



Molecular Biology (5)

Transcription

Mamoun Ahram, PhD

Resources



- This lecture
- Cooper, Ch. 4, pp. 119-121, Ch. 8



Definition of a gene

polypeptides is a sequence of amino acids that do not have 3D shape as a protein
polypeptied + it has 3D shape ← so



long Non-coding RNA ⇒ do not translated to protein

- The entire DNA sequence that is necessary for the synthesis of a functional RNA (mRNA, rRNA, tRNA, lncRNA, microRNA, etc.) or a polypeptide, which may become a protein or functional peptides.

messenger
ribosomal
transfer
only by mRNA

- The DNA sequence encompasses ^{يشمل} the coding region (that makes the protein), other regulatory sequences like a promoter, an enhancer, etc., or a non-coding region like introns.

- A cistron: an alternative term of a gene.

should be mature: has been processed (حاصل له كل عمليات الشكيل)

- If it encodes one polypeptide from one mRNA, it is monocistronic. → *the gene*
- If it encodes several or different polypeptides from ONE mRNA molecule, it is polycistronic.





The general mechanism of transcription



General description



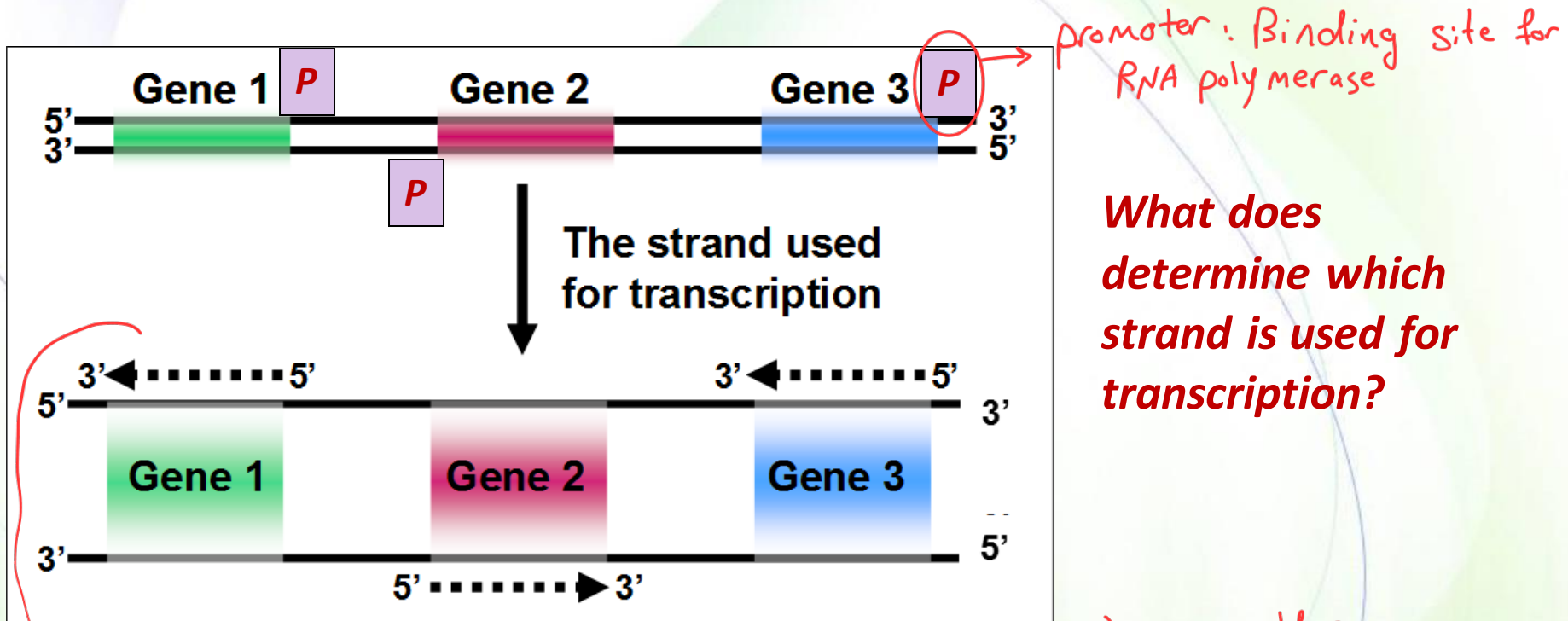
- Transcription is the process of **making RNA from DNA**.
- One of the two strands of the DNA double helix acts as a template for the synthesis of an RNA molecule.
 - *Remember?* In **DNA replication, both strands are the template of the daughter strands.**



Using DNA strands



- Although RNA polymerase can read both DNA strands, it uses one strand for any particular gene in order to make RNA.



What does determine which strand is used for transcription?

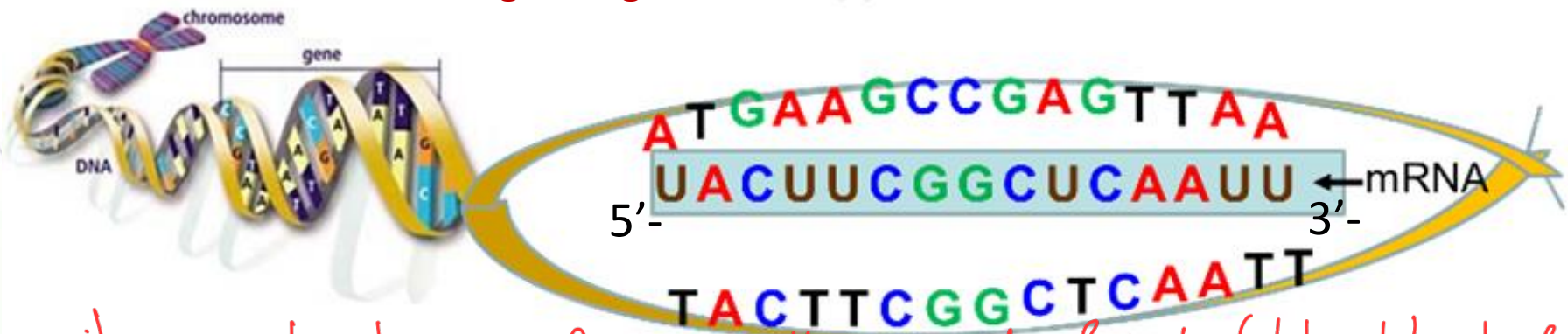


Complementary sequences



- RNA is complementary to its DNA template.
- The RNA chain produced by transcription is also known as the transcript.

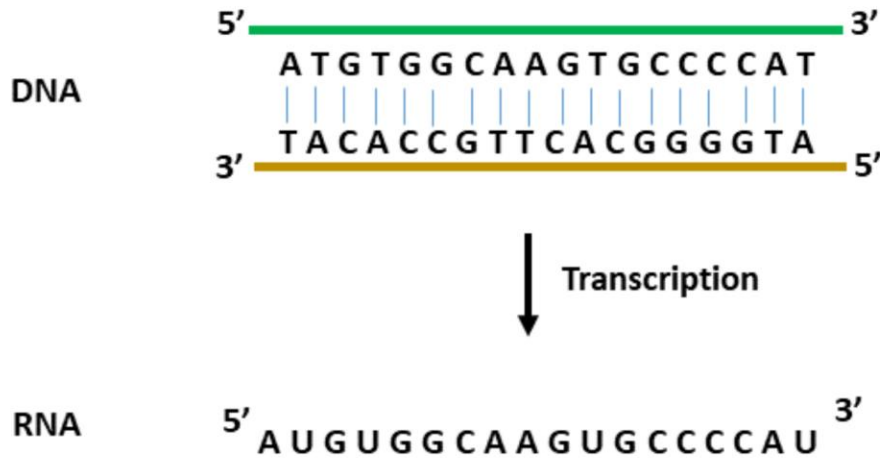
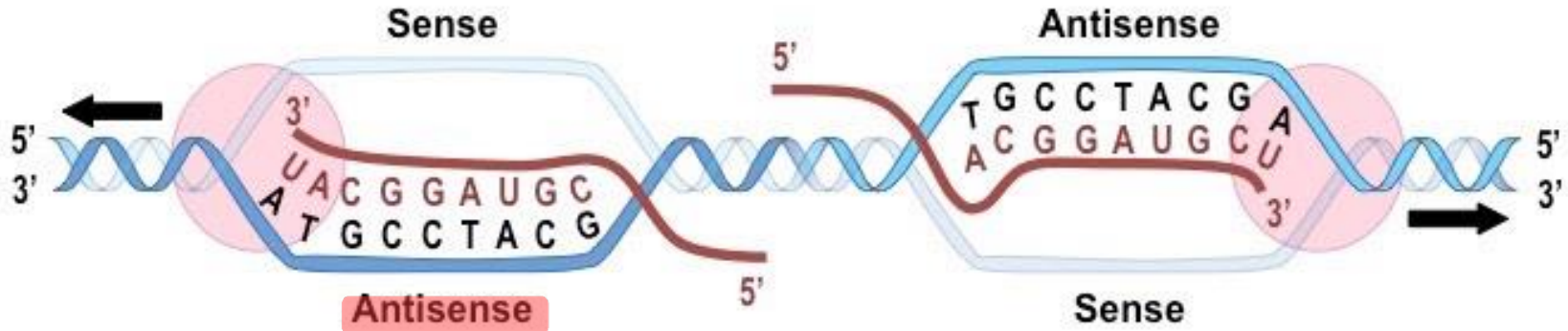
The growing RNA chain is extended in the 5' to 3' direction.



it is almost copy from the other strand of DNA (it has U instead of T)



More clarification and some extra terms



it has the same code of RNA

Non-template/ Sense/ Coding strand

Because it has a Complementary bases

Template / Antisense/ Non-coding strand
(transcribed strand)

Enzyme and substrate



- The enzymes that perform transcription are called RNA polymerases.
- They catalyze the formation of the phosphodiester bonds between two nucleotides.
- The substrates are nucleoside triphosphates (ATP, CTP, UTP, and GTP).
 - *(ribo nucleoside triphosphate)*
↳ not deoxyribo
 - **What are substrates for DNA polymerases?**
- Hydrolysis of high-energy bonds in NTPs provides the energy needed to drive the reaction forward.

*the energy come from same substrate (release of pyro phosphate)
triphosphate → mono phosphate*



DNA replication vs. transcription



- The RNA strand does not remain hydrogen-bonded to the DNA template strand. *So it will Fall Down*
- RNA polymerase reads the A in DNA and inserts U in the growing chain of RNA rather than T.
- RNA molecules are much shorter than DNA molecules.
- Unlike DNA, RNA **does not store** genetic information in cells.



DNA polymerase vs. RNA polymerase



- RNA polymerase catalyzes the linkage of **ribo**nucleotides, not **deoxyribo**nucleotides.
- Unlike DNA polymerases, RNA polymerases can start an RNA chain **without a primer**.
- RNA polymerases make about one mistake for every 10^4 nucleotides. *the DNA Replication make a mistake every 10⁸*
 - the consequences of an error in RNA transcription are much less significant than that in DNA replication.
- Although RNA polymerases are not as accurate as the DNA polymerases, they have a modest **proofreading mechanism**. *but less accuracy*

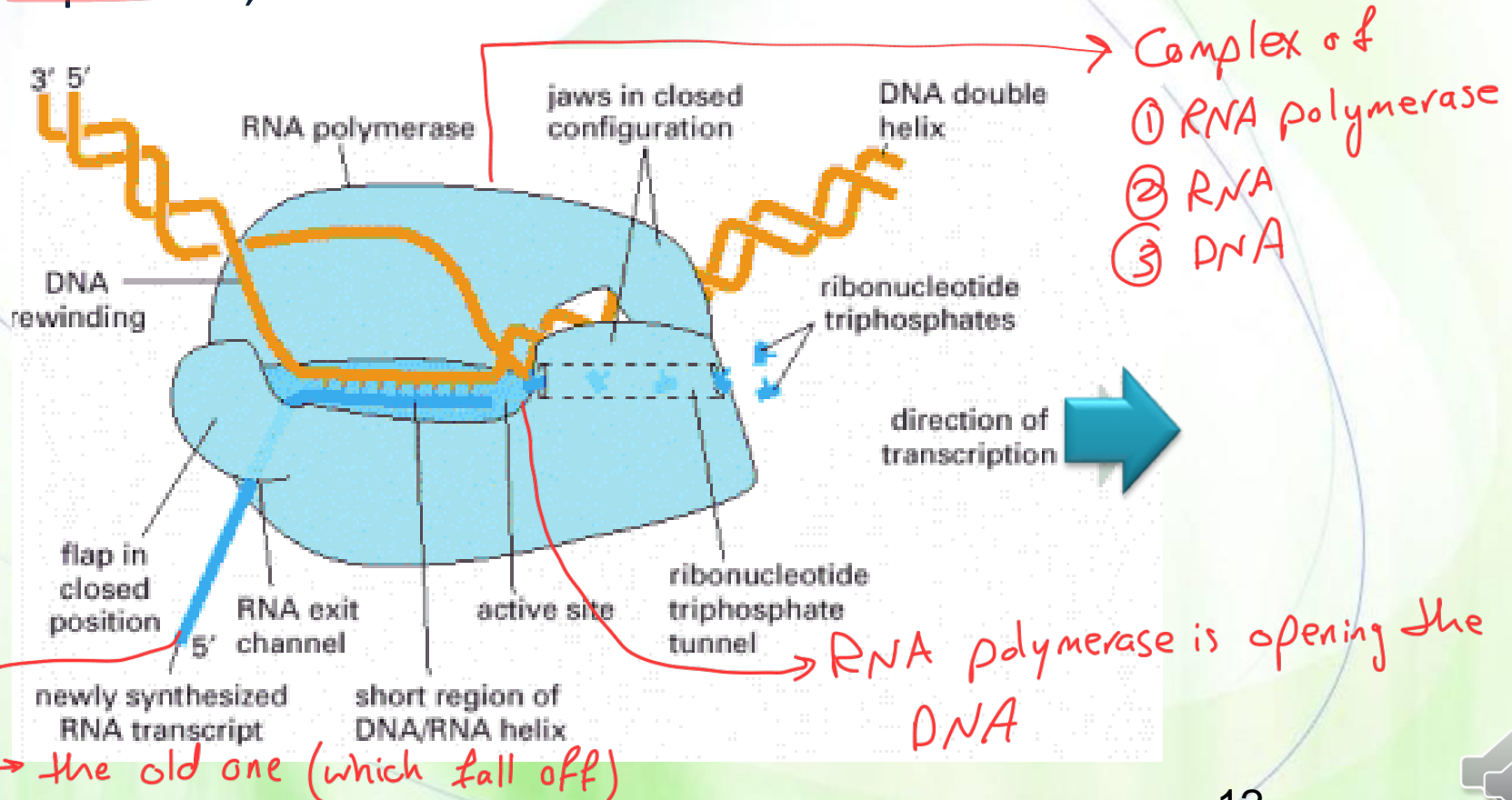


RNA binding to DNA is temporary



it hasn't bonds with DNA

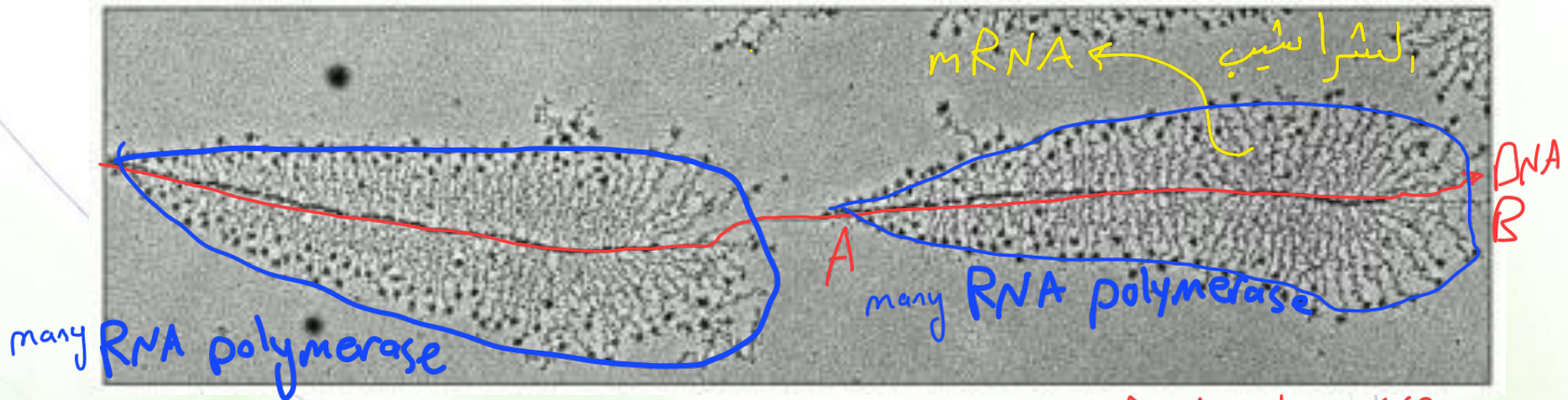
- As RNA is synthesized, it is **initially** bonded to DNA, but after a short distance, the older polymerized RNA nucleotides are **separated**, and the newer ones become bonded.



Polysomes



- This allows the simultaneous synthesis of many RNA chains from the same gene forming structures known as polysomes.



Where is the starting point of transcription?

Where is the beginning of the genes?

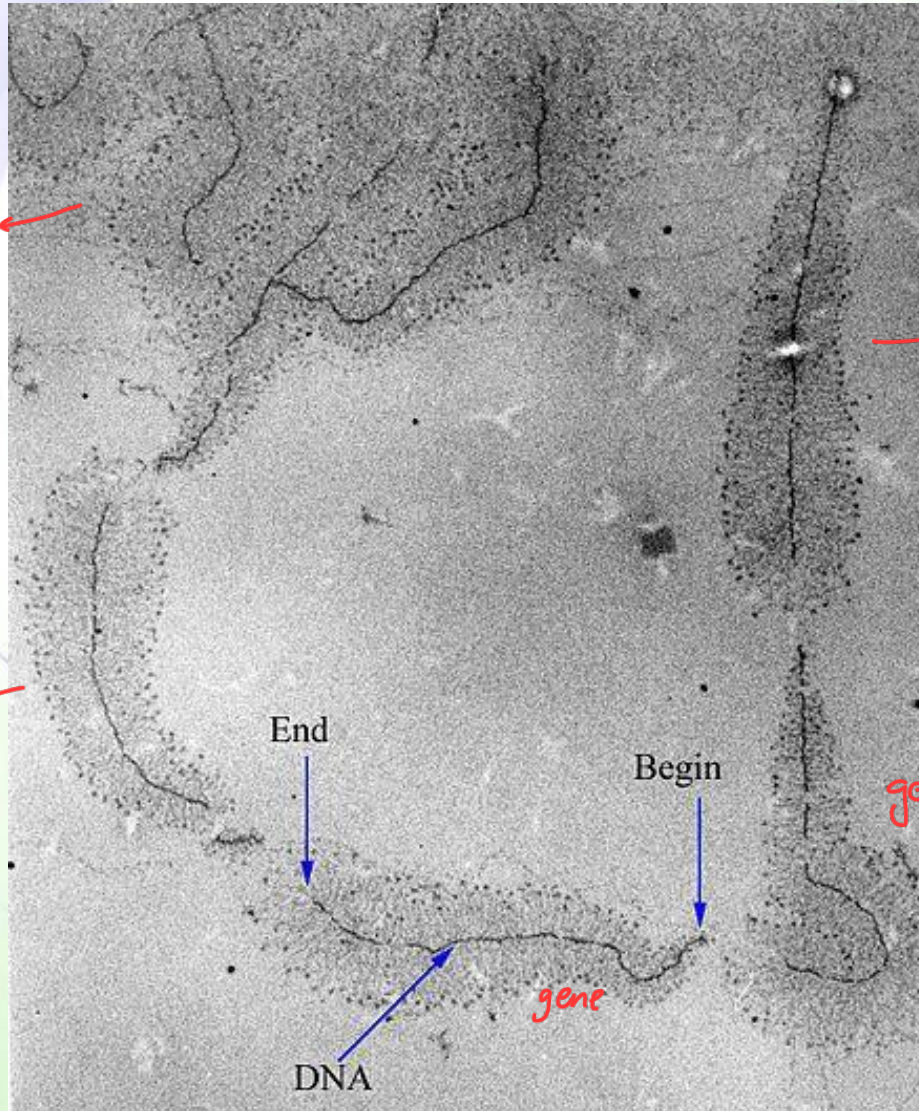
the point A because the RNA is very short but the fallen RNA in B is long

So many RNA polymerase transcript same gene

but started in different times



How many genes can you see?



all genes are being transcribed at the same moment.





Transcription in prokaryotes

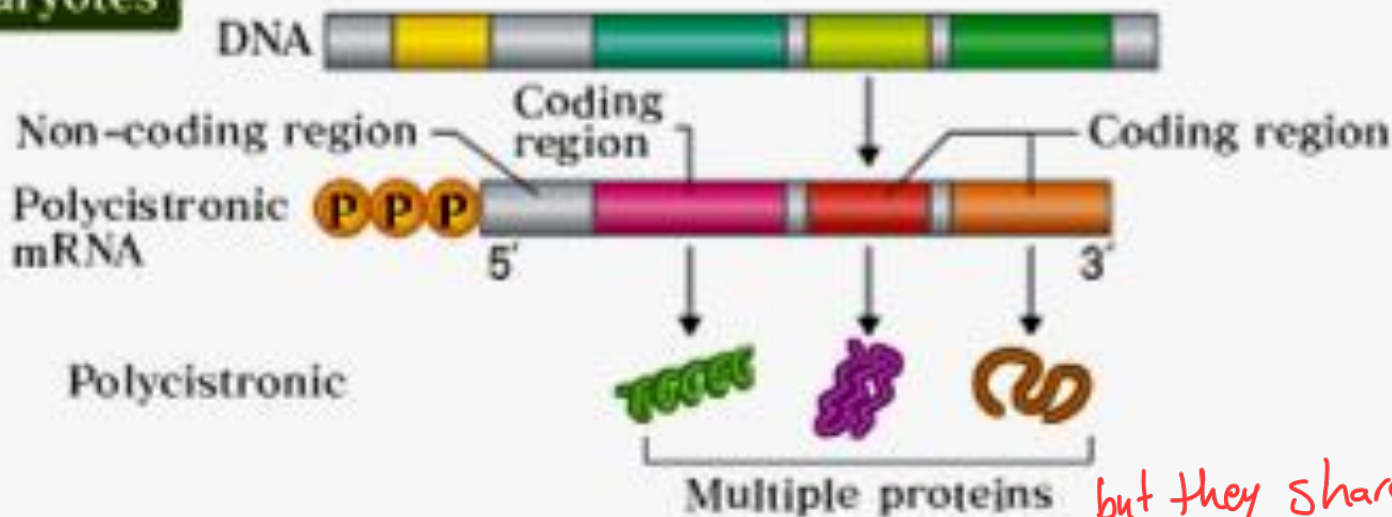


Prokaryotic genes (operons)



- In bacteria, genes can be polycistronic (*define!*). *that called*
- Genes that encode enzymes that are involved in related functions, are often transcribed as one unit from one cistron.
 - Example: the genes encoding the enzymes required to synthesize the amino acid tryptophan are contiguous. *from the same cistron*
- This cluster of genes comprises a single transcriptional unit referred to as an operon. *and the enzyme that synthesis lactose is also polycistronic*

Prokaryotes



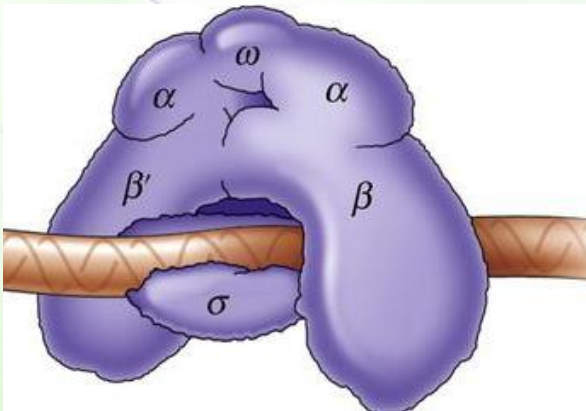
but they share same mechanism



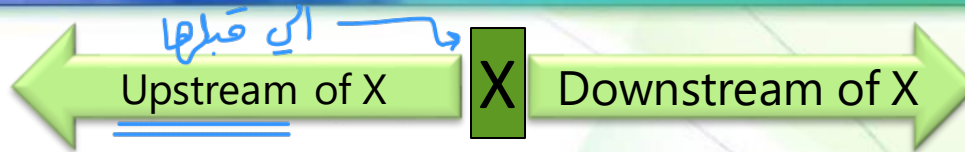
The RNA polymerase



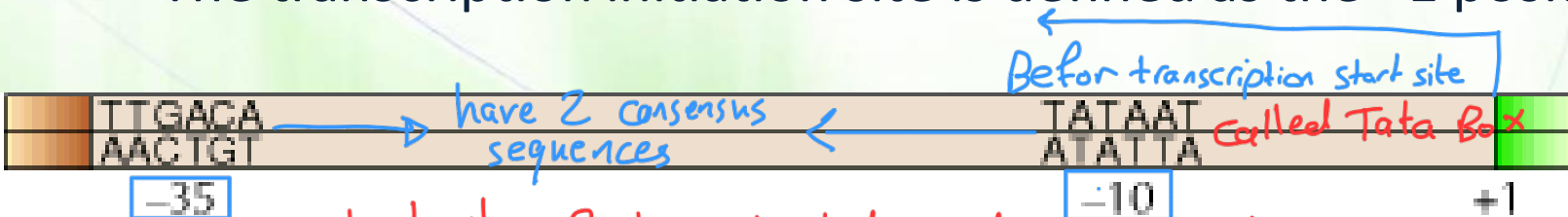
- E. coli RNA polymerase is made up of multiple polypeptide chains or subunits.
- The core polymerase consists of two α , one β , one β' , and one ω subunits. \rightarrow (core enzyme)
Omega \leftarrow
- The core polymerase is fully capable of catalyzing the polymerization of NTPs into RNA.
- The σ subunit is **not required** for the basic catalytic activity of the enzyme.



Consensus sequences (the promoter)



- The DNA sequence to which a RNA polymerase binds to initiate transcription of a gene is called the promoter.
 - A promoter is "**upstream**" of the transcription initiation site.
- The region upstream of the transcription initiation site contains two sets of sequences that are similar in a variety of genes.
 - **Consensus!**
- They are called the (-10) and (-35) elements because they are located approximately 10 and 35 base pairs **upstream of the transcription start site**.
- The transcription initiation site is defined as the +1 position.



Transcription start site: first nucleotide read by RNA polymerase
the 2th nucleotide called (+2) which we call it (+1)



Role of the σ subunit



it guides the RNA polymerase to the promoter region

- In the absence of σ , the RNA polymerase binds to DNA with low affinity and nonspecifically.
↳ low strength binding
- The role of σ is to identify and guide the polymerase to the -35 and -10 sequences.

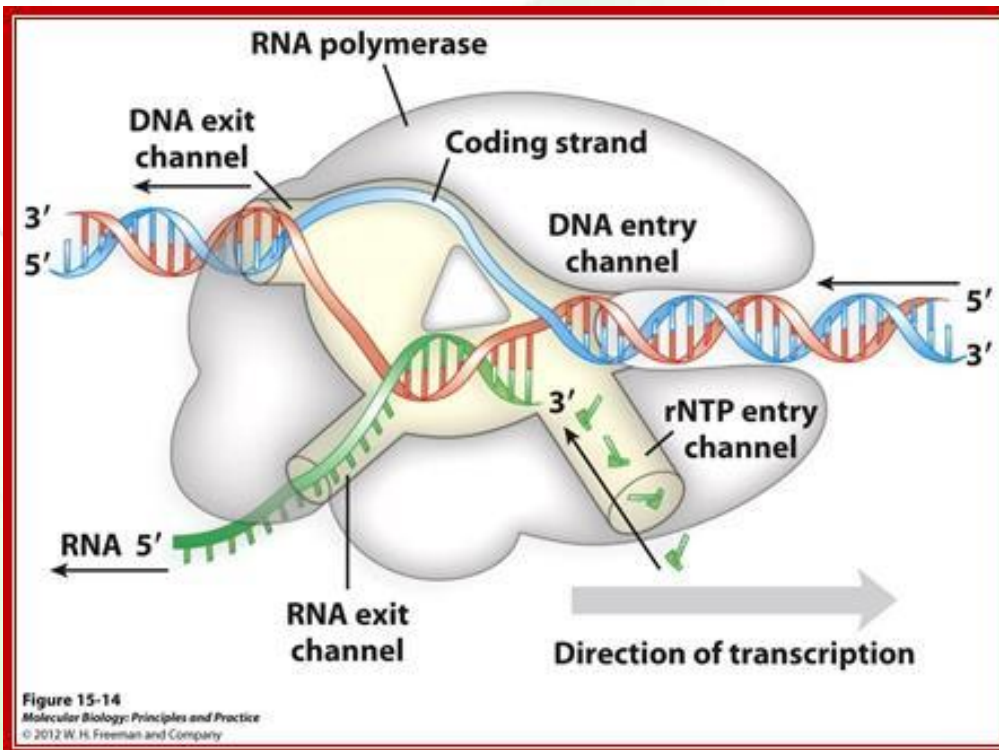


Figure 15-14
Molecular Biology: Principles and Practice
© 2012 W. H. Freeman and Company

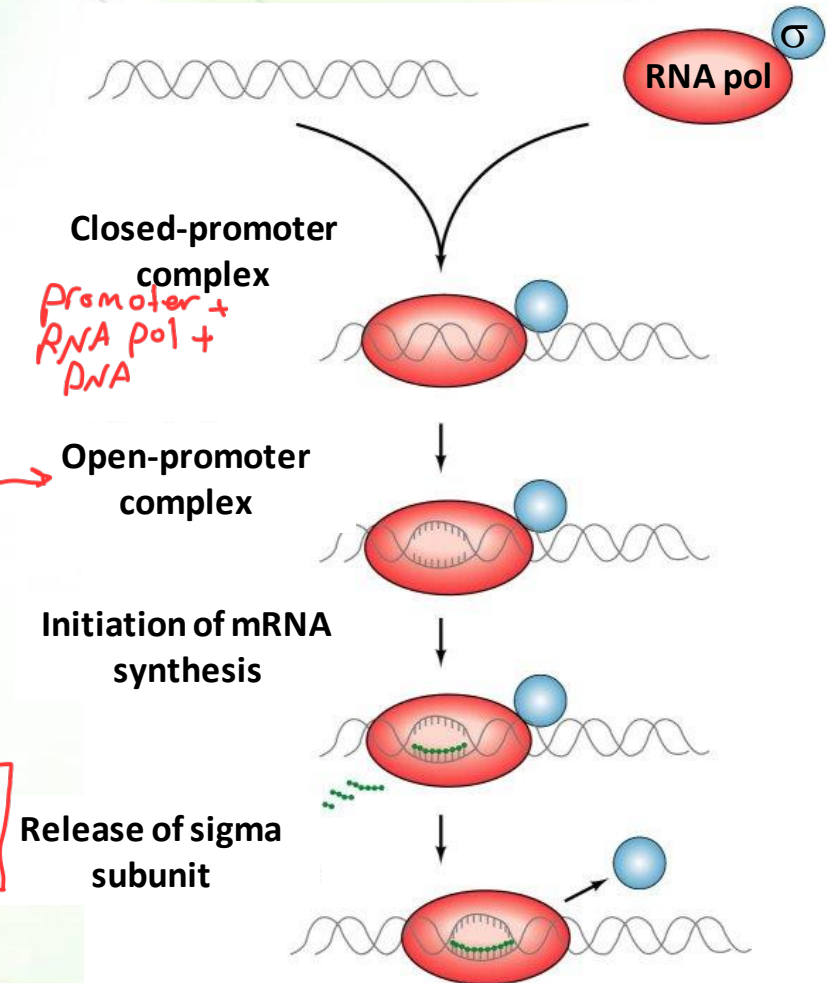


Mechanism of transcription



(initiation) ← first step

- The RNA polymerase binds to the promoter and opens it (like what?). *Helicase* then called
- The single-stranded DNA is now available as a template.
- Transcription is initiated by the joining of two NTPs.
- After addition of about 10 nucleotides, σ is released from the polymerase. *which will bind to other RNA pol.*
- *What do you think happens to it?*

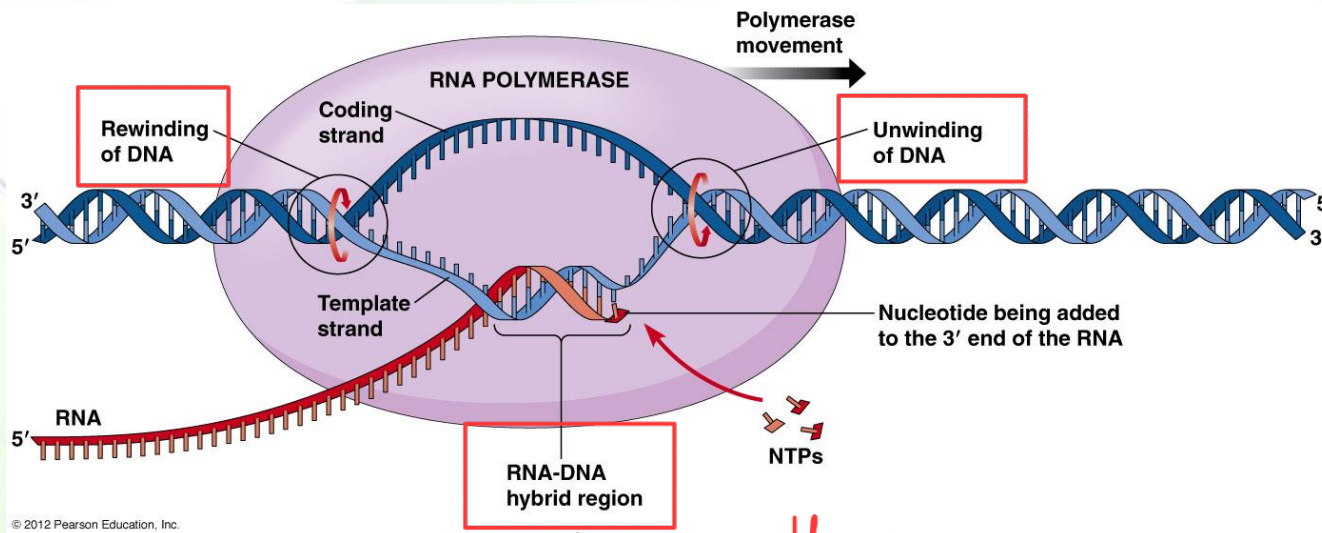


Mechanism of transcription



(elongation)

- As the polymerase moves forward, it
 - unwinds the template DNA ahead of it (*like what?*)
 - elongates the RNA
 - rewinds the DNA behind it



© 2012 Pearson Education, Inc.

↳ synthesis

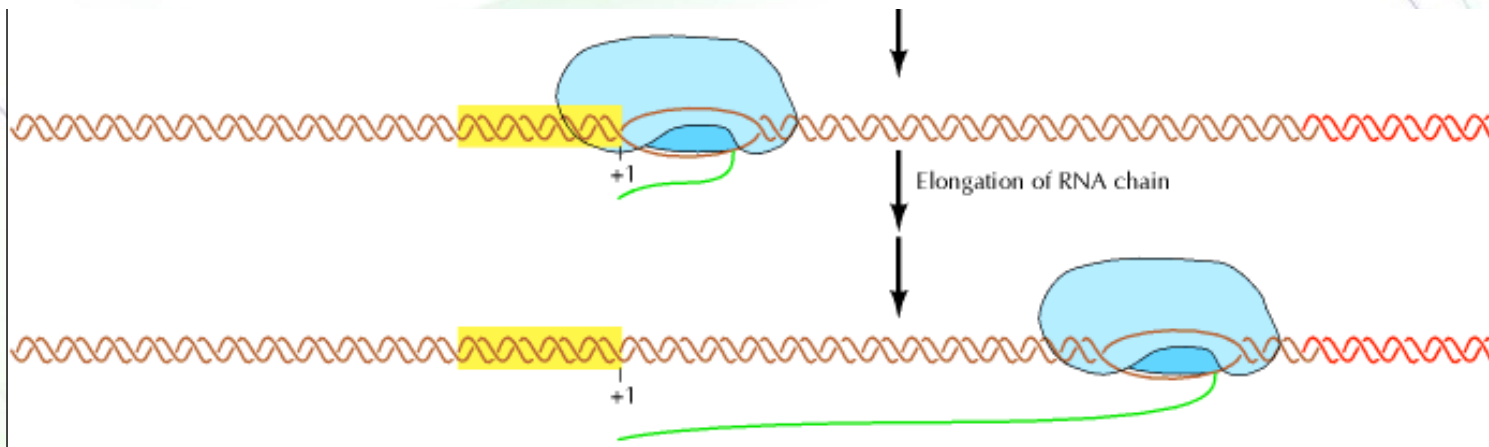


Mechanism of transcription



(termination) *final step*

- RNA synthesis continues until the polymerase encounters a termination signal where the RNA is released from the polymerase, and the enzyme dissociates from its DNA template.



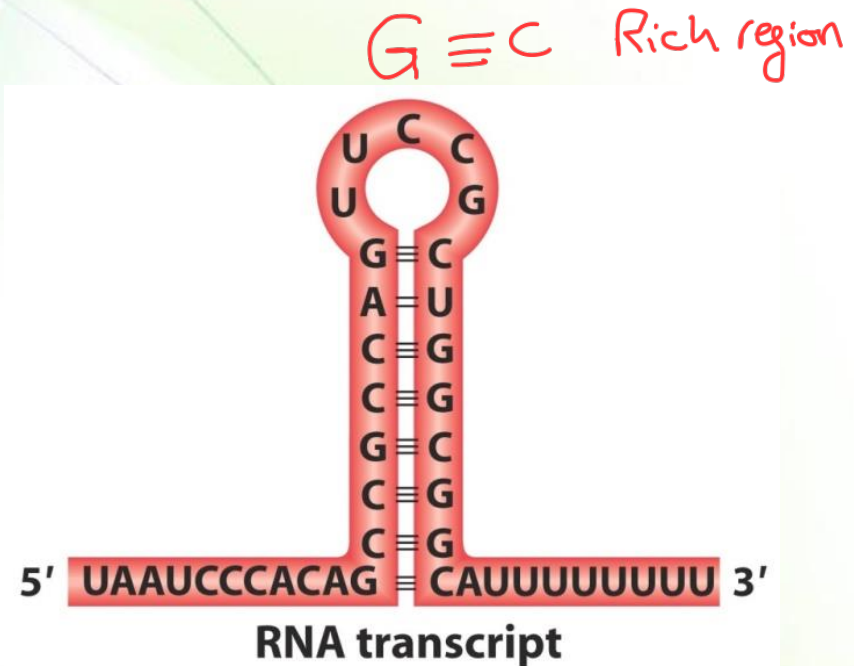
Termination sequences



which is consider consensus sequence too.

- The simplest and most common type of termination signal among genes (*what do we call it?*) in *E. coli* consists of a symmetrical inverted repeat of a GC-rich sequence followed by A residues (*why?*). and U on RNA

- Transcription of the GC-rich inverted repeat results in the formation of a stable and strong stem-loop structure.



Because it is weak the mRNA will disattach from DNA



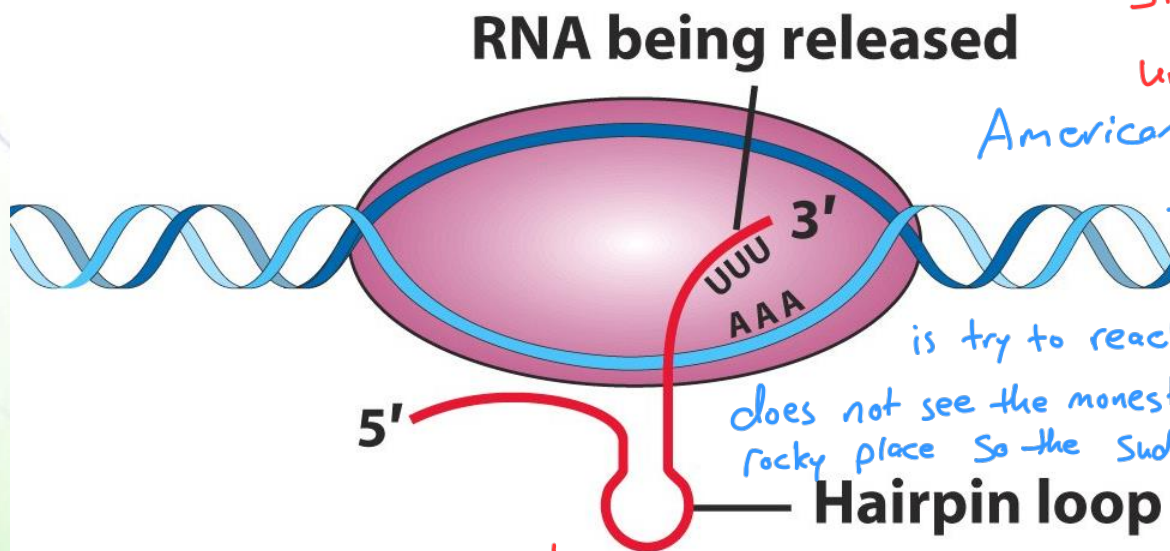
The effect of the stem loop structure



- The formation of this structure breaks RNA association with the DNA template, **destabilizes** the RNA polymerase binding to DNA, and terminates transcription.

the doctor said this story to make it easy to understand (I don't know how 😊)

American action movie:
the hero is walking on green land and monester is try to reach him (from Back) But the hero does not see the monester and he reach a wet and rocky place So the Suddenly the monester appeared and because the monester has



heavy weight (شكاه كين جحي من و من 😊) the earth has shivered and the hero fall down (كمان شكاه رطل من جوي بشير 😊)

* الله يسامك يا دكتور على هيك قصة
كيت بدني فيها من قادر اكل دراسة
😊



لأنني كارت إنك ما دورت عليها 😄 جيت لك إياها

