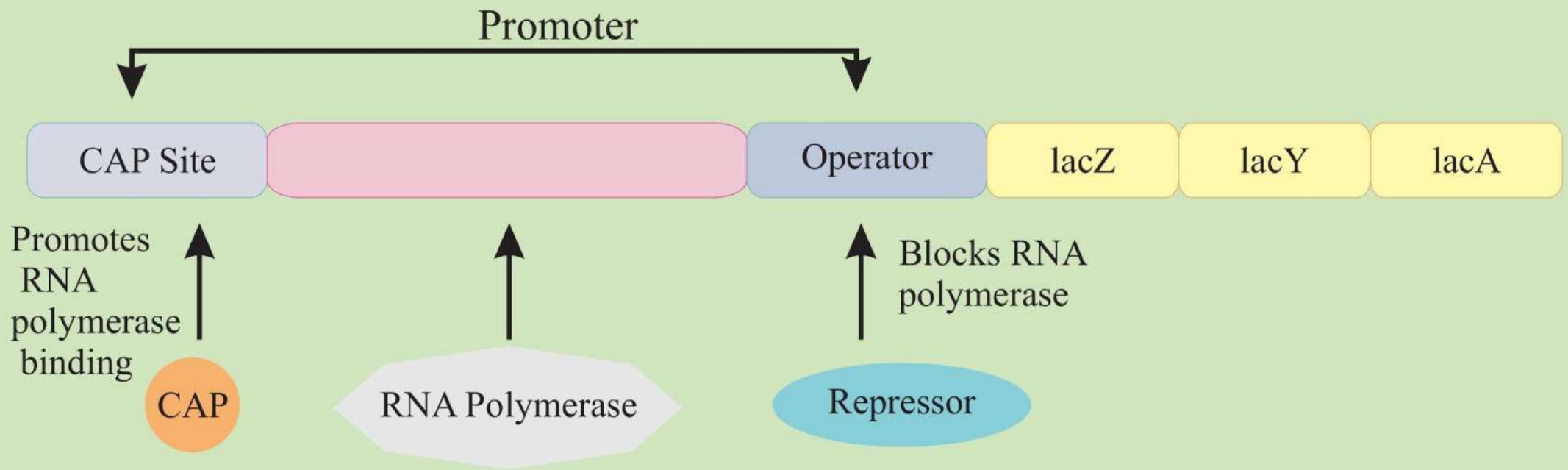
- This entire package is referred to as an operon.

structural genes ← التي ربح تنتج enzymes تدخل في metabolic pathways  
 regulatory genes ← تنتج proteins تتكلم في انتاج structural genes } operon

- So operon is a linear array of the genes that are involved in a metabolic pathway.
- One of the best understood examples is the lactose operon of E. coli.

للمجموعة الجينات التي تدخل في

metabolism of lactase in this bacteria



**THE LAC OPERON**



## The lactose operon of E coli (as a model of prokaryotic gene regulation)

- Lac operon contains the genes responsible for lactose metabolism by E coli bacteria when lactose is available to the cell but glucose is not.
- [Note: Bacteria use glucose as a fuel in preference to any other sugar.]

E coli تفضل استخدام glucose ولكن في بعض الأحيان تفضل بالي استخدام lactase كموصلر ملاقة  
عند عدم وجود glucose في الخلية

**\*The Lac operon of E-coli is formed of:**

**1-Structural genes:** They are three linked **inducible** genes as follows:

inducible genes  
 (يحل لها expression عند وجود inducer)

• **-Lac Z gene;** encodes  **$\beta$ -galactosidase** that hydrolyses lactose to glucose and galactose.

ينتج  $\beta$ -galactosidase بكمية كبيرة  
 lactose  $\rightarrow$  glucose + galactose

• **-Lac Y gene:** encodes **permease** enzyme that allows lactose transport into the cells.

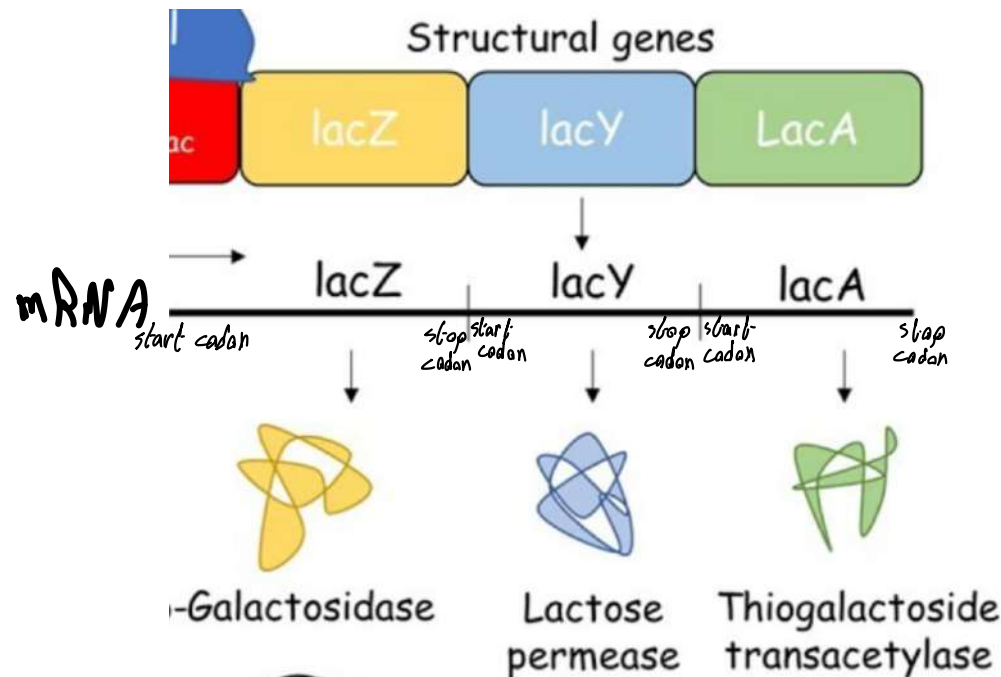
ينتج permease يسمح بدخول lactose إلى الخلية

• **-Lac A gene:** encodes **thiogalactoside transacetylase** of unknown function.

ينتج thiogalactoside transacetylase  
 وظيفته غير معروفة

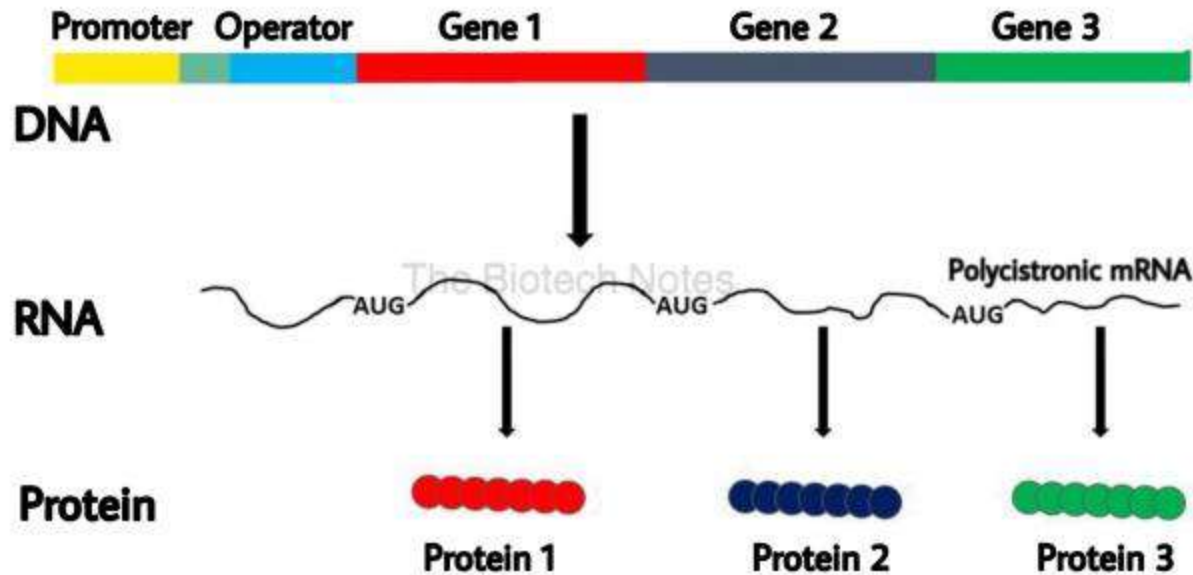
• The lacA gene encodes thiogalactoside transacetylase, which rids the cell of toxic thiogalactosides that also get transported in by lacY. (i.e. cellular detoxification)

بس الآن يُقال انه يدخل الخلية من toxic thiogalactosides (تدخل عن طريق permease) وينقل acetyl group وينقل منه



- The three linked genes are transcribed into one large polycistronic mRNA molecule that contains multiple independent translation start and stop codons for each cistron.  
ہے یعنی اسی ایک ٹرانسکرپٹ cistron
- Thus, each protein is translated separately and they are not processed from a single large precursor protein.  
لے یعنی انہم لیسوا عبارة عن س upanib لبروتین کیر precursor protein

- اگر 3 جینات ہیں تو transcription ایک ہی mRNA واحد (ولیس کی جین نتیجہ mRNA کا ہے)۔  
 - ایک ہی mRNA جو start codon > stop codon تک جین (یعنی نتیجہ 3 proteins enzymes)۔



- **A gene** is a part of DNA that gets transcribed into an RNA( mRNA, tRNA, rRNA or any other form of rna) *بيني. لو + stop codon + start codon و mRNA من جزيء ← cistron*
- **Cistron** is a part of mRNA that begins with a start codon, ends with a stop codon and in between these codons lies the series of codon which code for a single polypeptide. *النامية codon protein في.*
- You can say that cistron is the part of mRNA that gets translated into polypeptide.

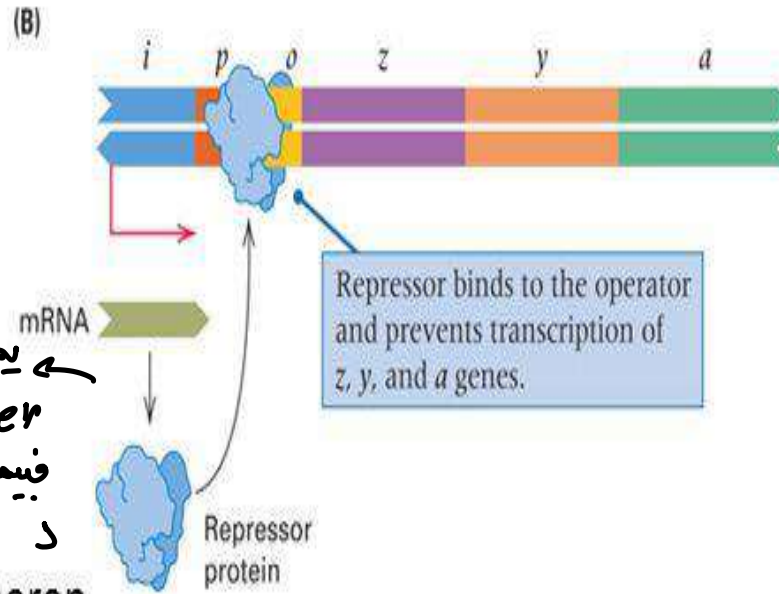
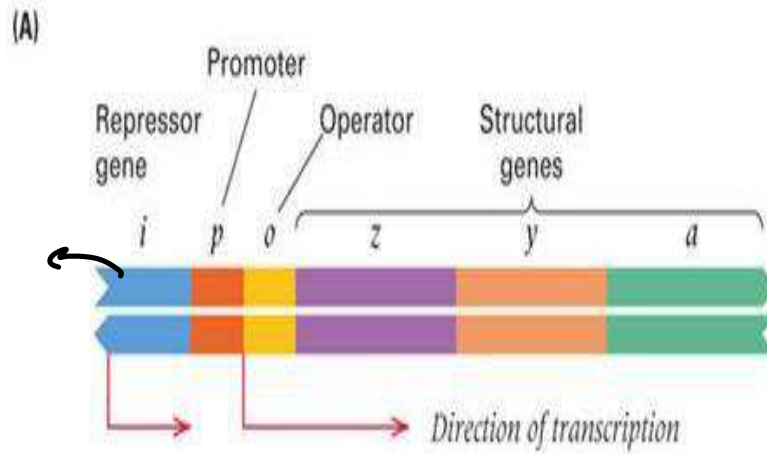
constitutive genes هي عبارة عن  
المنتجات التي ينتجها إنتاجاً  
بالتوازي

2-Regulatory gene or lac I gene: It is  
lac repressor ينتج Lac operon دائماً مقبول  
constitutive genes بسبب وجود Lac repressor  
products and codes for the regulatory  
protein (Lac repressor).

**3-Operator region:** At which Lac repressor binds  
and inhibits gene expression.

**4-A single common Promoter:** It is the site  
where RNA polymerase binds to it and start  
transcription of the structural gene.

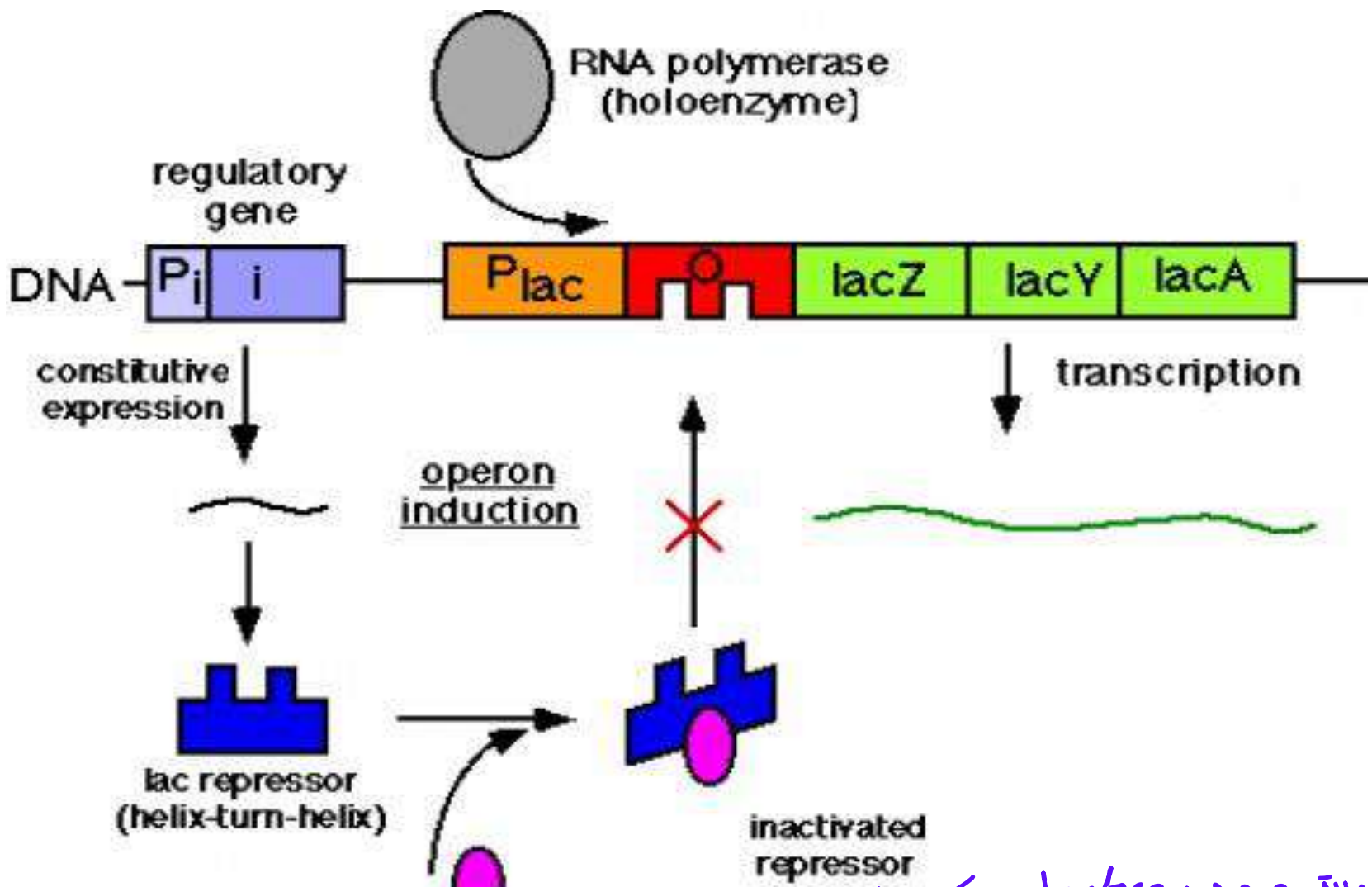
regular gene  
lac repressor



يعمل في  
operator ويكون كغلق  
promoter (أي RNA polymerase يرتبط فيه)  
فيمنع حدوث  
transcription  
structural gene

Figure 9.4a/b: lac operon

طبيعي وجود repressor دائما لأنه الفروض ما مستخدم lactose، إلا عند  
غياب glucose



يتم صنع  $i$  repressor وغيره من الكودون  
 بحيث لا يستطيع الارتباط  
 بـ  $O$  (عند غياب  $glucose$ )  
 inducer (allolactose) → isomer  
 lactose من

في حالة مع وجود  $lactose$  لن يكون لدينا  
 inducer وحتى انه لا يوجد  $lactose$  نعمل له  
 metabolism



## ■ When glucose is the only sugar available (Gene repression):

- In this case, the lac operon is repressed (**turned off**).  
→ repressors واقف على operator
- Repression is mediated by the repressor protein binding to the operator site, which is downstream of the promoter region.
- Binding of the repressor interferes with the progress of RNA polymerase, and blocks transcription of the structural genes.
- This is an example of negative regulation.

إرباط repressor ← يمنع إرباط RNA polymerase

## When only lactose is available (Gene induction):

- In this case, the lac operon is induced (**maximally expressed or turned on**).
- A small amount of lactose is converted to an isomer, allolactose. This compound is an inducer that binds to the repressor protein, **changing its conformation** so that it can no longer bind to the operator.
- This allows RNA polymerase to enter at the promoter region and initiate transcription of the structural genes. **This is an example of positive regulation.**
- After the inducer or lactose is removed, expression of the lac operon stops quickly because **the lac mRNA is unstable and decays within minutes.** *لکٹوز گلوکوز و جیو د glucose*

5' AAA AUG AGU AAG 3'

Which of the following DNA strands could have been the template for this RNA?

Choose 1 answer:

- (A) 3' TTT ATG TGC TTC 5'
- (B) 3' UUU TAC UCA UUC 5'
- (C) 3' AAA ATG AGT AAG 5'
- (D) 3' TTT TAC TCA TTC 5'

Which of the following is true regarding the process of transcription?

Choose 1 answer:

- (A) Transcription occurs for individual genes.
- (B) Transcription uses both strands of DNA to make mRNA.
- (C) DNA polymerases control transcription.
- (D) The three stages of transcription are initiation, elimination, and reduction.

Match the following events with the correct stage of transcription.

|  | Initiation            | Elongation            | Termination           |
|--|-----------------------|-----------------------|-----------------------|
| RNA polymerase stops transcribing.   | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| RNA polymerase binds to the promoter.  | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |
| RNA polymerase adds complementary nucleotides to the 3' end of the RNA strand. | <input type="radio"/> | <input type="radio"/> | <input type="radio"/> |

What steps are needed to produce a mature mRNA?

Choose all answers that apply:

- (A) A tail of C nucleotides is added to the end of the RNA.
- (B) A 3' cap is added to the beginning of the RNA.
- (C) Exons are joined together to form the mature mRNA.
- (D) Introns are removed from the sequence.