Synthesis of RNA molecules: Transcription

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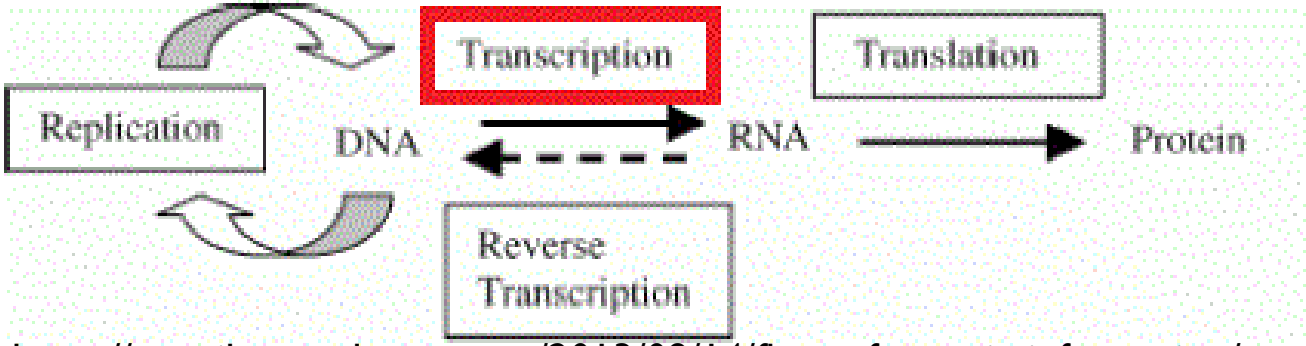
GENERAL FEATURES

- The flow of genetic information (central dogma)



https://mgmibt.wordpress.com/2013/09/14/flow-of-genetic-information/

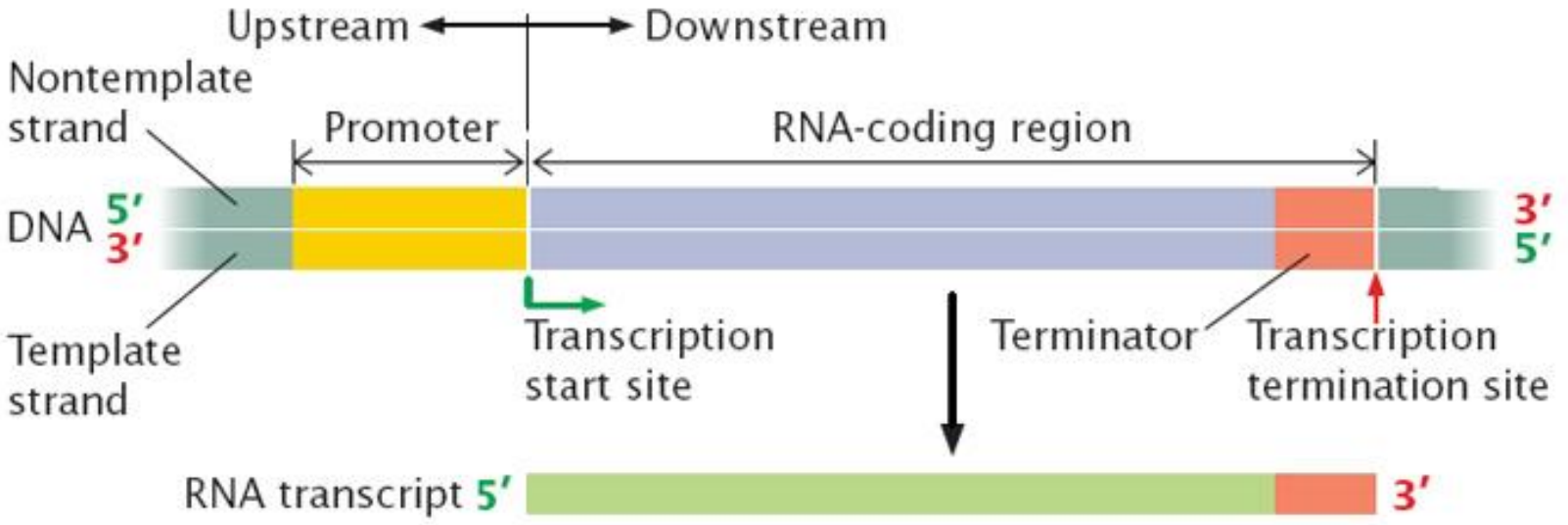
- The genetic information is transcribed from DNA to RNA
- Synthesis of RNA molecules using DNA as a template
- Primary transcript/pre-RNA

processing

mature RNA

- At the DNA containing part of the cells
- DNA serves as a template
- Enzyme: RNA polymerase (forms 3'-5' phosphodiester bonds)
- The direction of the synthesis is 5'-3' from the point of view from the new RNA molecule!!! (but from the point of view of DNA it is 3' to 5')
- Substrate: ribonucleoside-triphosphate
- β (beta) and γ (gamma) phosphate groups are released during the synthesis
- Bases in RNA: A, U, G, C (no T)

- Transcription unit
  - 1. Initiator/promoter region
  - 2. RNA coding region
  - 3. Terminator



http://bioap.wikispaces.com/Ch+17+Collaboration

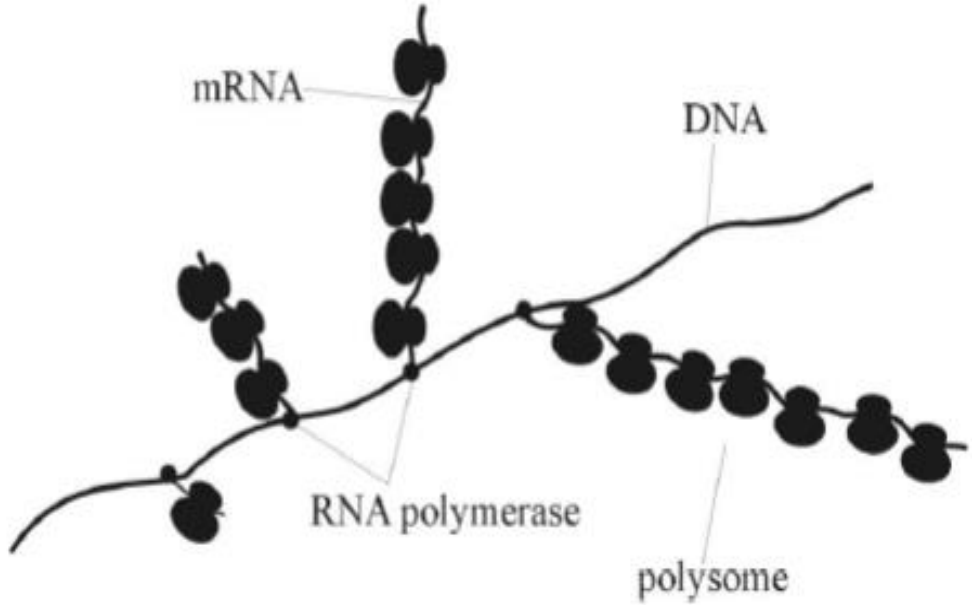
- Asymmetrical
- No need for primers

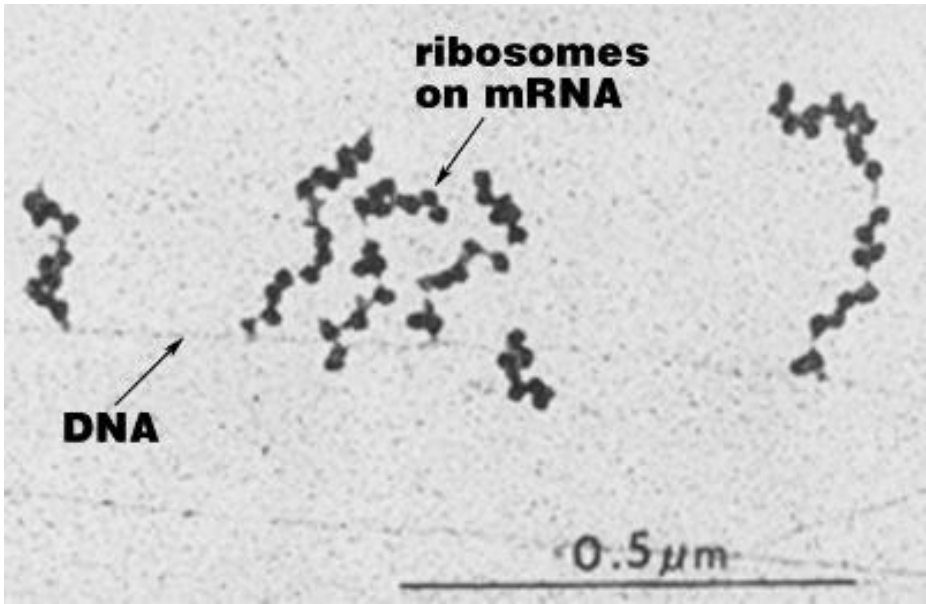
Steps of transcription

- **Initiation**
  - Transcriptosome binds here (enzymes for DNA denaturation, regulatory proteins, RNA polymerase etc.)
  - Regulatory role of promoter
- **Elongation**
  - Starts from +1 site
  - RNA polymerase incorporates the complementary ribonucleotides (phosphodiester bond formation)
  - 5' tryphosphate end of the newly synthesized RNA molecule
  - The growing 3' end is attached to the active strand of the DNA
- **Termination**
  - By different mechanisms in pro- and eukaryotes

TRANSCRIPTION IN PROKARYOTES

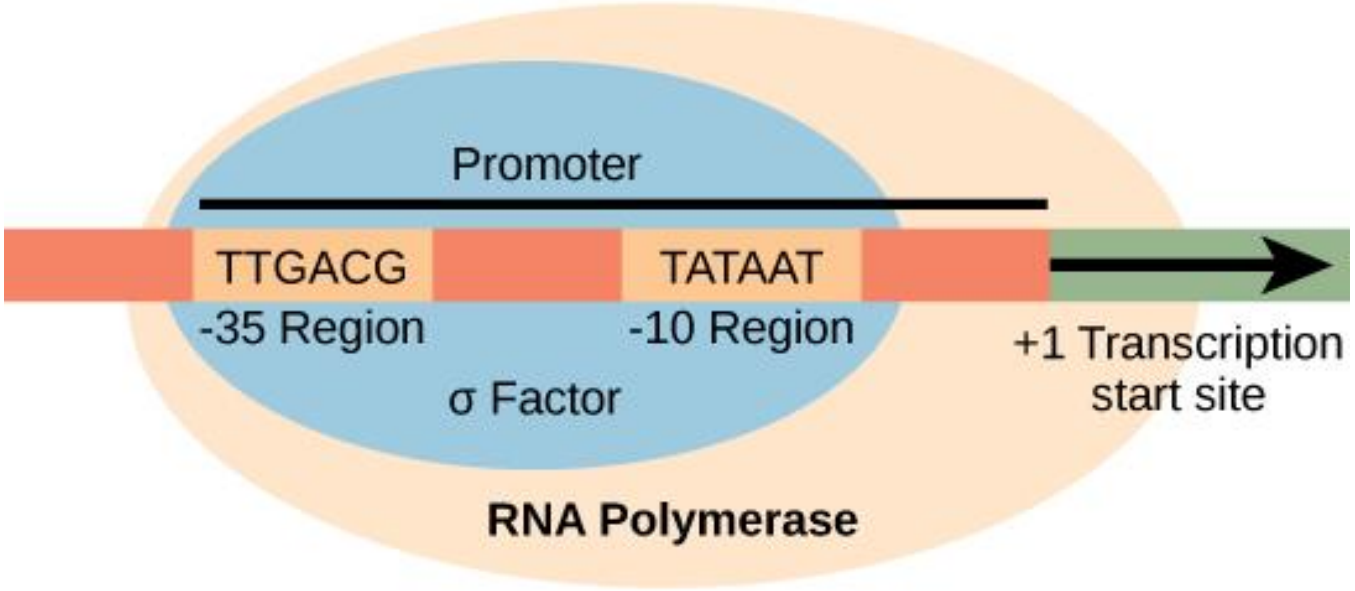
- In the nucleoid region
- Coupled transcription, translation→**chromosome-polysome complex**
  - No nuclear envelope
  - No processing in case of prokaryotic mRNA
  - The direction of transcription and translation are the same





Promoter in prokaryotes

- -35 and -10 (Pribnow-box) sequence
- RNA polymerase binds here
- Core enzyme + sigma subunit (the sigma subunit of RNA polymerase recognizes the promoter region)
- DNA denaturation happens here

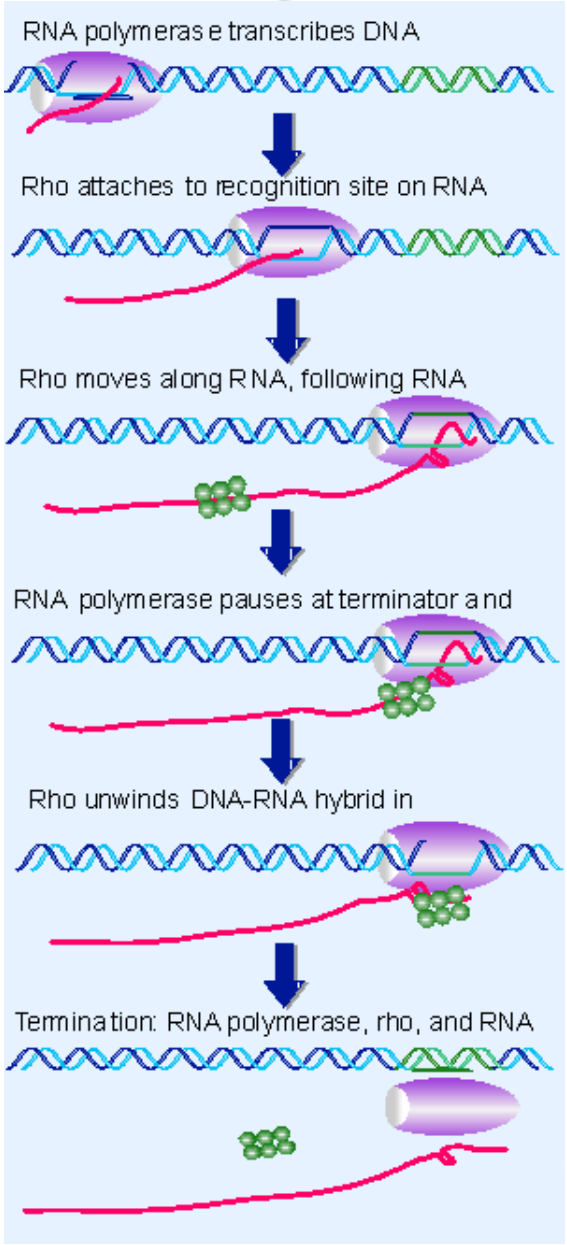


https://www.boundless.com/biology/textbooks/boundless-biology-textbook/genes-and-proteins-15/prokaryotic-transcription-107/initiation-of-transcription-in-prokaryotes-443-11667/

Termination in prokaryotes

Rho dependent

ρ factor binds to a specific sequence on the RNA and cuts off the RNA molecule from the DNA by its helicase activity



http://genes.atspace.org/9.10.html

Rho independent

the new RNA forms a hairpin by selfcomplementer basepairing and „tears off" the RNA molecule from the DNA (poly-U region after the hairpin forming region)

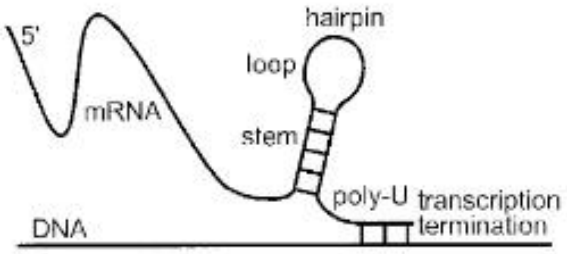


Figure 1. Model of a rho-independent transcription terminator.

http://gcat.davidson.edu/Spring2010/terminators/background/background.html

Pre-RNA processing in prokaryotes

- Posttranscriptional (the whole new RNA strand is already synthesized when the processing starts)
- Prokaryotic mRNA is mature (no processing is needed) → remember the chromosome-polysome complex
- Prokaryotic tRNA and rRNA is processed by exo- and endonucleases

A little help

- https://www.youtube.com/watch?v=1b-bRVgqof0
- https://www.youtube.com/watch?v=pNVPB6NFIZU
- A very detailed description: http://www.cliffsnotes.com/sciences/biology/biochemistry-ii/rna-and-transcription/transcription-in-prokaryotes

TRANSCRIPTION IN EUKARYOTES

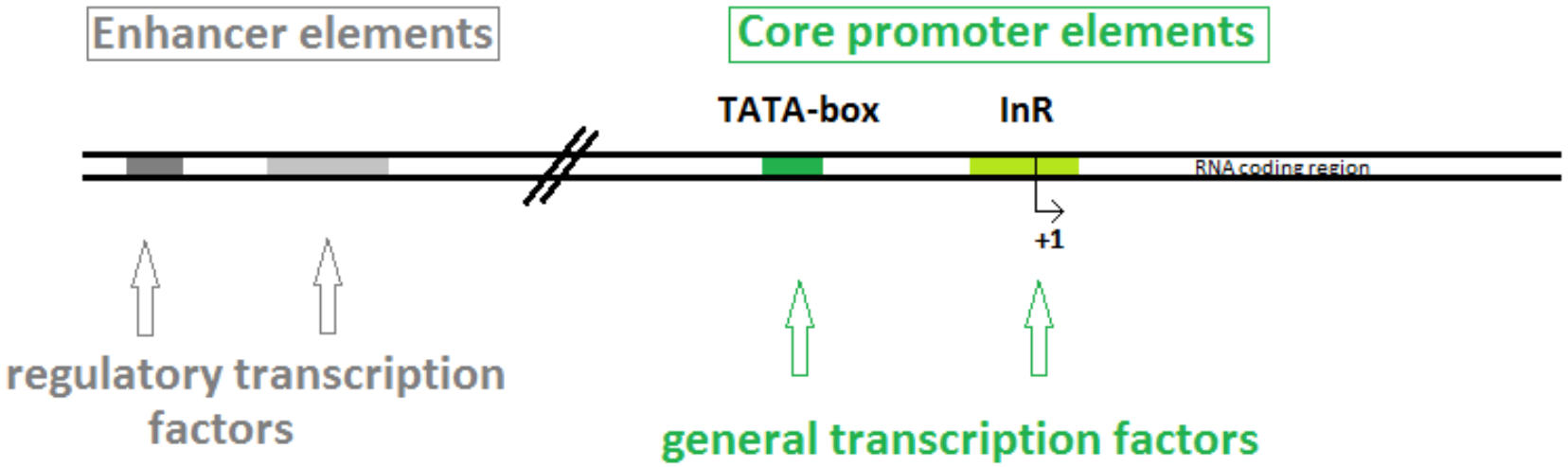
- In the nucleus (**chromatin**=proteins+DNA)
- DNA accessibility influences transcription (the proteins can overlie the transcription unit)
- Different RNA polymerases:

	RNA polymerase I	RNA polymerase II	RNA polymerase III
Product	pre-rRNA	pre-mRNA	5S rRNA tRNAs
Location	nucleolus	extranucleolar chromatin	

- No coupled transcription, translation
  - Nuclear envelope
  - mRNA processing
- Mature RNA transported to the cytosol

Promoter in eukaryotes

- Transcription factors! (RNA polymerase cannot bind directly to the promoter)
- Much more complex, more precise regulation is possible
- Core promoter:
  - Right before the RNA coding region
  - Sequences: TATA-box and InR
- Enhancer elements:
  - Can be far away from the RNA coding region
  - Influence the transcription



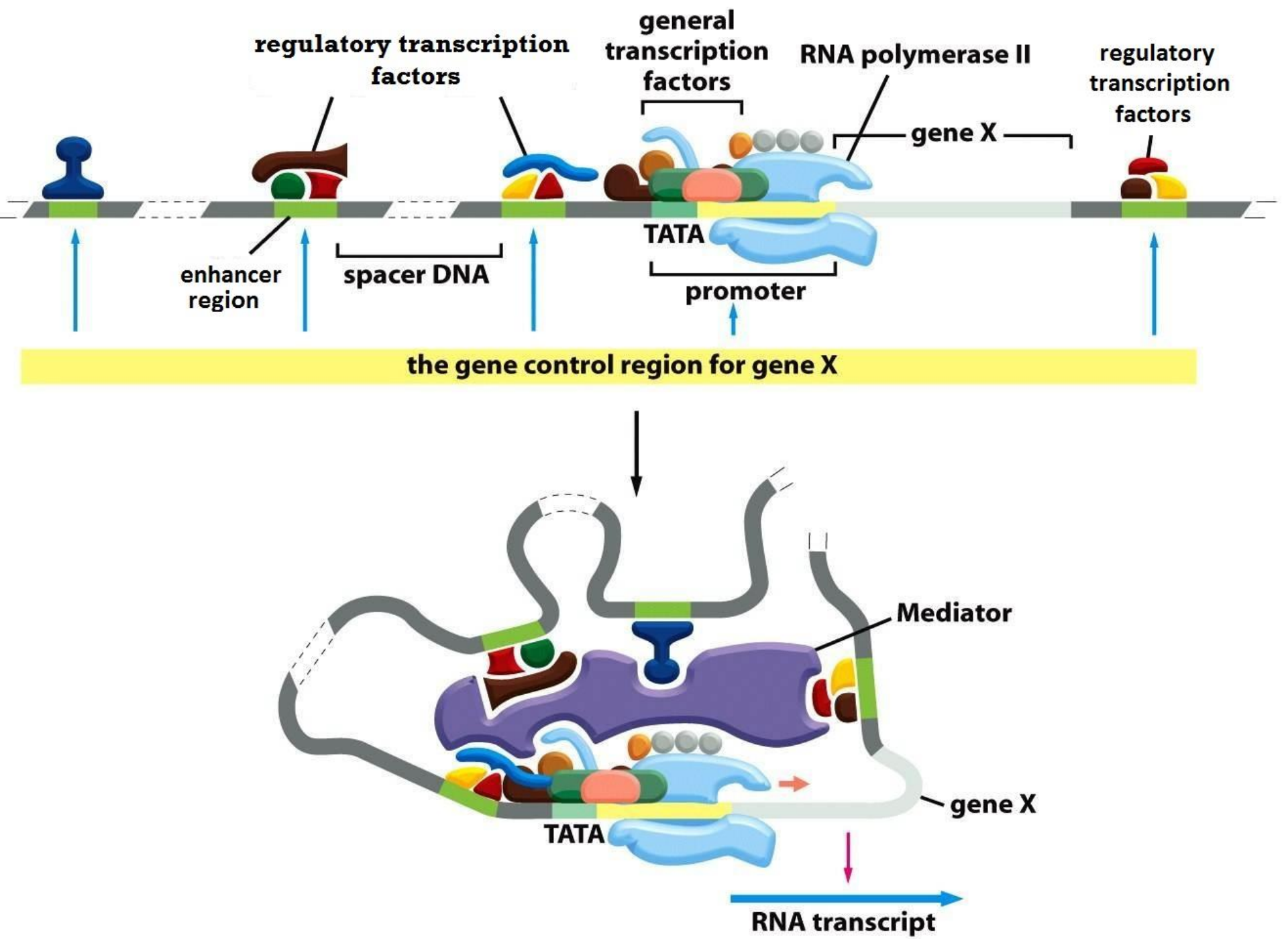
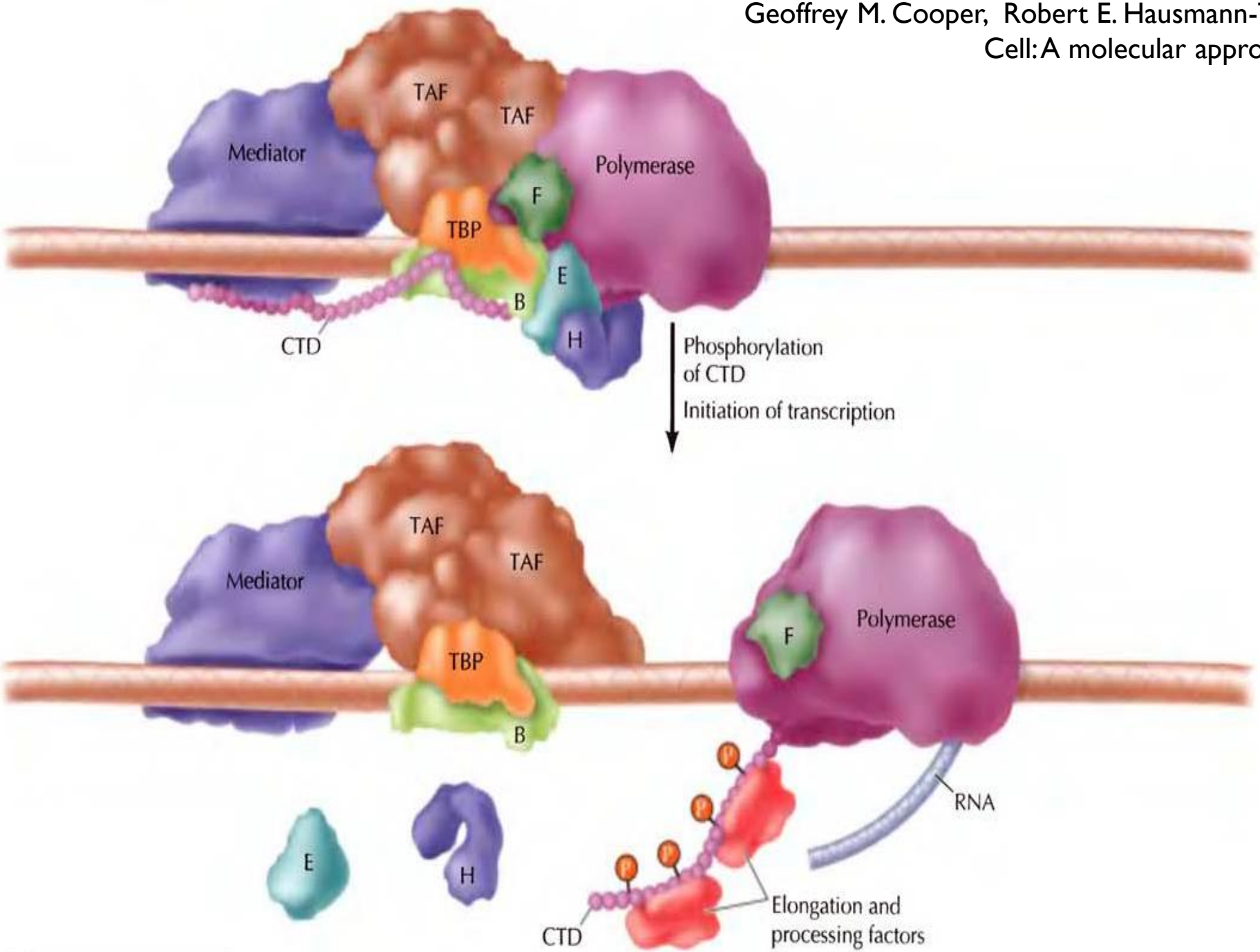


Figure 7-44 Molecular Biology of the Cell 5/e (© Garland Science 2008)

Elongation in eukaryotes

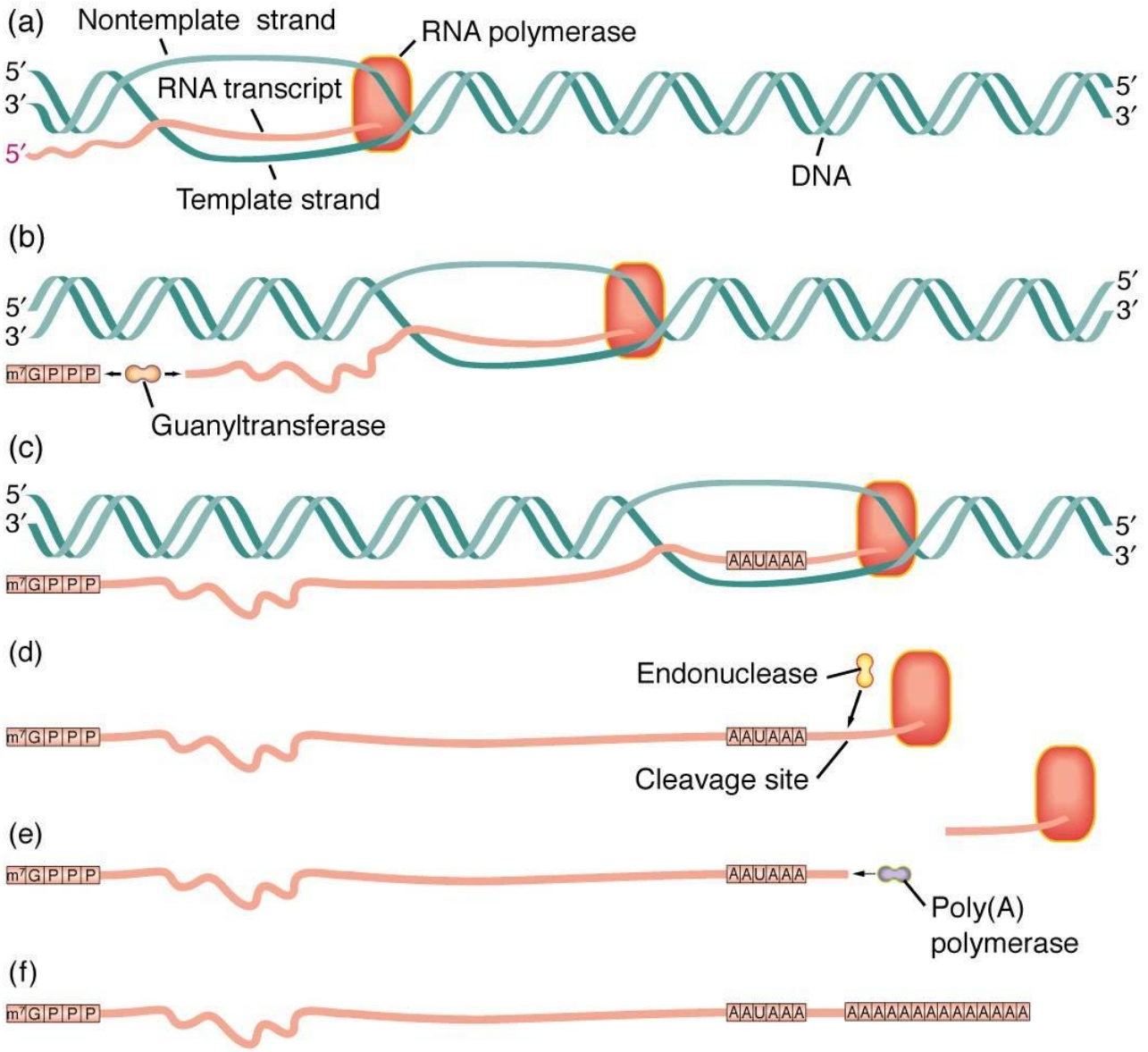
- Similar to the prokaryotic mechanism
- Elongation factors and other proteins are attached to the RNA polymerase

Geoffrey M. Cooper, Robert E. Hausmann-The Cell: A molecular approach



Termination in eukaryotes

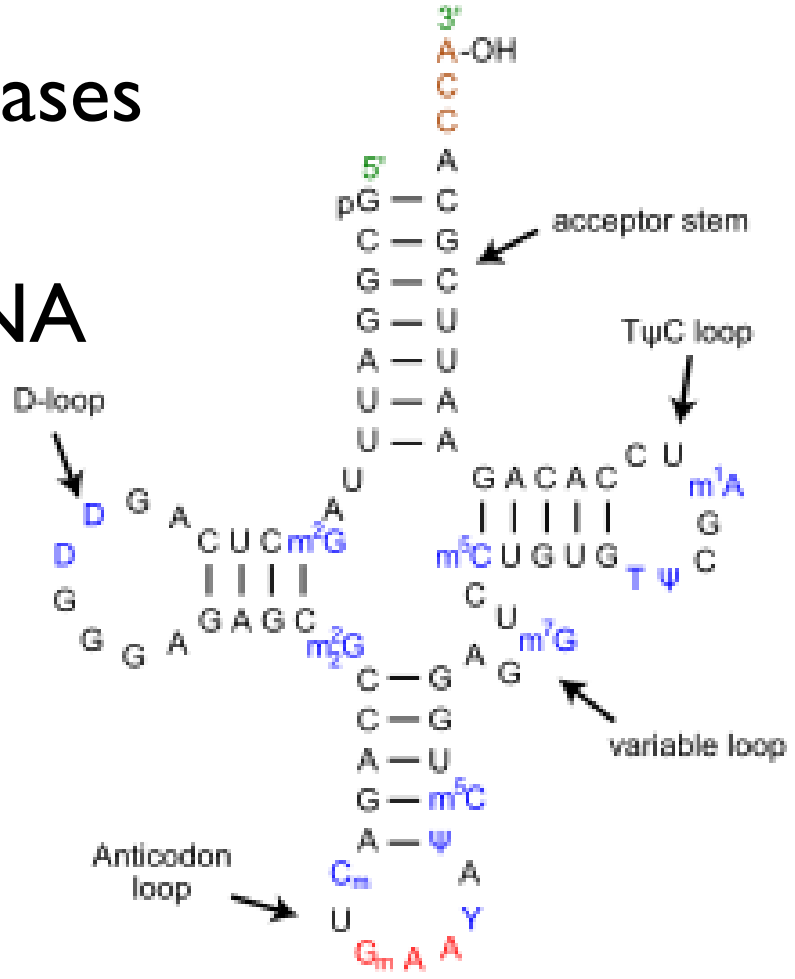
- Poly-adenilation sequence transcribed to the mRNA
- Protein complex binds to this sequence and cuts the RNA strand (endonuclease)



http://www.mun.ca/biology/scarr/MGA2_03-11.html

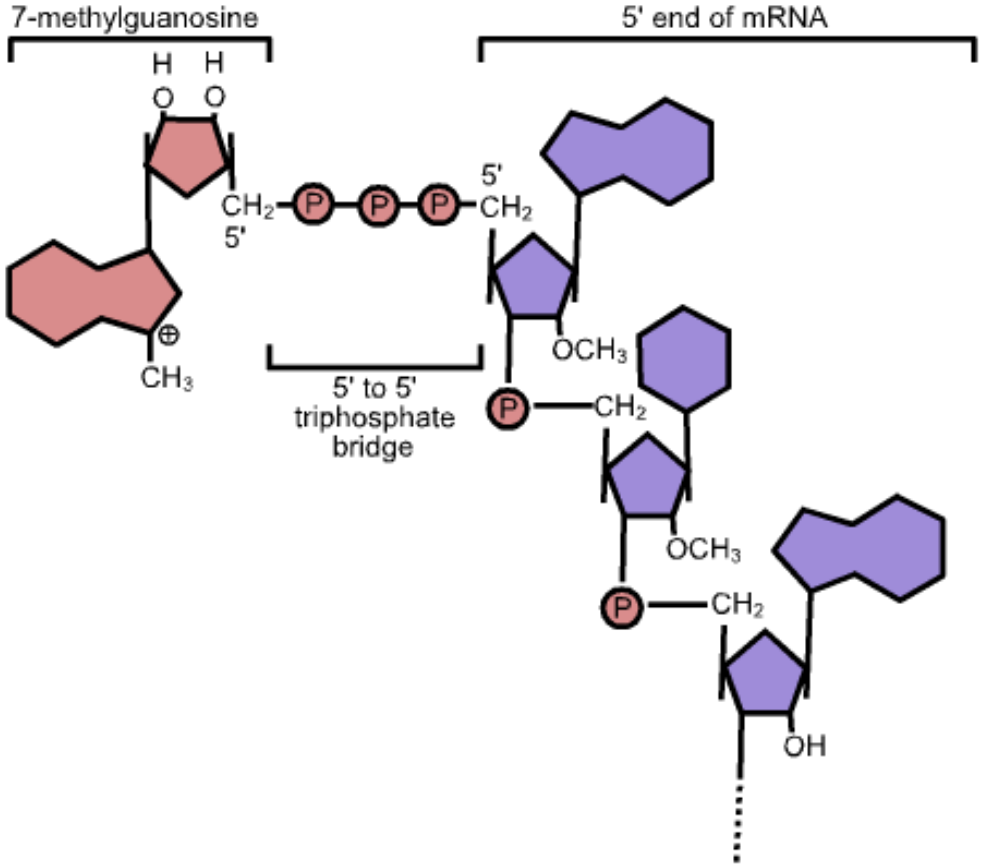
Pre-RNA processing in eukaryotes

- rRNA and tRNA: exo- and endonucleases, chemical modifications, addition of bases posttranscriptionally
- Cloverleaf structure of tRNA



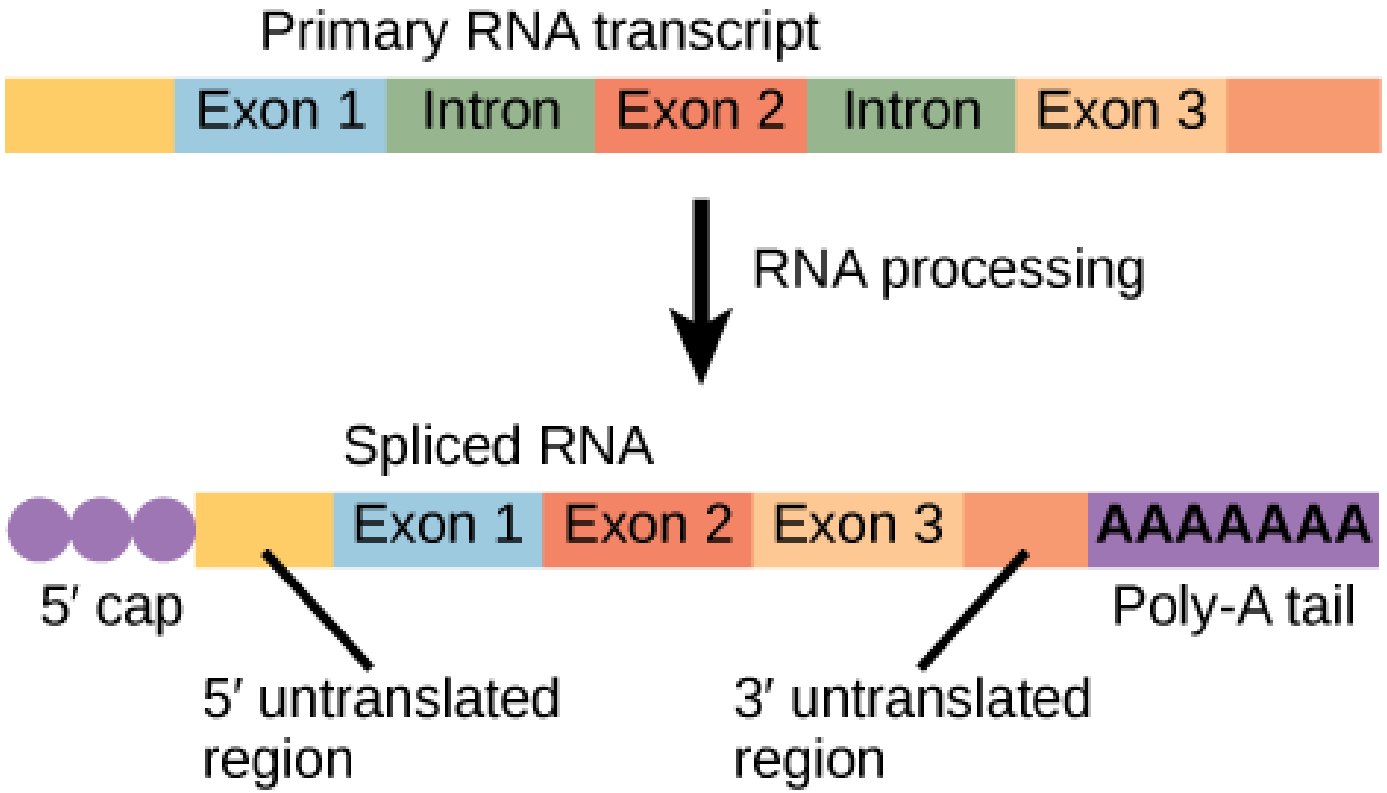
Pre-RNA processing in eukaryotes

- mRNA:
  - **5’ cap formation** (protection against degradation, ribosome binding)
  - **3’ poly-A tail** (protection against degradation, poly-A polymerase synthesizes it)
  - **splicing**



Pre-RNA processing in eukaryotes

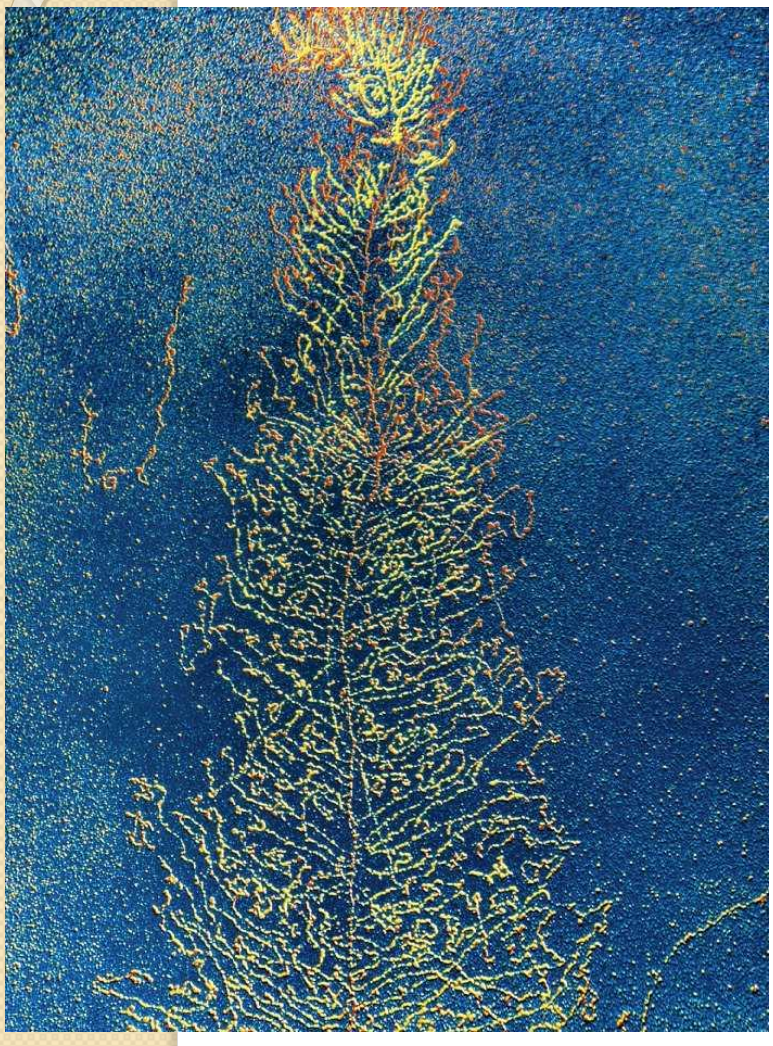
- Splicing:
  - Eukaryotic pre-mRNA contains exons and introns
  - Performed by RNA-protein complexes (RNP)



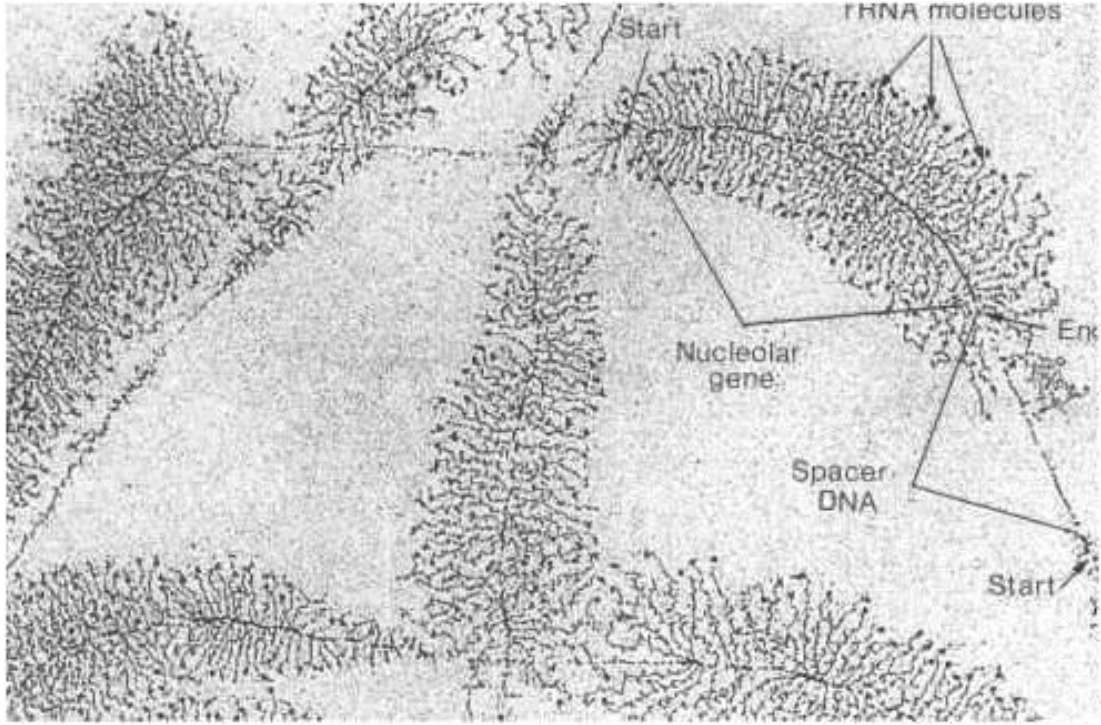
A little help again

- https://www.youtube.com/watch?v=SMtWvDbfHLo
- https://www.youtube.com/watch?v=P6Nyce-4oG4

Thank You for Your attention!



http://bio3400.nicerweb.com/Locked/media/ch13/christmas_tree_rRNA.html



http://www.proprofs.com/flashcards/story.php?title=mcb-block-3-organelles

rRNA transcription: the so called „Christmas tree" structure