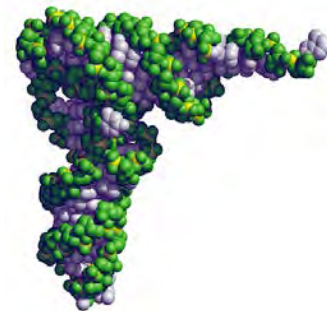
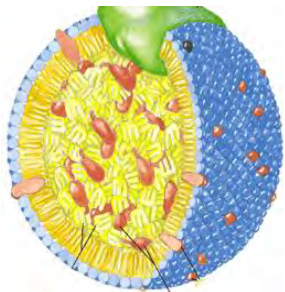


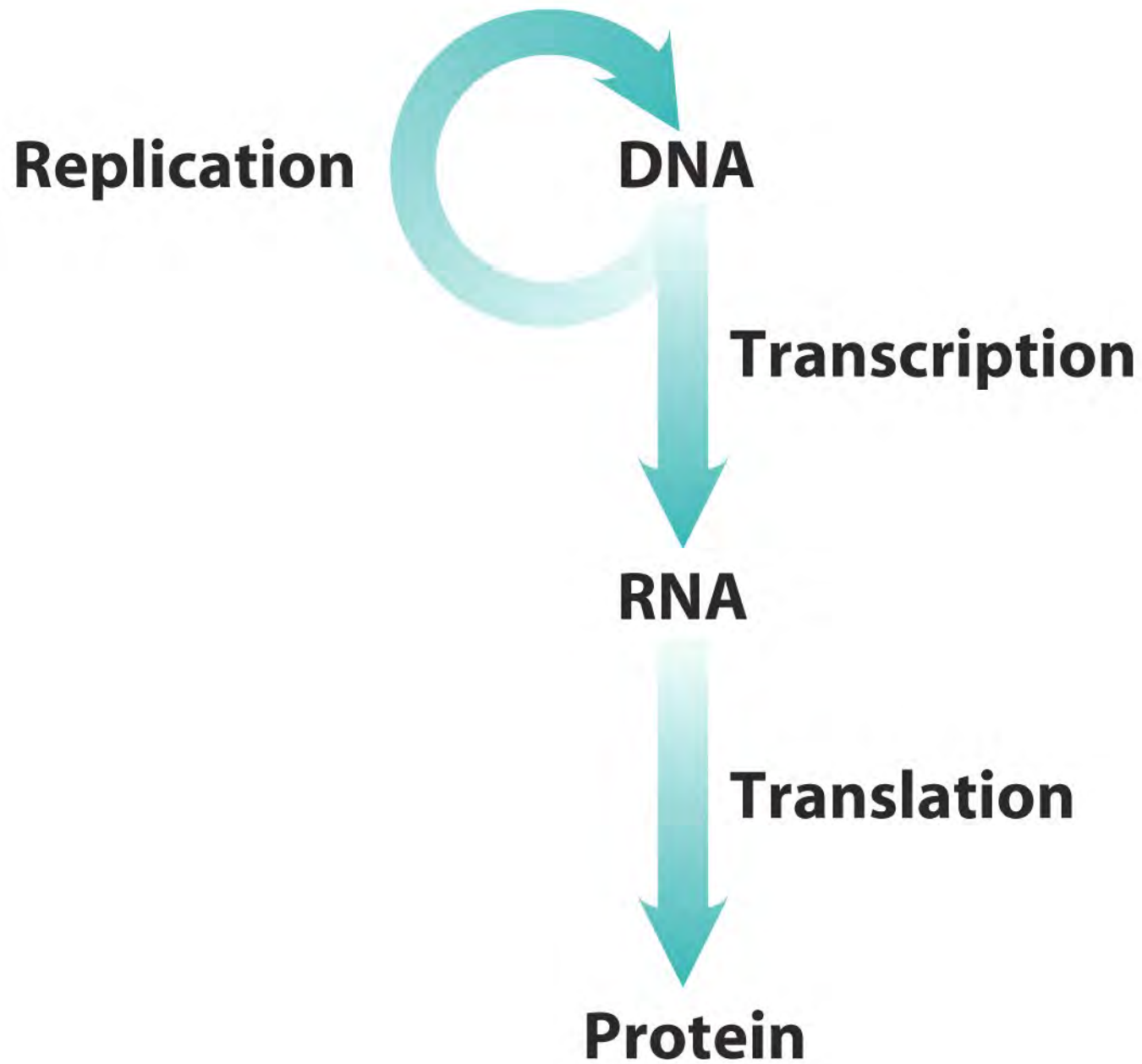


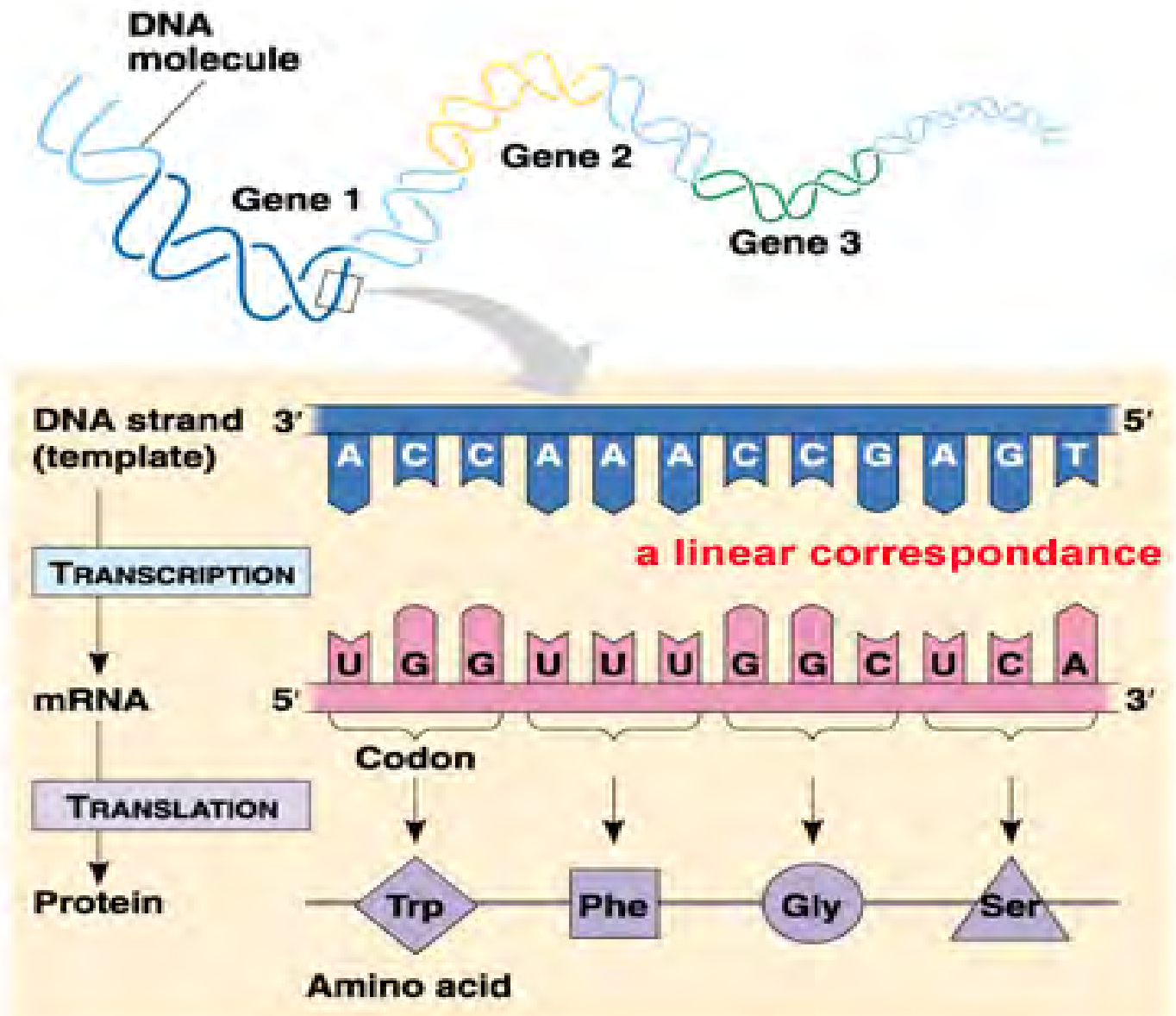
# BIOCHEMISTRY REVIEW

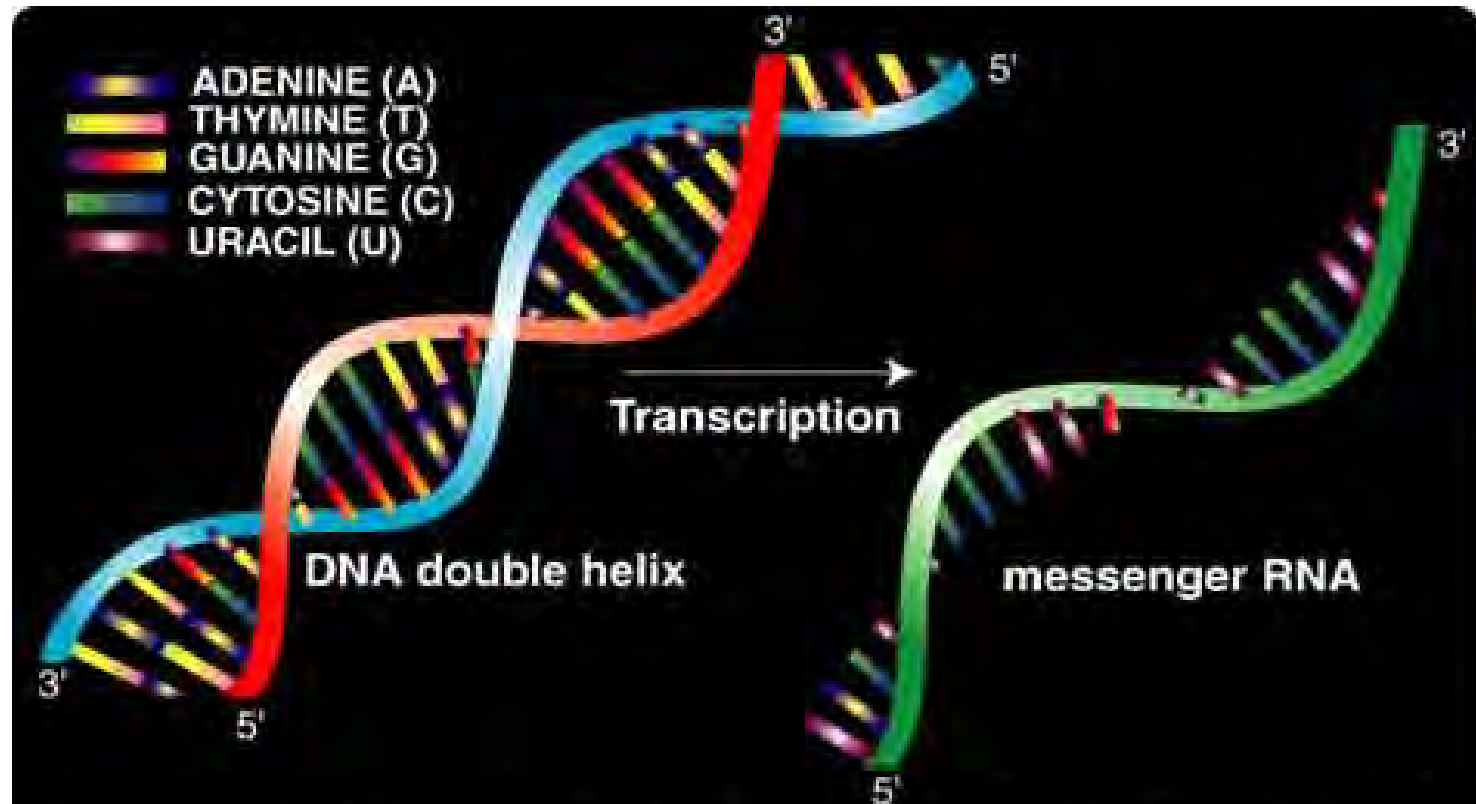
## Overview of Biomolecules

### Chapter 12 Transcription









Formation of messenger RNA from a DNA template strand. The strand in blue, the 3'-5' strand is the template strand. The RNA polymerase transcribes the information in this strand. During this transcription, A becomes U, T becomes A, G becomes C and C becomes G.



**(a) Monocistronic**



**(b) Polycistronic**



# Are You Getting It??



---

**Which are general characteristics of transcription?**  
*(multiple answers)*

- a) An entire DNA molecule is transcribed at one time.
- b) A DNA double-helix is denatured to create a template.
- c) Base-pairs that can form include  $G \equiv C$  and  $A = U$ .
- d) The RNA strand made is complementary to a DNA strand.
- e) Monocistronic mRNA consists entirely of coding regions.
- f) Polycistronic mRNA contains non-coding spacers.



# Are You Getting It??



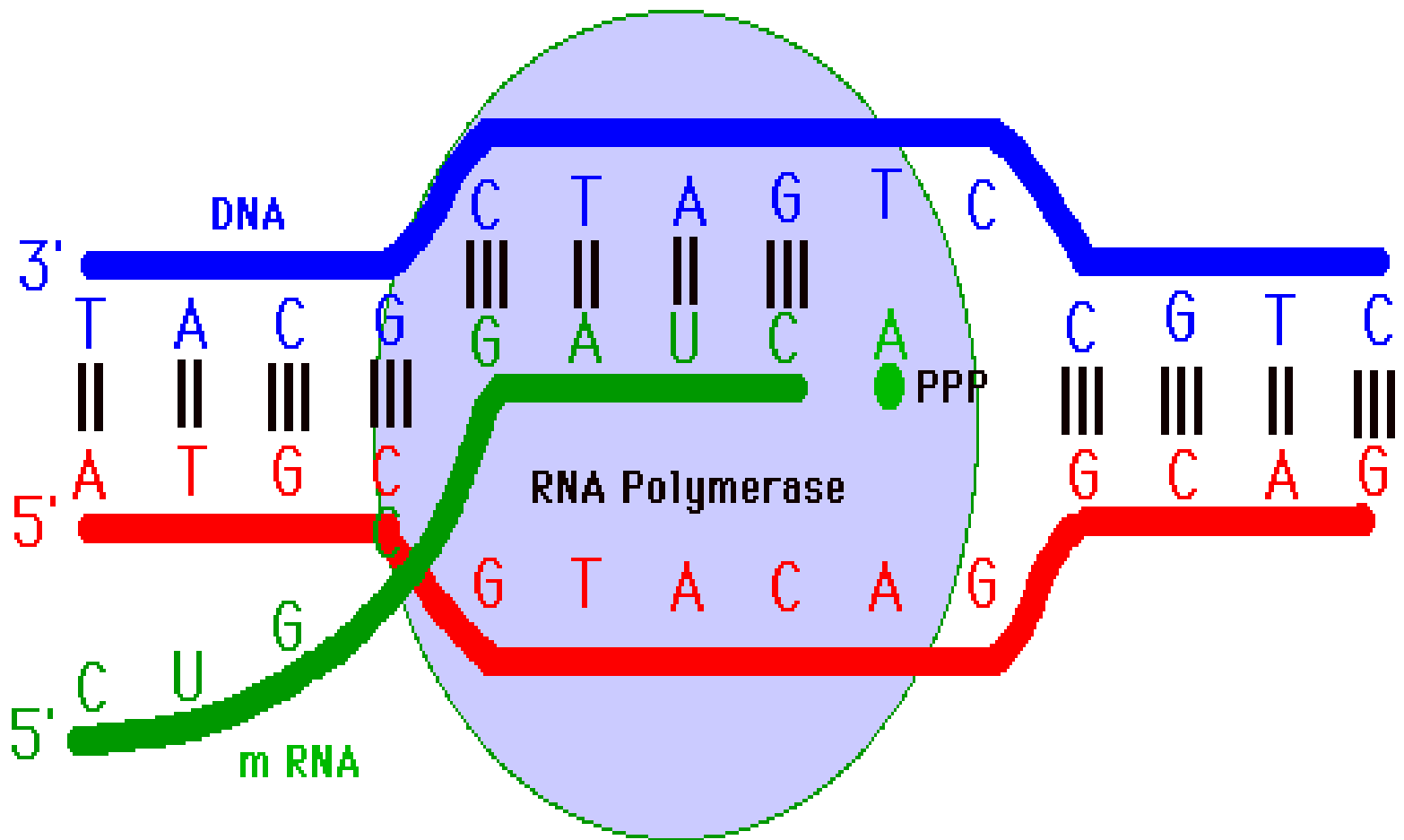
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## Answer

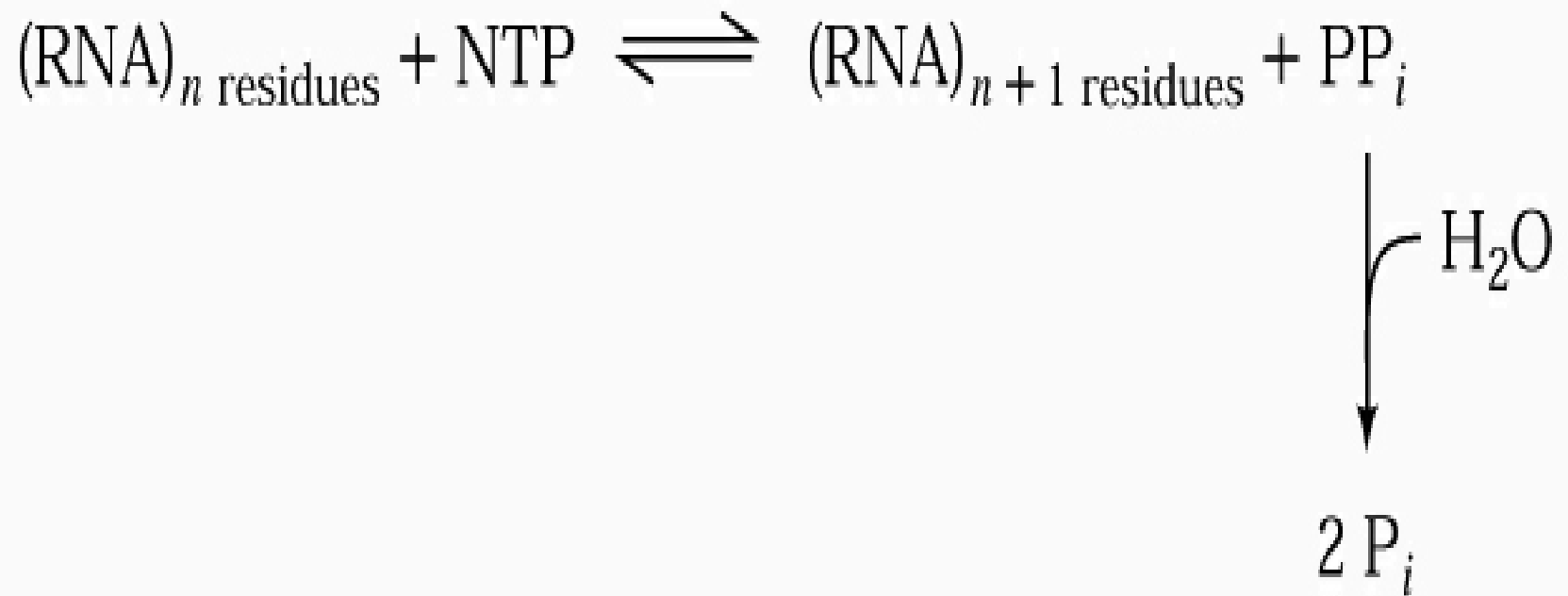
---

Which are general characteristics of transcription?

- a) An entire DNA molecule is transcribed at one time.
- b) A DNA double-helix is denatured to create a template.*
- c) Base-pairs that can form include  $G \equiv C$  and  $A = U$ .*
- d) The RNA strand made is complementary to a DNA strand.*
- e) Monocistronic mRNA consists entirely of coding regions.
- f) Polycistronic mRNA contains non-coding spacers.*



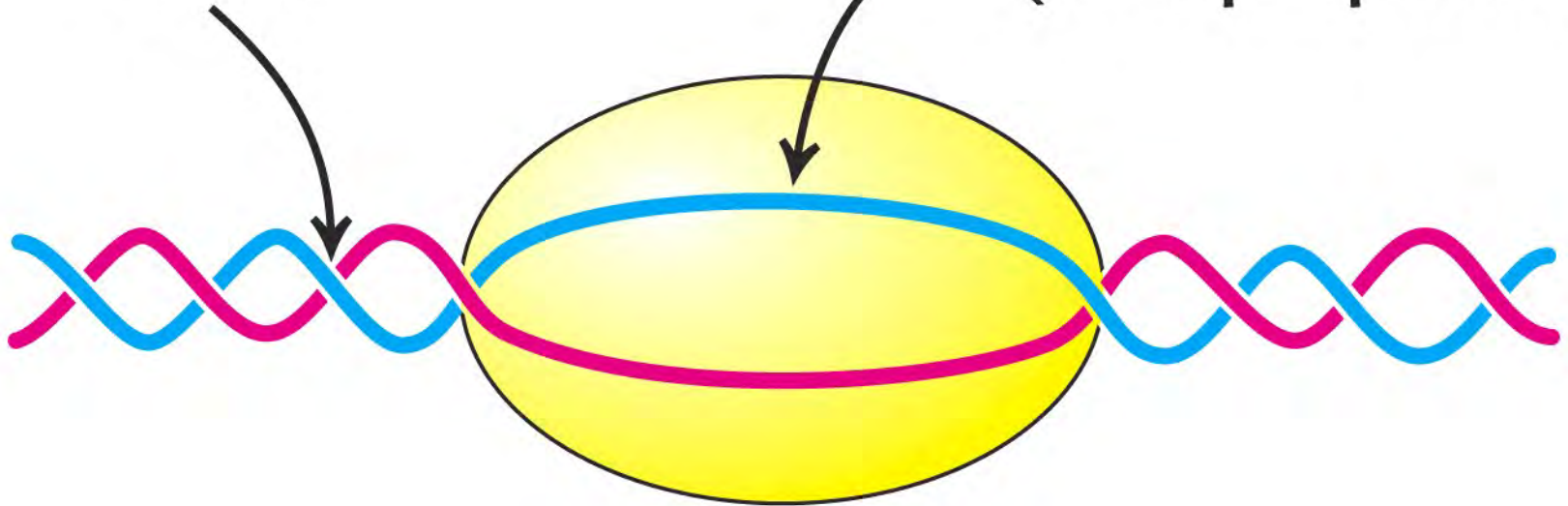




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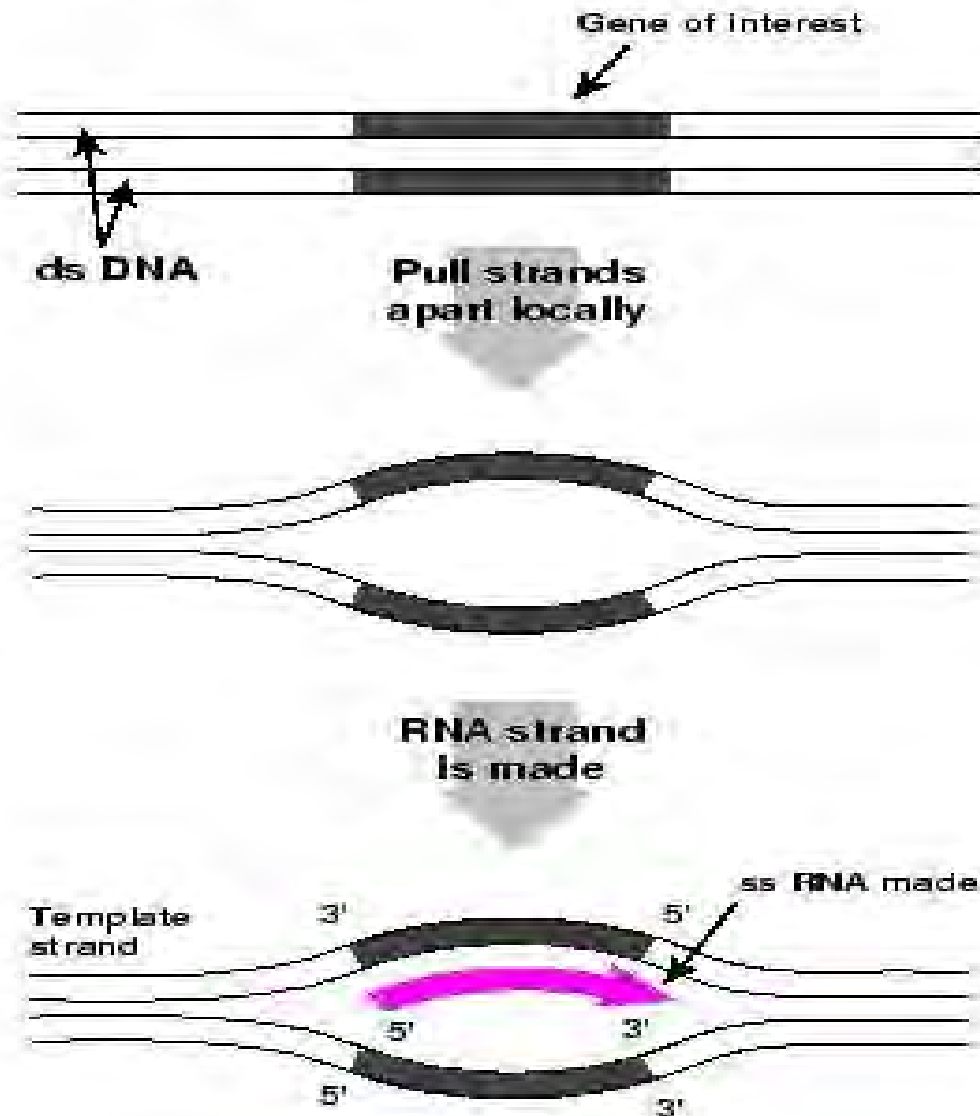
Double-helical  
DNA

Unwound DNA  
(17 bp opened)



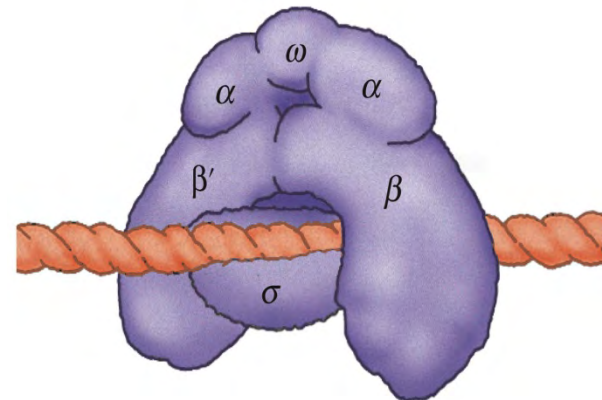
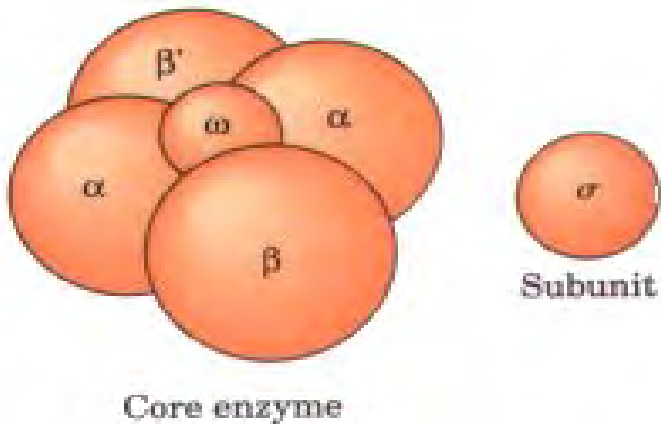
RNA polymerase

## 6.1 TRANSCRIPTION: THE PRINCIPLE



**TABLE 28.1** Subunits of RNA polymerase from *E. coli*

Subunit	Gene	Number	Mass (kd)
$\alpha$	<i>rpoA</i>	2	37
$\beta$	<i>rpoB</i>	1	151
$\beta'$	<i>rpoC</i>	1	155
$\sigma^{70}$	<i>rpoD</i>	1	70





# Are You Getting It??



---

Which are characteristics of E. coli RNA polymerase?  
*(multiple answers)*

- a) It is a multimeric protein that forms a holoenzyme.
- b) It uses ribonucleoside triphosphates as substrates.
- c) It can copy either DNA strand in a gene.
- d) It polymerizes in the 3' → 5' direction.
- e) It has helicase activity.
- f) It has proof-reading activity.



# Are You Getting It??



---

## Answer

---

Which are characteristics of E. coli RNA polymerase?

- a) *It is a multimeric protein that forms a holoenzyme.*
- b) *It uses ribonucleoside triphosphates as substrates.*
- c) It can copy either DNA strand in a gene.
- d) It polymerizes in the 3' → 5' direction.
- e) *It has helicase activity.*
- f) It has proof-reading activity.

Transcription  
starts here



3'

5'            -10

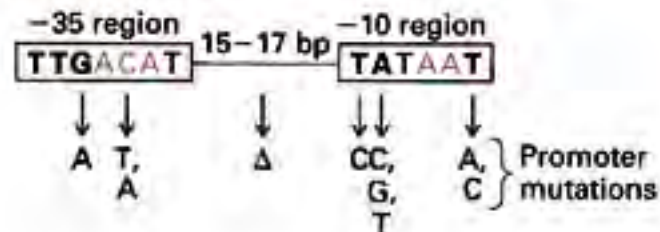
- (A) C G T A T G T T G T G T G G A
  - (B) G C T A T G G T T A T T T C A
  - (C) G T T A A C T A G T A C G C A
  - (D) G T G A T A C T G A G C A C A
  - (E) G T T T T C A T G C C T C C A
- T A T A A T

(a) Strong *E. coli* promoters

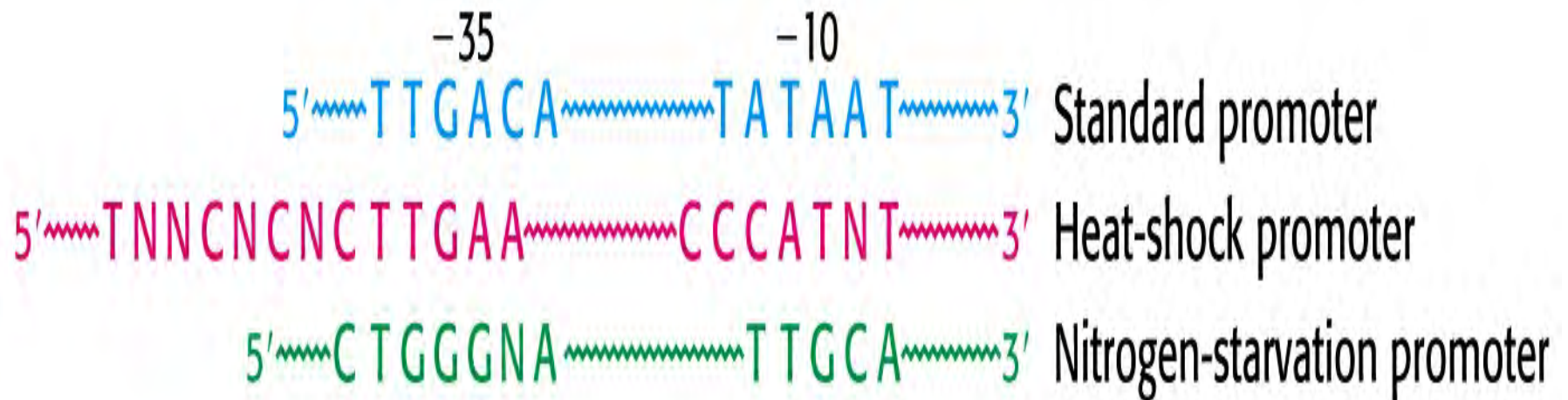
tyr tRNA	TCTCAACGTAACACTTTTACAGCGGCG • • CGTCATTTGATATGATGC • GCCCCGCTTCCCGATAAGGG
rrn D1	GATCAAAAAAATACTTGTGCAAAAAA • • TTGGGATCCCTATAATGCGCCTCCGTTGAGACGACAACG
rrn X1	ATGCATTTTTCCGC TTGTCTTCCTGA • • GCCGACTCCCTATAATGCGCCTCCATCGACACGGCGGAT
rrn (DXE) <sub>2</sub>	CCTGAAATTCAGGGTTGACTCTGAAA • • GAGGAAAGCGTAATATAC • GCCACCTCGCGACAGTGAGC
rrn E1	CTGCAATTTTTCTATTGCGGCCTGCG • • GAGAACTCCCTATAATGCGCCTCCATCGACACGGCGGAT
rrn A1	TTTTAAATTTCTCTTTGTCAAGGCCGG • • AATAACTCCCTATAATGCGCCACCACTGACACGGAAACAA
rrn A2	GCAAAAATAAATGCTTGACTCTGTAG • • CGGGAAGGCGTATTATGC • ACACCCTCGCGCCGCTGAGAA
λ P <sub>R</sub>	TAACACCGTGCGTGT TTGACTATTTTA • CCTCTGGCGGTGATAATGG • • TTGCATGTACTAAGGAGGT
λ P <sub>L</sub>	TATCTCTGGCGGTG TTGACATAAATA • CCACTGGCGGTGATACTGA • • GCACATCAGCAGGACGCAC
T7 A3	GTGAAACAAAACGG TTGACAACATGA • AGTAAACACGGTACGATGT • ACCACATGAAACGACAGTGA
T7 A1	TATCAAAAAGAGTATTGACTTAAAGT • CTAACCTATAGGATACTTA • CAGCCATCGAGAGGGACACG
T7 A2	ACGAAAACAGGTATTGACAACATGAAGTAACATGCAGTAAGATAC • AAATCGCTAGGTAACACTAG
fd VIII	GATACAAATCTCCGTTGTACTTTTGTT • • TCGCGCTTGGTATAATCG • CTGGGGGTCAAAGATGAGTG

-35
-10
+1

(b) Consensus sequences of  $\sigma^{70}$  promoters





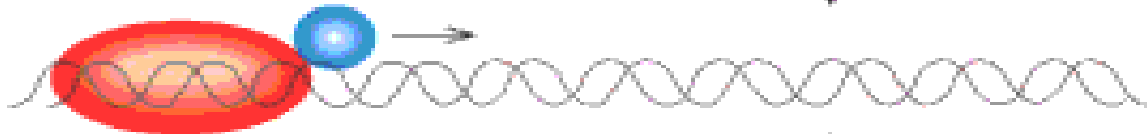


**Figure 6.7**

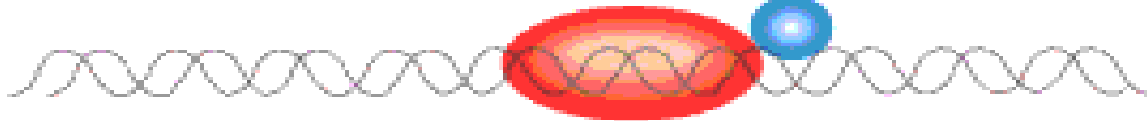
(a) DNA binding



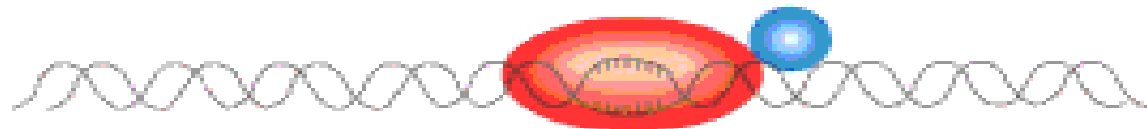
(b) Promoter search



(c) Closed promoter complex formation



(d) Open promoter complex formation





# Are You Getting It??



---

Which are properties of E. coli promoters?  
*(multiple answers)*

- a) All promoters have the same base sequence.
- b) The -10 sequence is A=T rich.
- c) The -35 sequence is where transcription starts.
- d) Promoters are recognized by the  $\sigma$  subunit.
- e) Promoters are located downstream of the gene.



# Are You Getting It??



---

## Answer

---

Which are properties of E. coli promoters?

- a) All promoters have the same base sequence.
- b) The -10 sequence is A=T rich.*
- c) The -35 sequence is where transcription starts.
- d) Promoters are recognized by the  $\sigma$  subunit.*
- e) Promoters are located downstream of the gene.

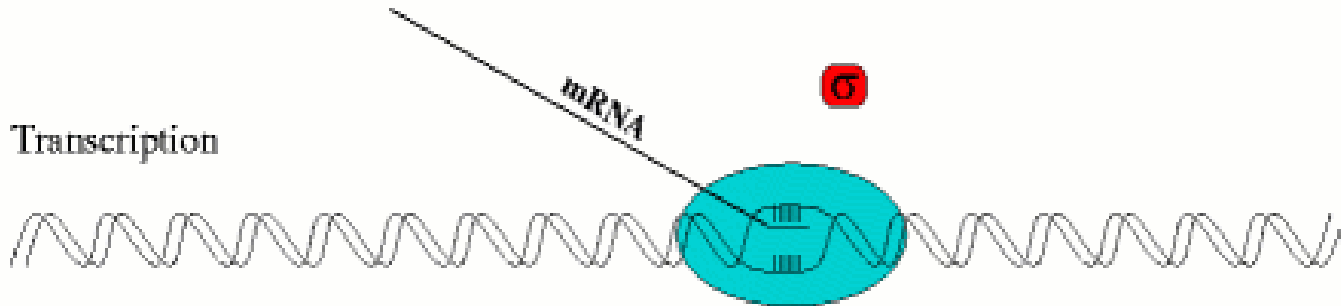
Closed promoter complex

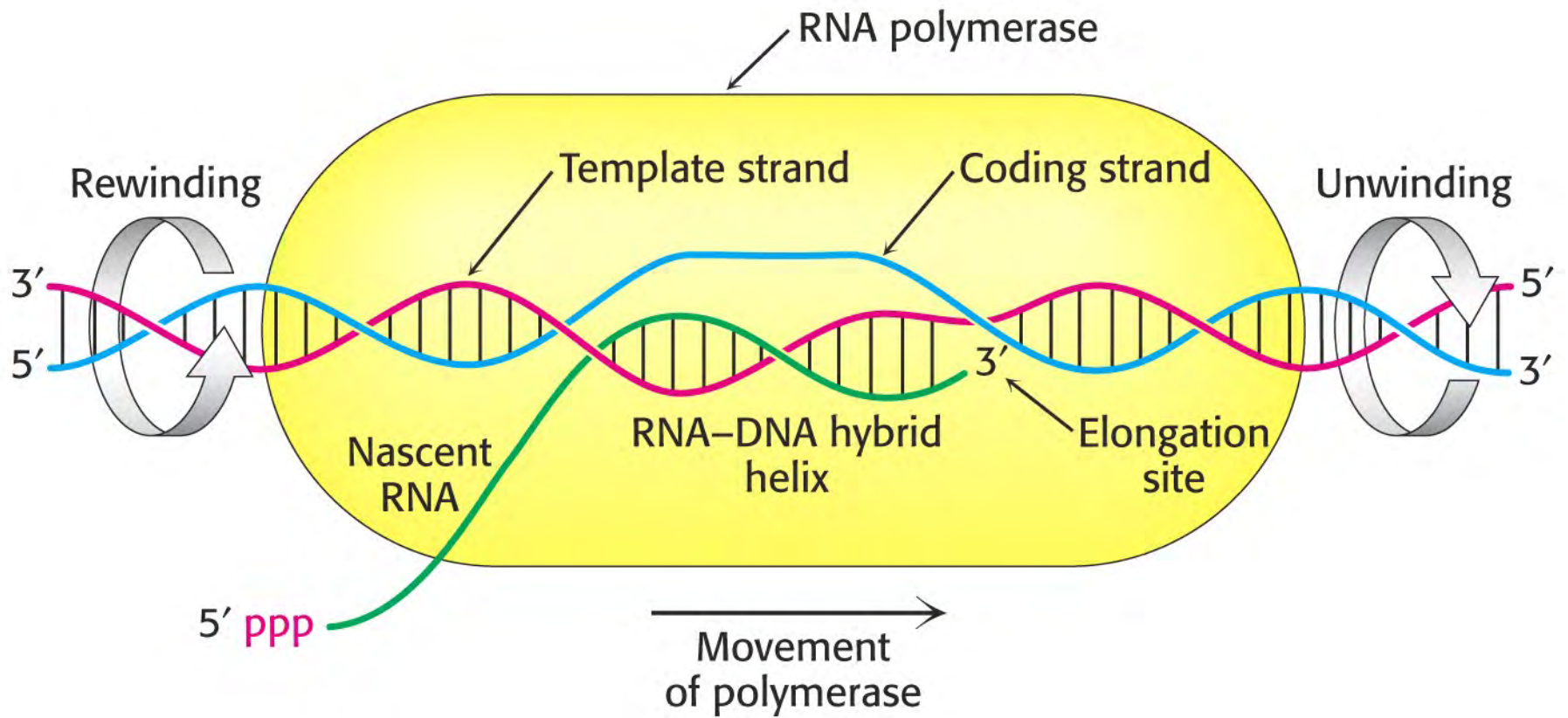


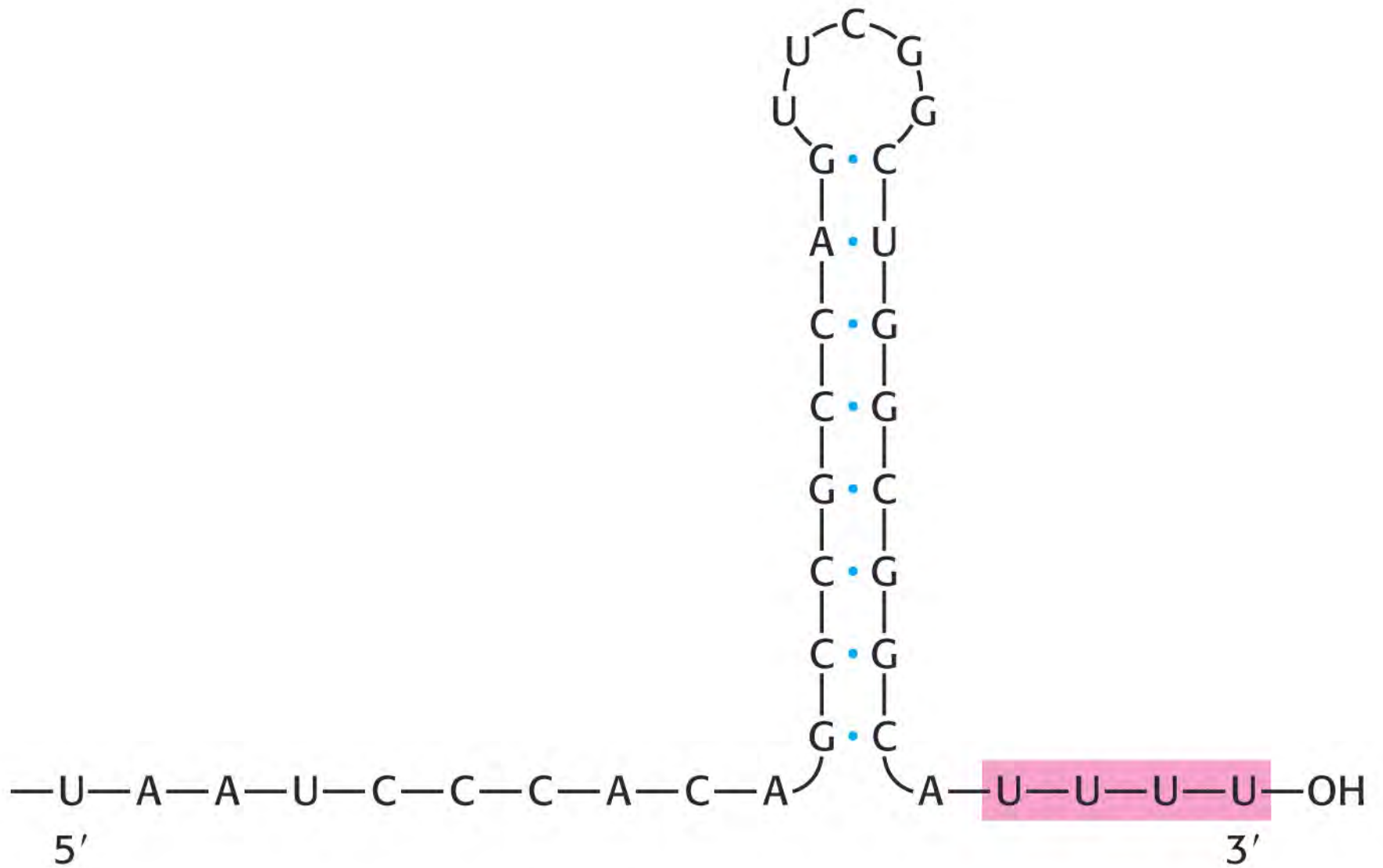
Open promoter complex



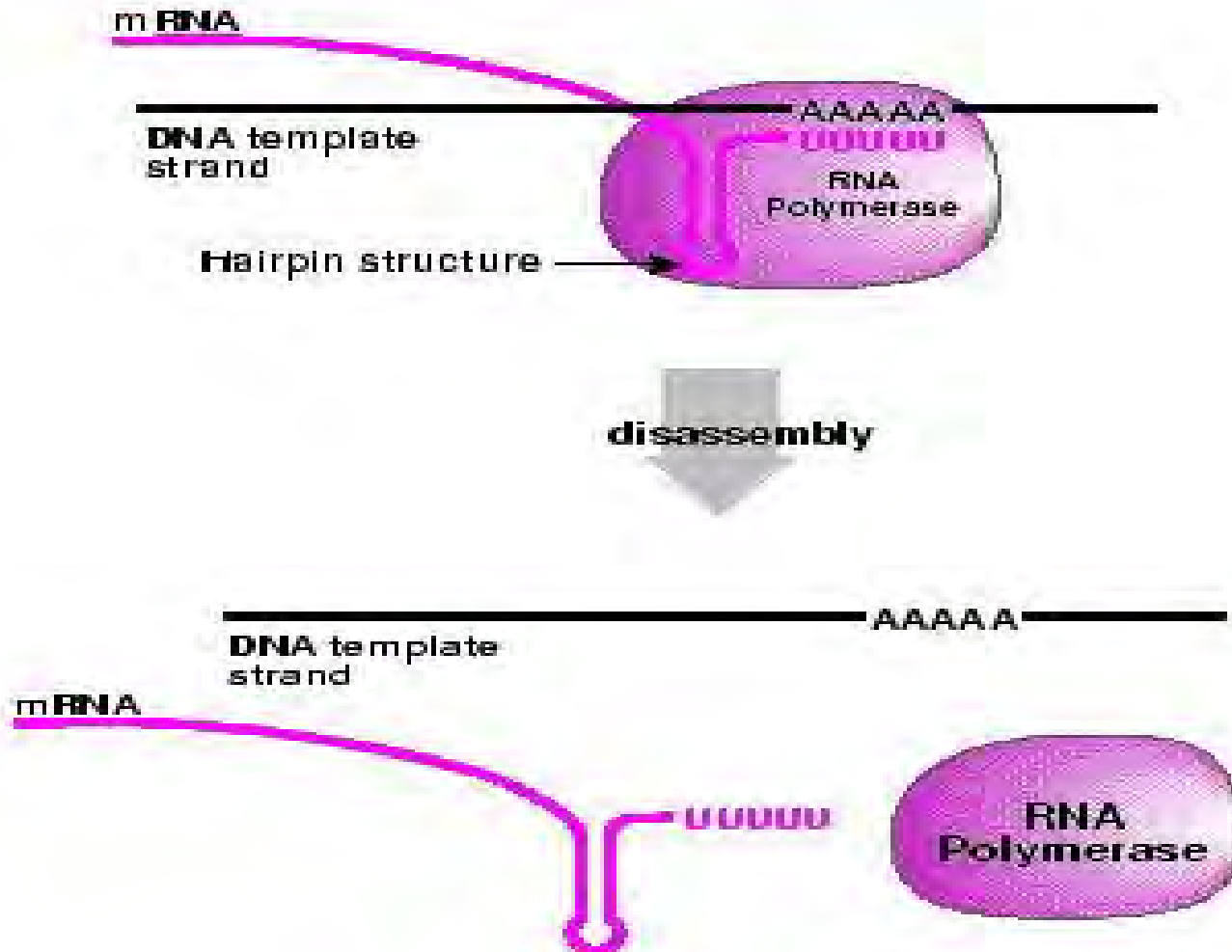
Transcription



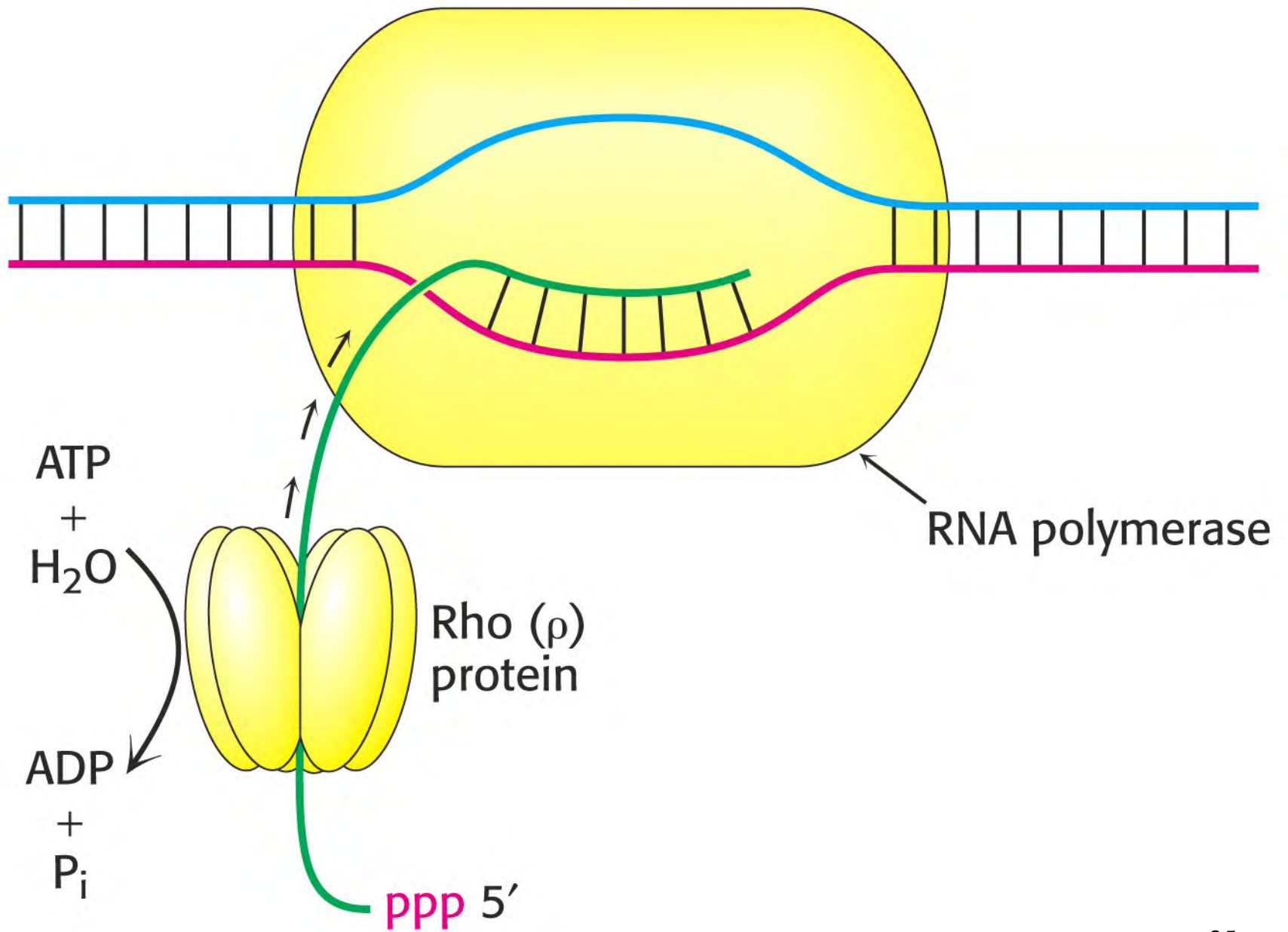




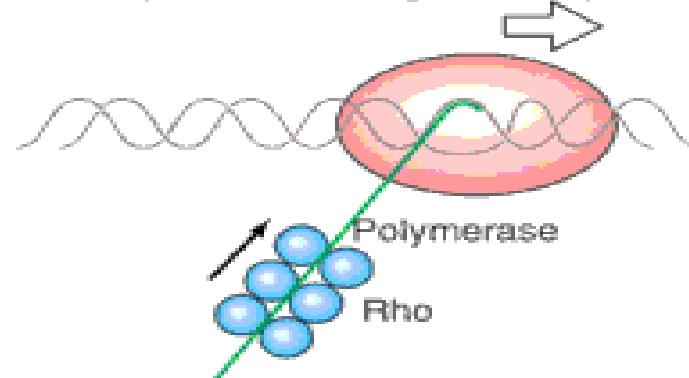
## 6.10 TERMINATION OF TRANSCRIPTION



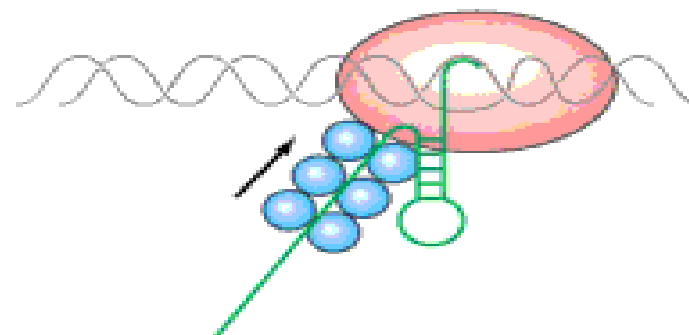




(a) Rho binds to transcript at rho loading site and pursues polymerase.



(b) Hairpin forms; polymerase pauses; rho catches up.



(c) Rho helicase releases transcript and causes termination.

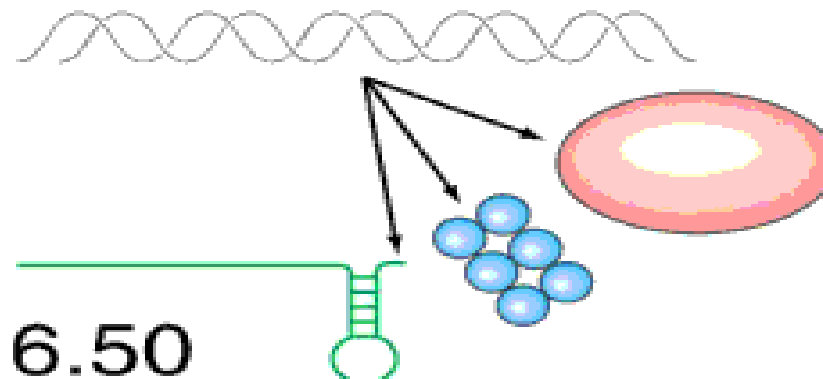


Figure 6.50



# Are You Getting It??



---

**Which events occur during transcription in E. coli?**  
*(multiple answers)*

- a) RNA polymerase denatures a small area of DNA.
- b) RNA polymerase makes phosphodiester bonds.
- c) The mRNA forms hydrogen bonds with the DNA.
- d) Termination of transcription uses a hairpin structure.
- e) The rho protein is a type of RNA polymerase.



# Are You Getting It??



---

## Answer

---

Which events occur during transcription in E. coli?

- a) *RNA polymerase denatures a small area of DNA.*
- b) *RNA polymerase makes phosphodiester bonds.*
- c) *The mRNA forms hydrogen bonds with the DNA.*
- d) *Termination of transcription uses a hairpin structure.*
- e) The rho protein is a type of RNA polymerase.

**TABLE 28.2 Eukaryotic RNA polymerases**

Type	Location	Cellular transcripts	Effects of $\alpha$ -amanitin
I	Nucleolus	18S, 5.8S, and 28S rRNA	Insensitive
II	Nucleoplasm	mRNA precursors and snRNA	Strongly inhibited
III	Nucleoplasm	tRNA and 5S rRNA	Inhibited by high concentrations

5' T<sub>82</sub> A<sub>97</sub> T<sub>93</sub> A<sub>85</sub> A<sub>63</sub> A<sub>88</sub> A<sub>50</sub> 3'

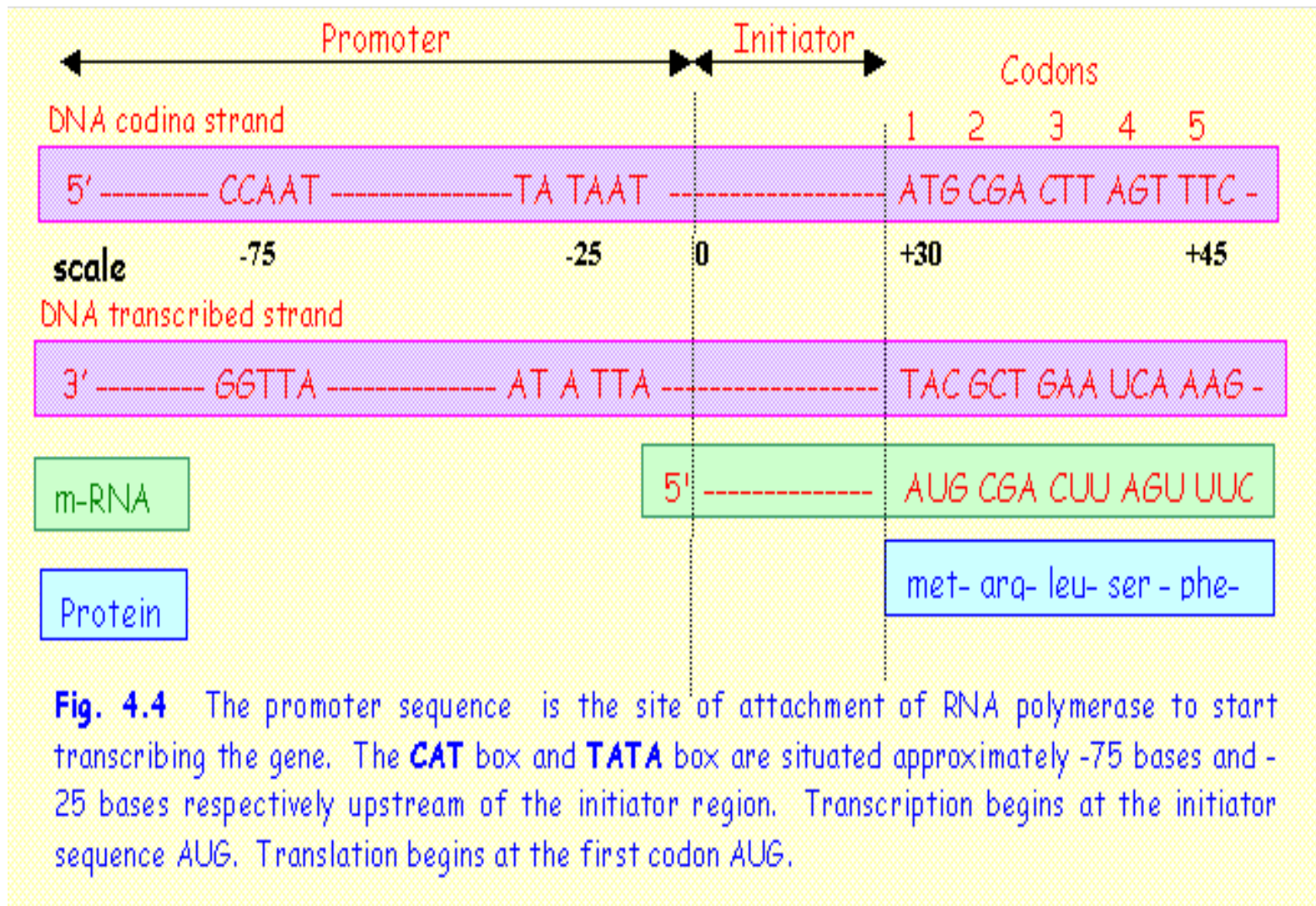
**TATA box**

5' G G N C A A T C T 3'

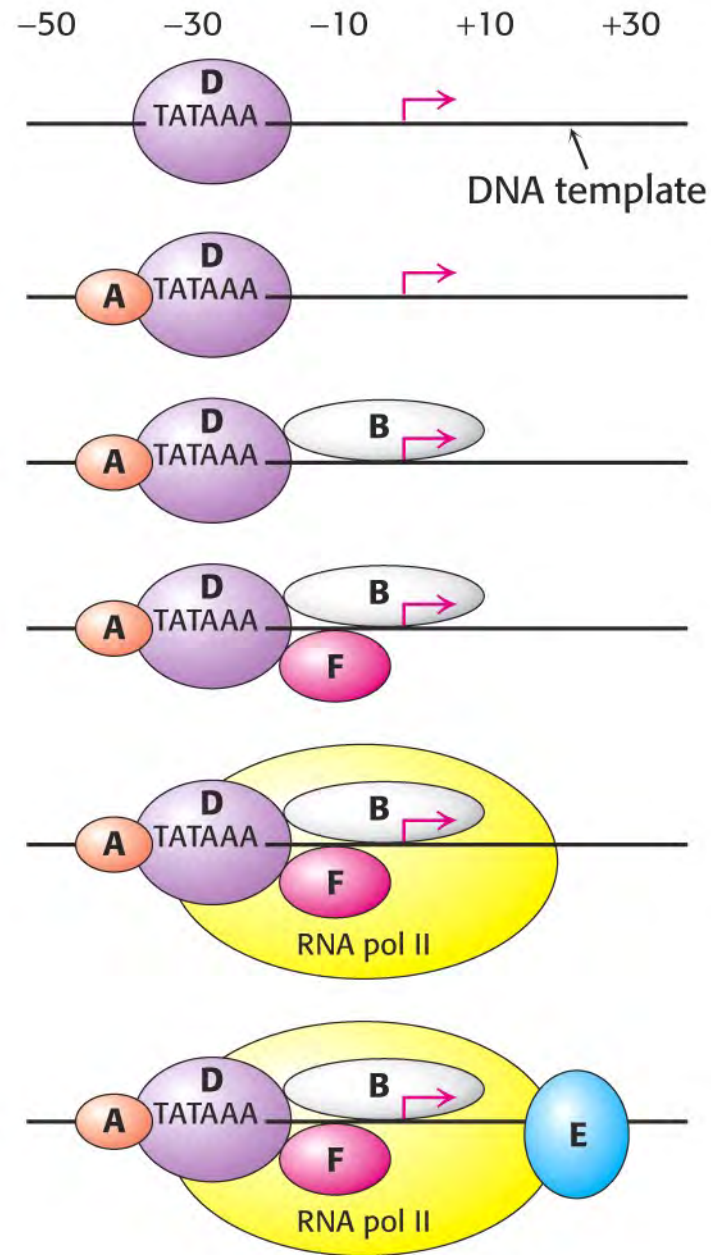
**CAAT box**

5' G G G C G G 3'

**GC box**

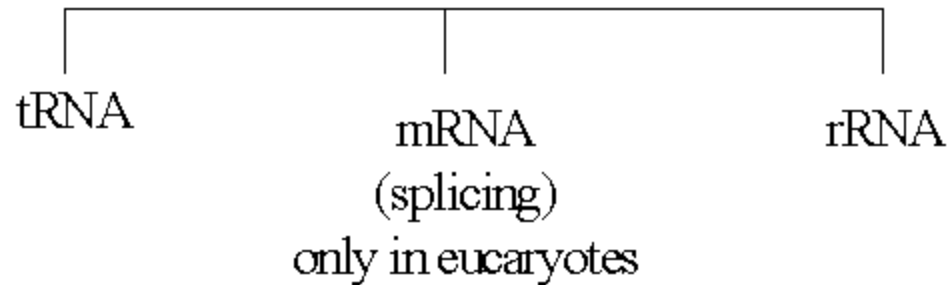


**Fig. 4.4** The promoter sequence is the site of attachment of RNA polymerase to start transcribing the gene. The **CAT** box and **TATA** box are situated approximately -75 bases and -25 bases respectively upstream of the initiator region. Transcription begins at the initiator sequence AUG. Translation begins at the first codon AUG.





# Processing of rRNA and tRNA



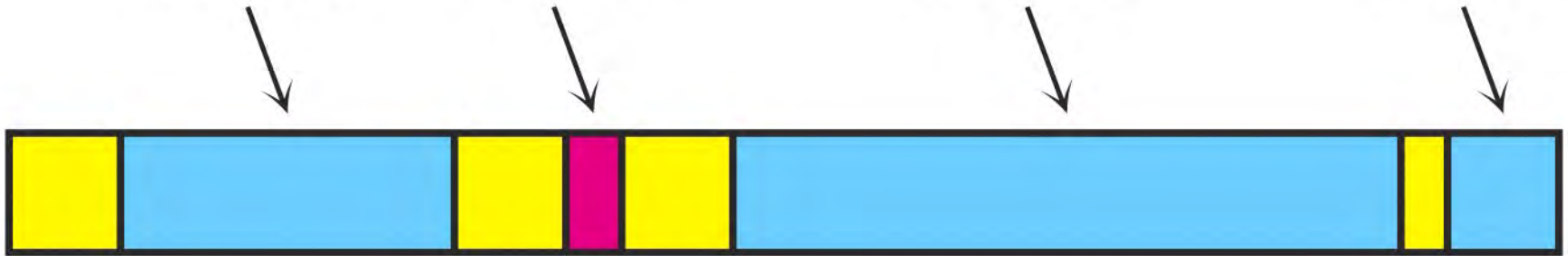
In eucaryotes and procaryotes, rRNAs are synthesized as a long precursor, and further cleaved to generate mature transcripts.

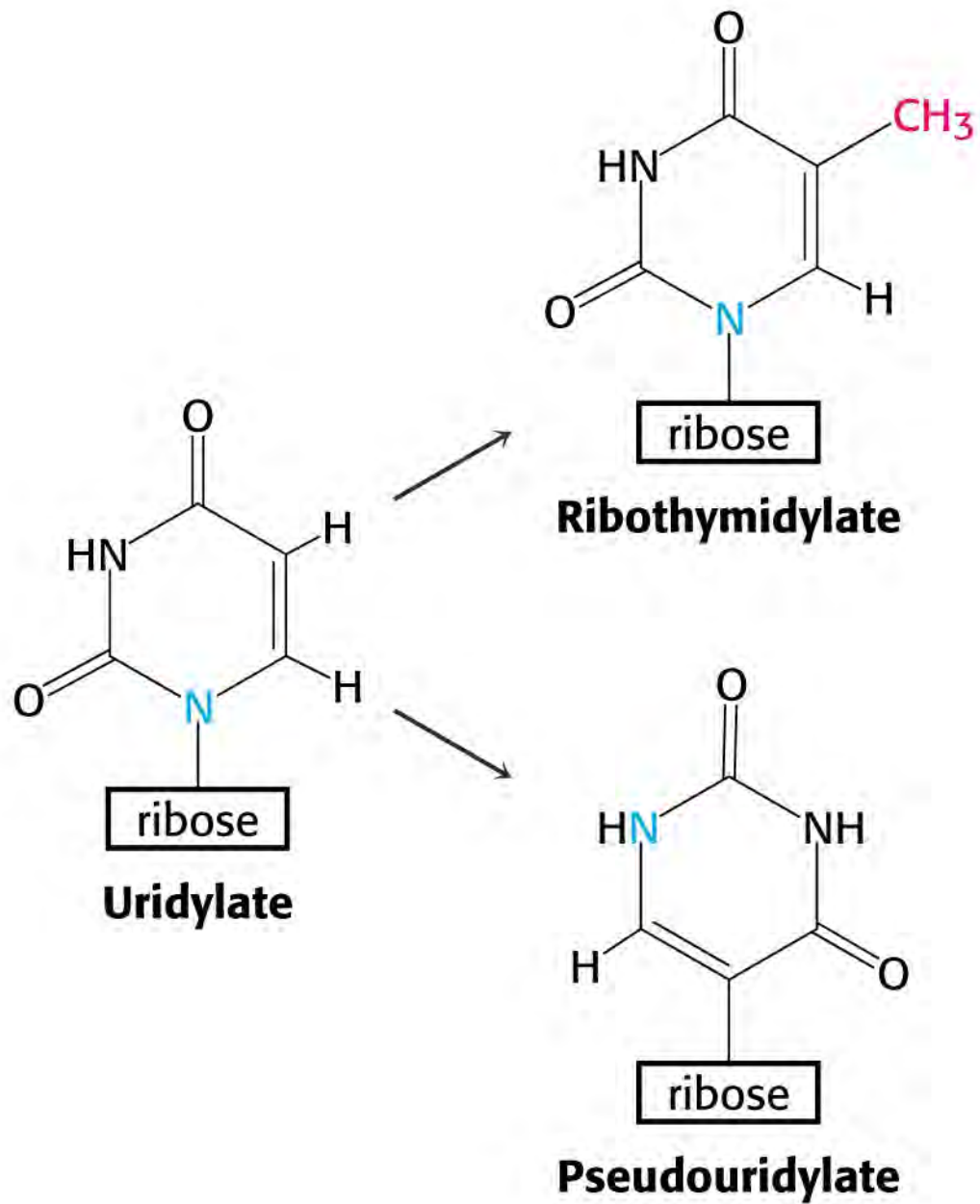
16S  
rRNA

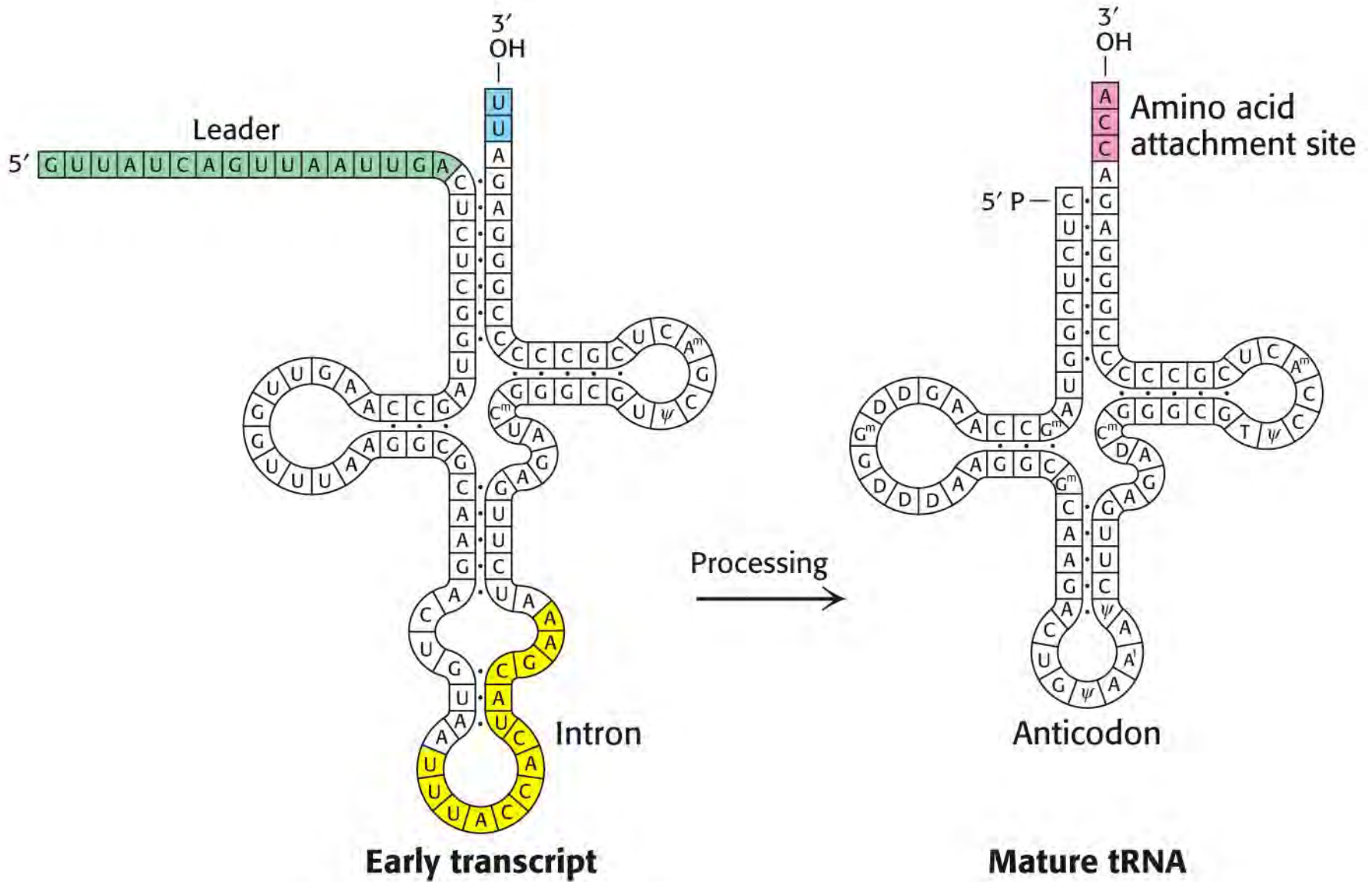
tRNA

23S  
rRNA

5S  
rRNA









# Are You Getting It??



---

**Which are characteristics of RNA processing in E. coli?**  
*(multiple answers)*

- a) mRNAs are extensively modified.
- b) rRNAs do not require processing.
- c) tRNAs undergo modification of bases.
- d) RNA transcripts are cut by specific nucleases.
- e) RNA processing is carried out by transcription factors.



# Are You Getting It??



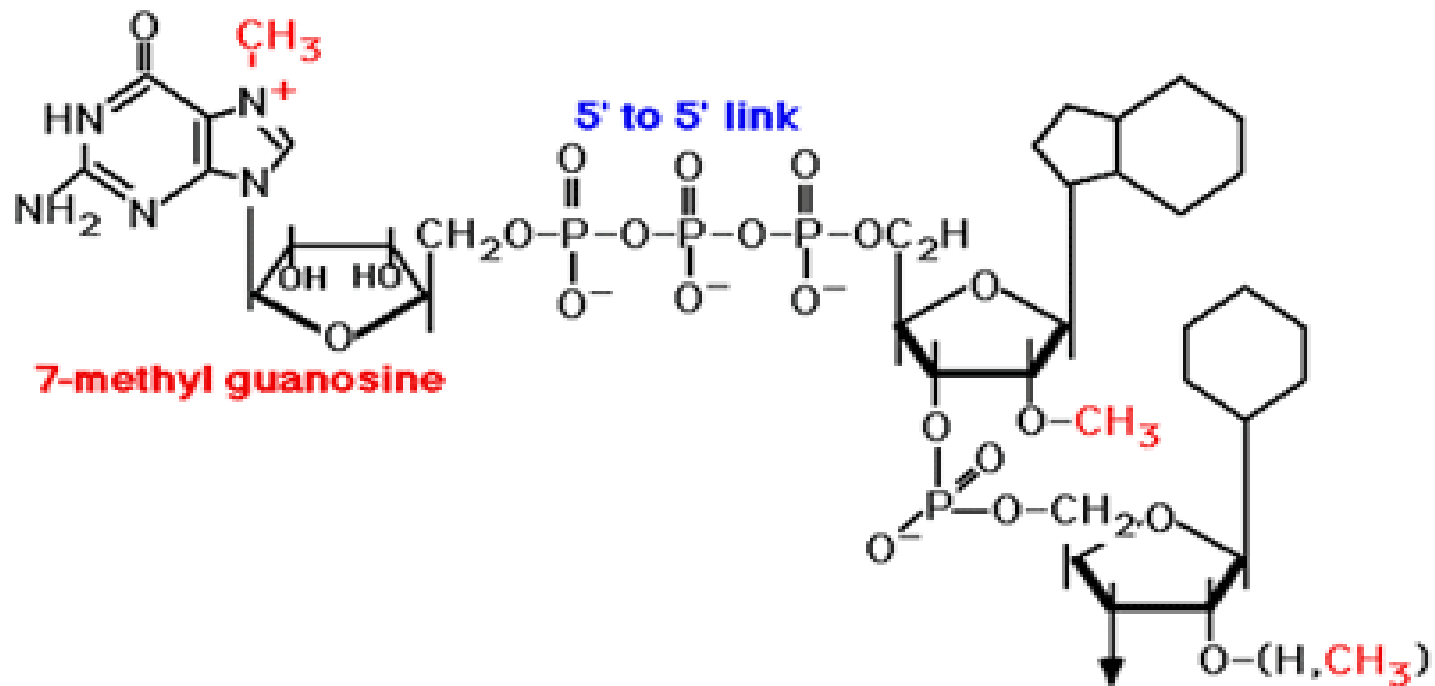
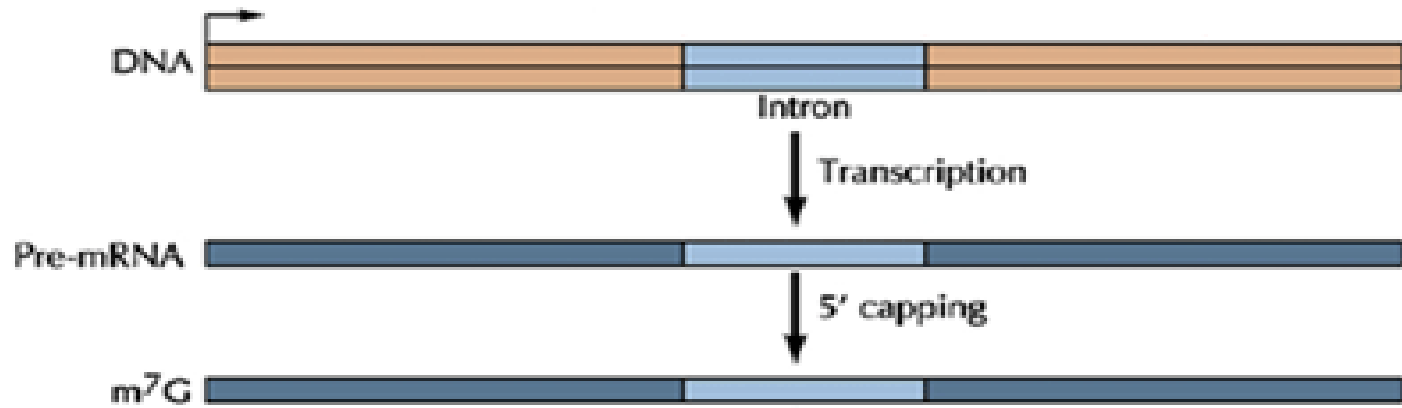
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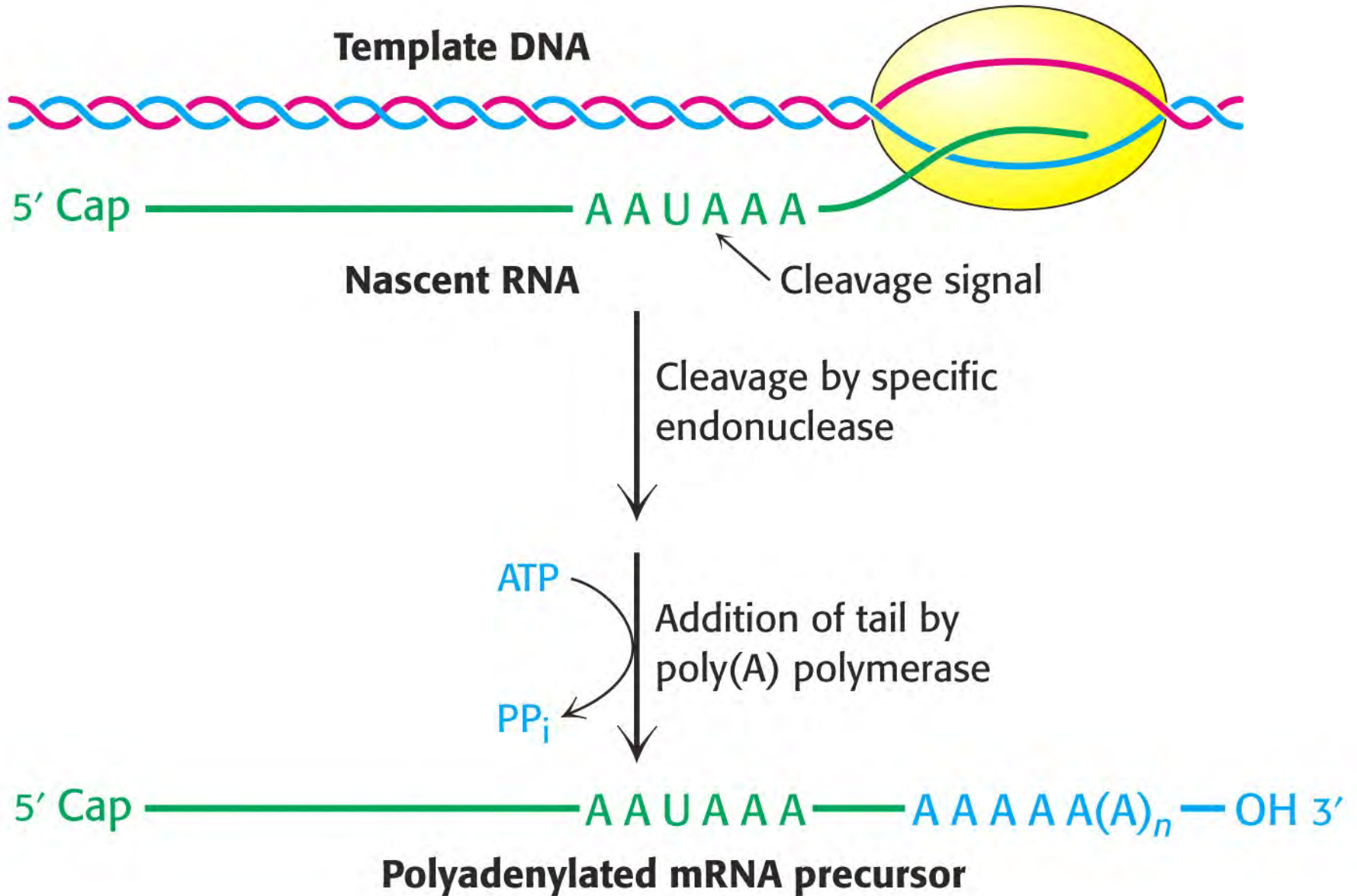
## Answer

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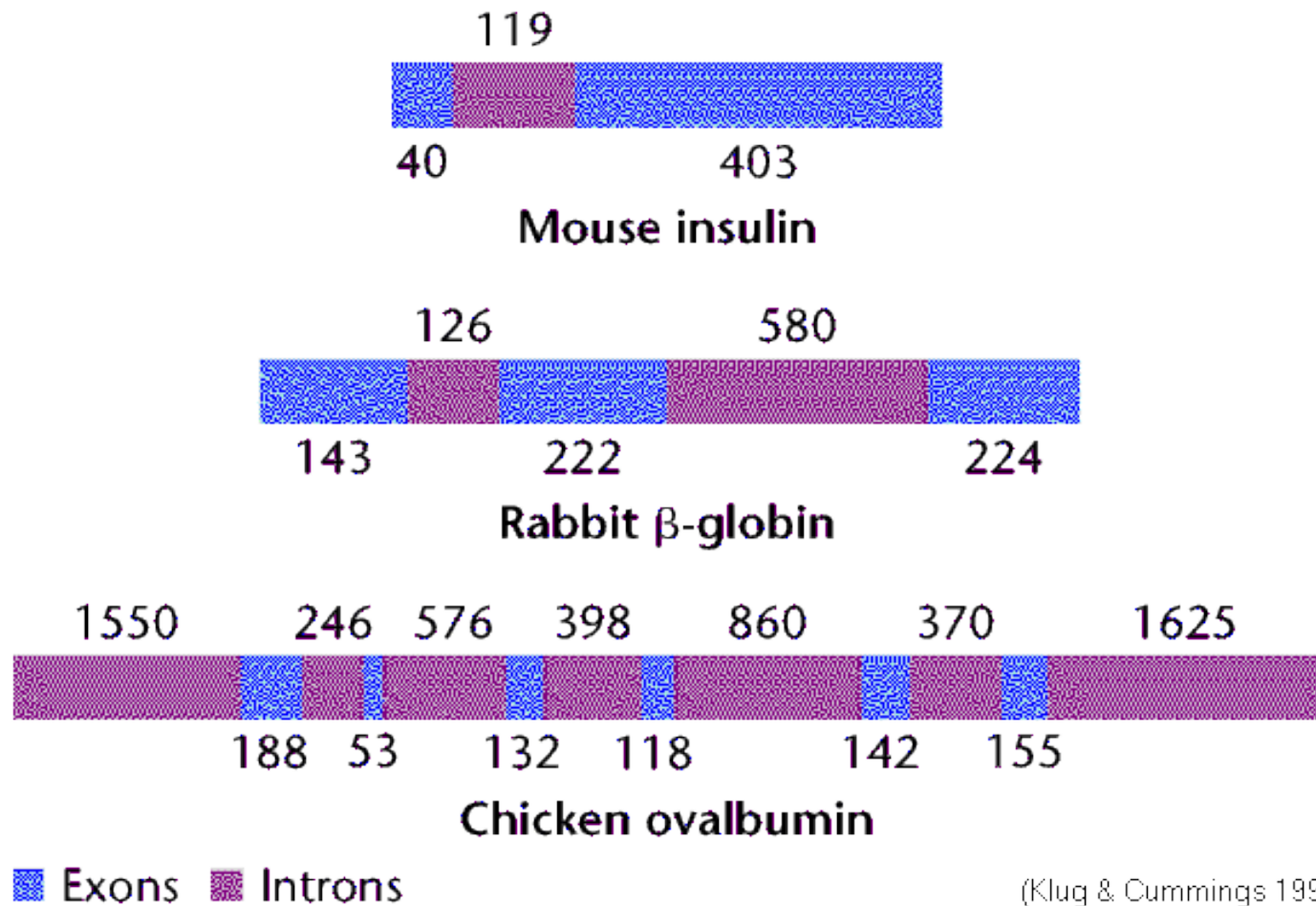
Which are characteristics of RNA processing in E. coli?

- a) mRNAs are extensively modified.
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- c) *tRNAs undergo modification of bases.***
- d) *RNA transcripts are cut by specific nucleases.***
- e) RNA processing is carried out by transcription factors.

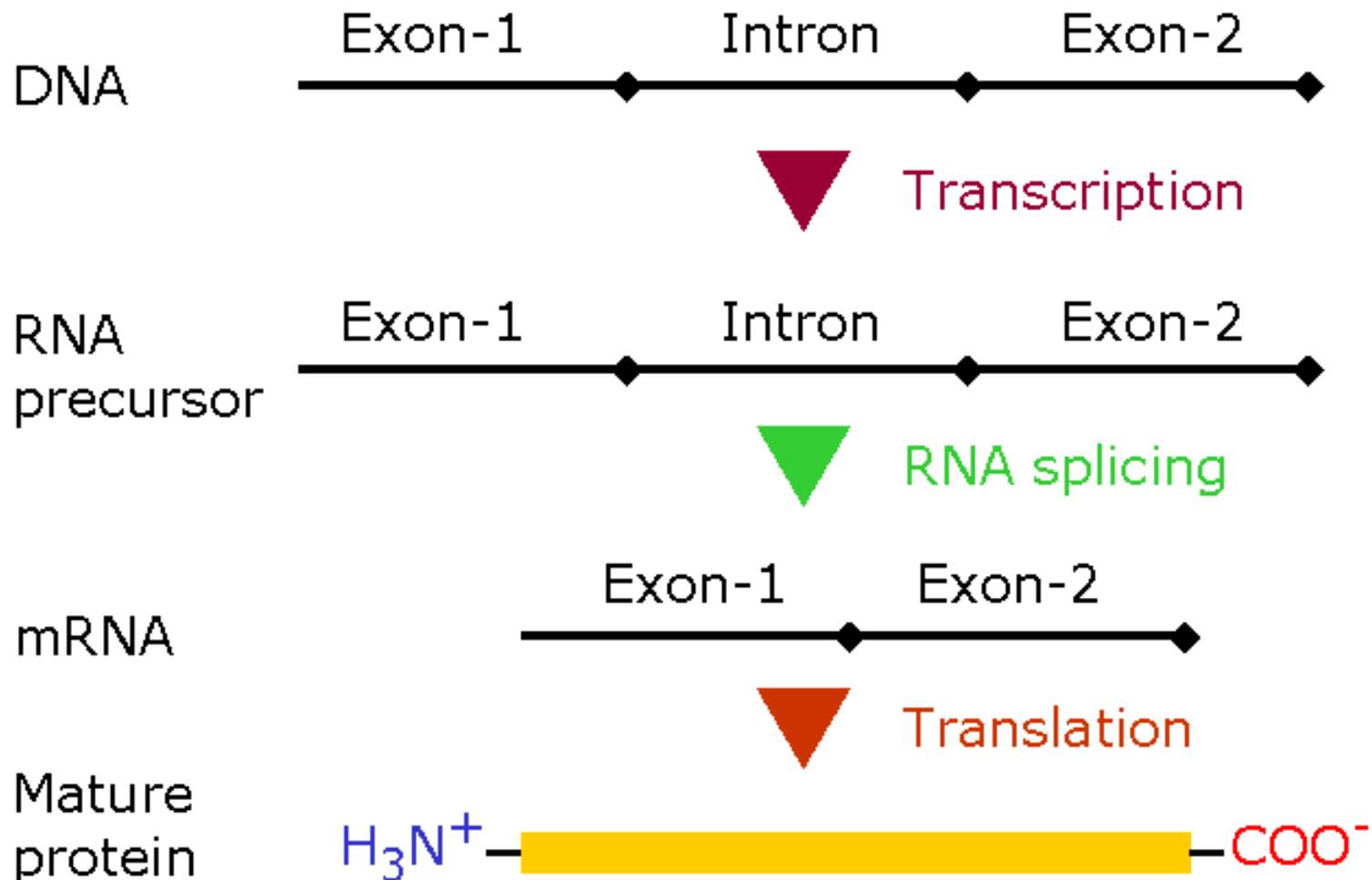








# RNA splicing





# Are You Getting It??



---

Which are characteristics of mRNA processing in eukaryotes? (*multiple answers*)

- a) mRNA is processed to produce hnRNA.
- b) The 5'- end is modified with a methylguanosine nucleotide.
- c) The 3'- end is modified with a sequence of adenosine nucleotides.
- d) Introns are cut out of the gene and joined together.
- e) Exons from adjacent genes are spliced together.



# Are You Getting It??



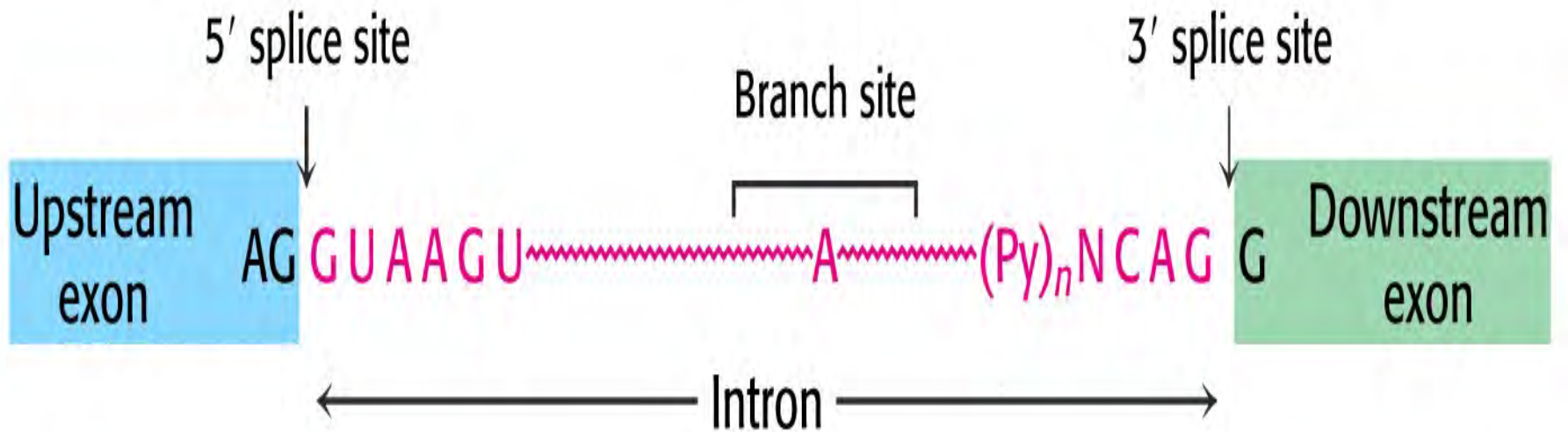
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## Answer

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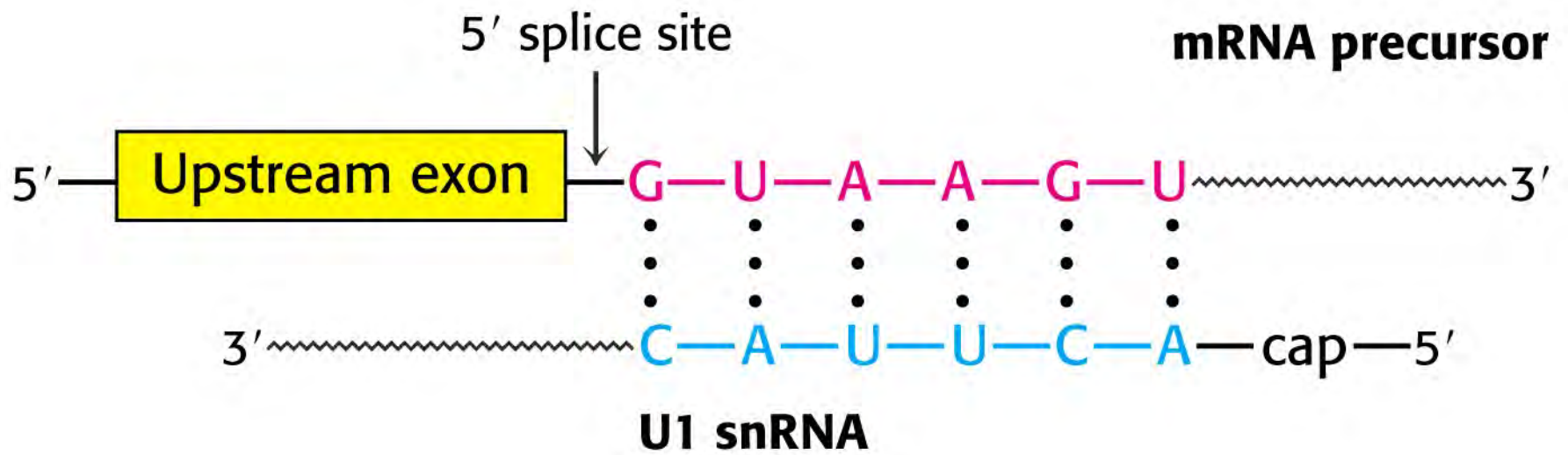
Which are characteristics of mRNA processing in eukaryotes?

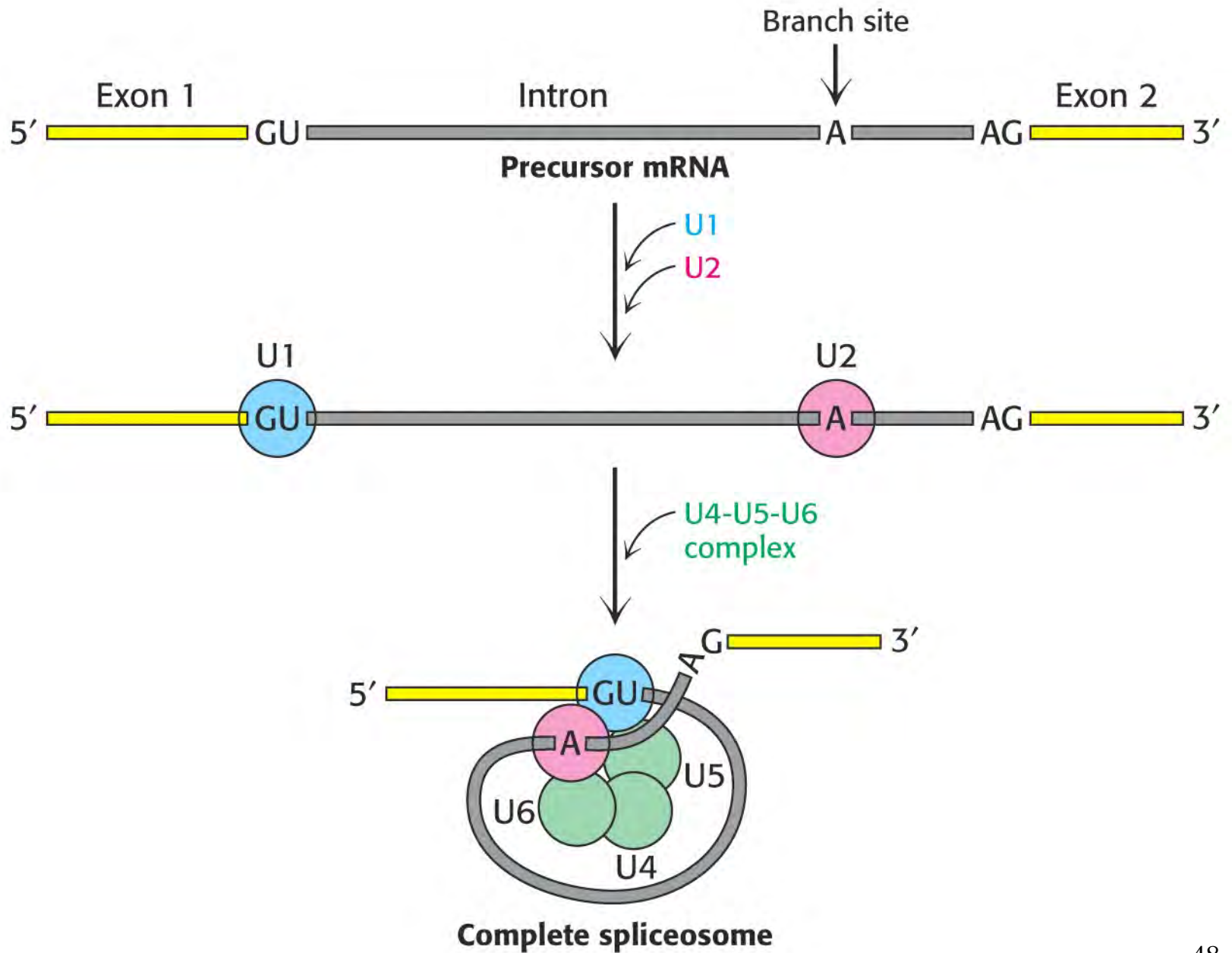
- a) mRNA is processed to produce hnRNA.
- b) *The 5'- end is modified with a methylguanosine nucleotide.***
- c) *The 3'- end is modified with a sequence of adenosine nucleotides.***
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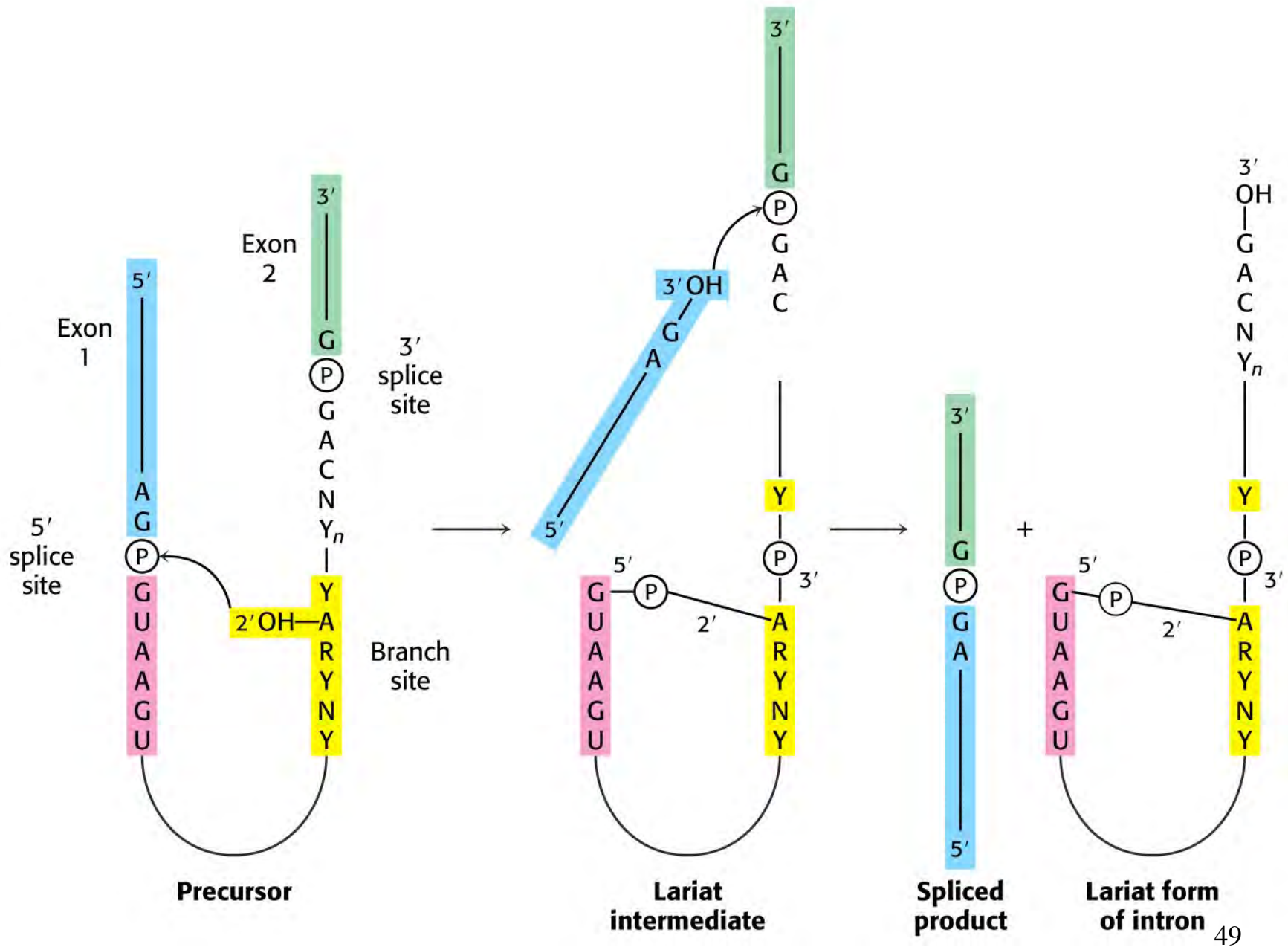
**TABLE 28.3** Small nuclear ribonucleoprotein particles (snRNPs) in the splicing of mRNA precursors

snRNP	Size of snRNA (nucleotides)	Role
U1	165	Binds the 5' splice site and then the 3' splice site
U2	185	Binds the branch site and forms part of the catalytic center
U5	116	Binds the 5' splice site
U4	145	Masks the catalytic activity of U6
U6	106	Catalyzes splicing





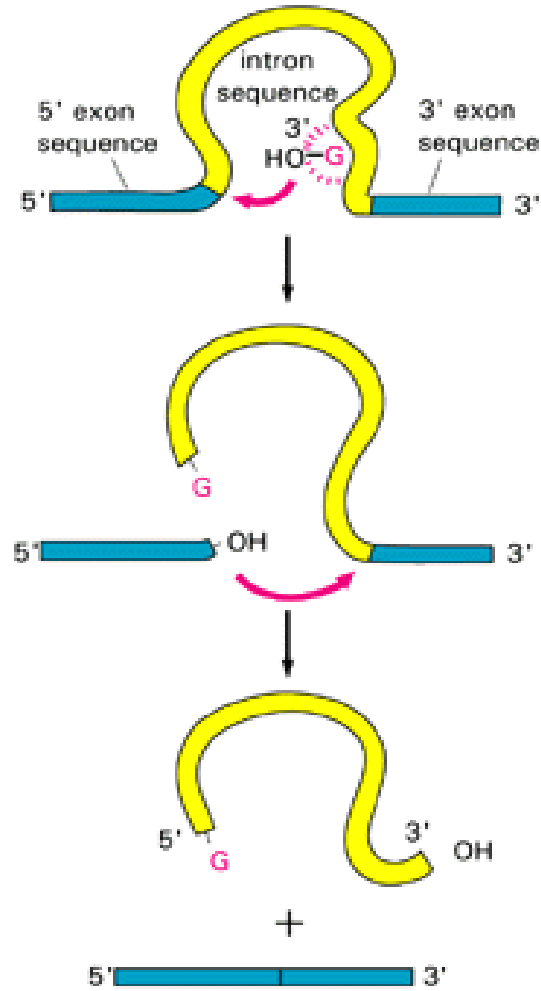




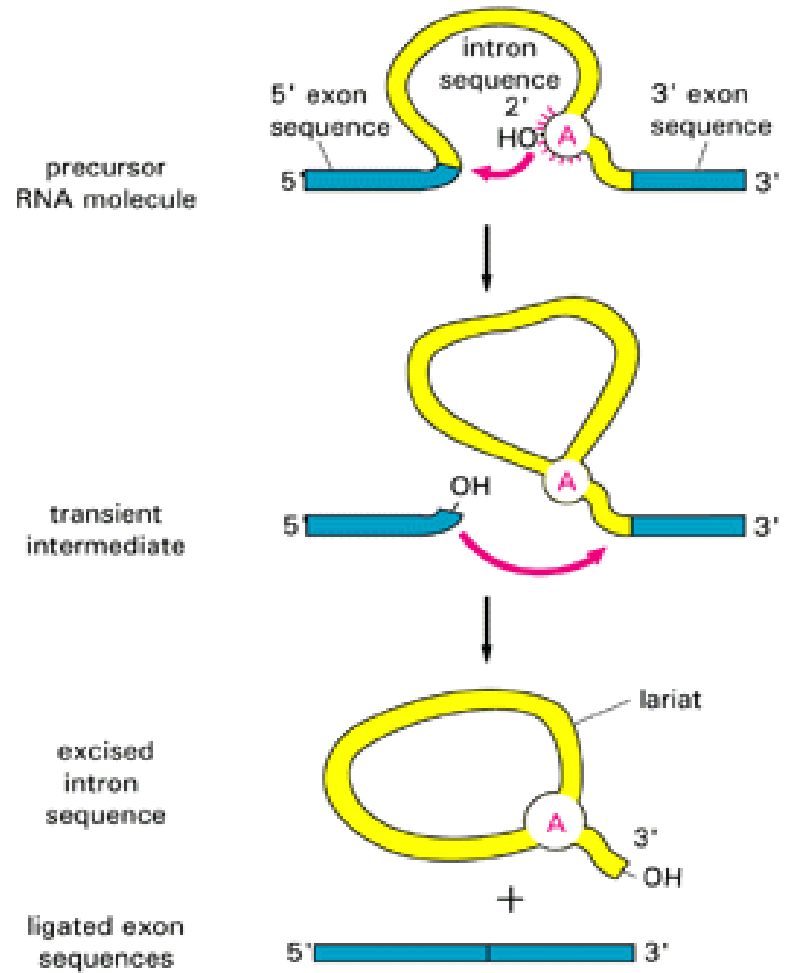
# Introns

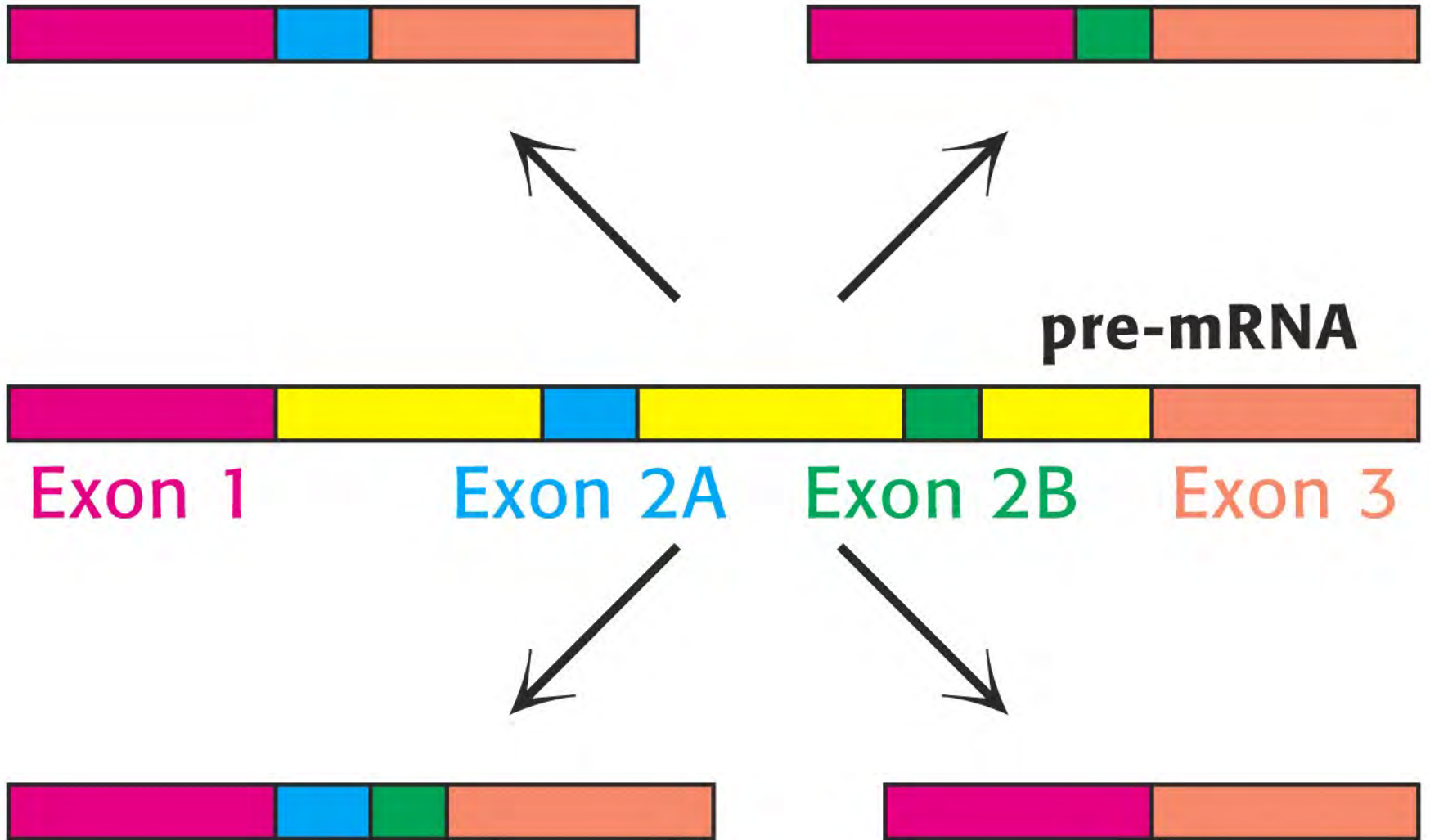
Type	Mechanism	Occurrence
Pre-mRNA	spliceosome	eukaryotic nucleus-mRNA
Group I	Self-splicing G-cofactor	lower eukaryotic rRNA, a few rRNA and tRNAs in fungi and plant mitochondria and chloroplasts
Group II	Self-splicing	a few structural, tRNA and rRNA in fungi and plant mitochondria and chloroplasts

Group I self-splicing intron sequences



Group II self-splicing intron sequences







# Are You Getting It??



---

**Which are characteristics of RNA splicing?**  
*(multiple answers)*

- a) All introns are removed by the same mechanism.
- b) All genes have the same number of introns.
- c) Each pre-mRNA can be processed in only one way.
- d) snRNAs can bind to splice sites and branch sites.
- e) Lariat structures can form during splicing.
- f) RNA can act as an enzyme during splicing.



# Are You Getting It??



---

## Answer

---

Which are characteristics of RNA splicing?

- a) All introns are removed by the same mechanism.
- b) All genes have the same number of introns.
- c) Each pre-mRNA can be processed in only one way.
- d) *snRNAs can bind to splice sites and branch sites.***
- e) *Lariat structures can form during splicing.***
- f) *RNA can act as an enzyme during splicing.***

