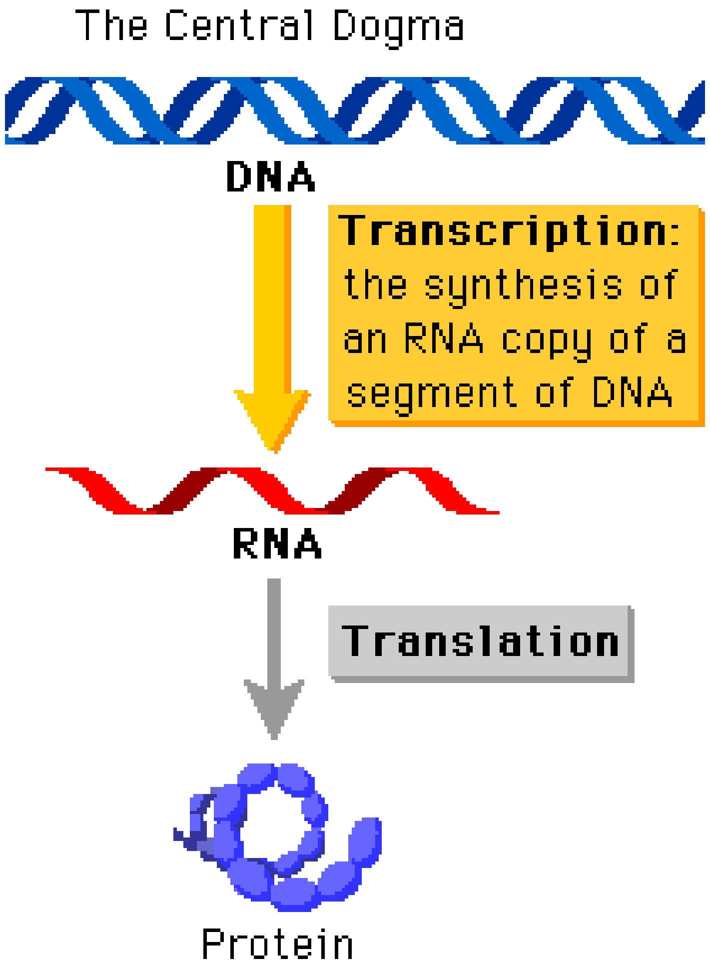
Transcription

Synthesis of RNA molecules

Bálint Balogh

- The **central dogma** of molecular biology: flow of genetic information

  DNA ⟶ RNA ⟶ protein



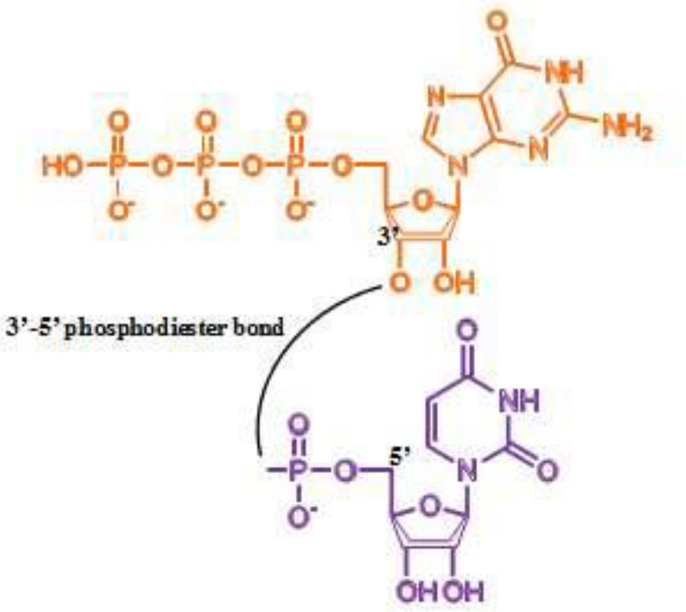
Transcription: the synthesis of an RNA copy of a segment of DNA

http://www.phschool.com/science/biology_place/biocoach/transcription/overview.html

General features

- *Transcription*= RNA synthesis on a DNA template strand
- The genetic information is transcribed from DNA to RNA
- The *mRNA* provides the information for protein synthesis
- At the DNA containing part of the cells
- **RNA polymerase** is responsible for RNA synthesis
  - Building blocks/substrate: ribonucleoside-triphosphates (NTPs)
  - 3’-5’ phosphodiester bonds are formed
- The direction of RNA synthesis is 5’-3’ from the point of view of the newly synthesized RNA molecule (but from the point of view of the DNA it is 3’-5’)
- **Primer independent**

- Ribonucleoside triphosphates: one ribose+ one nitrogen-containing heterocyclic base+ 3 phosphates
- Bases: A, G, C, U (T in DNA)
- β(beta)and γ(gamma) phosphate groups are released during the synthesis



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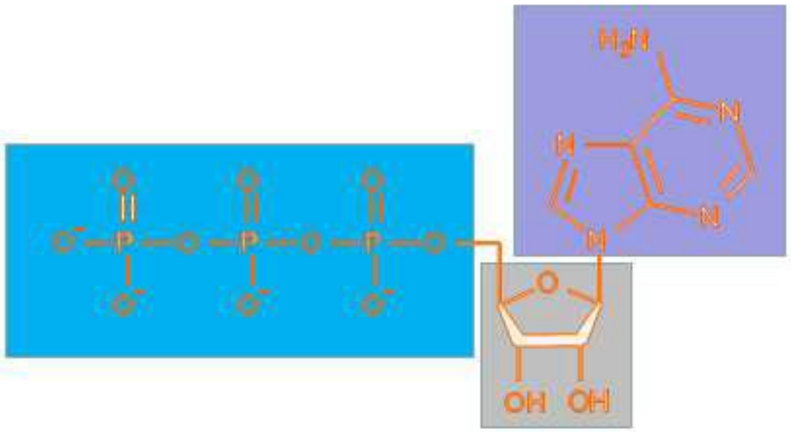

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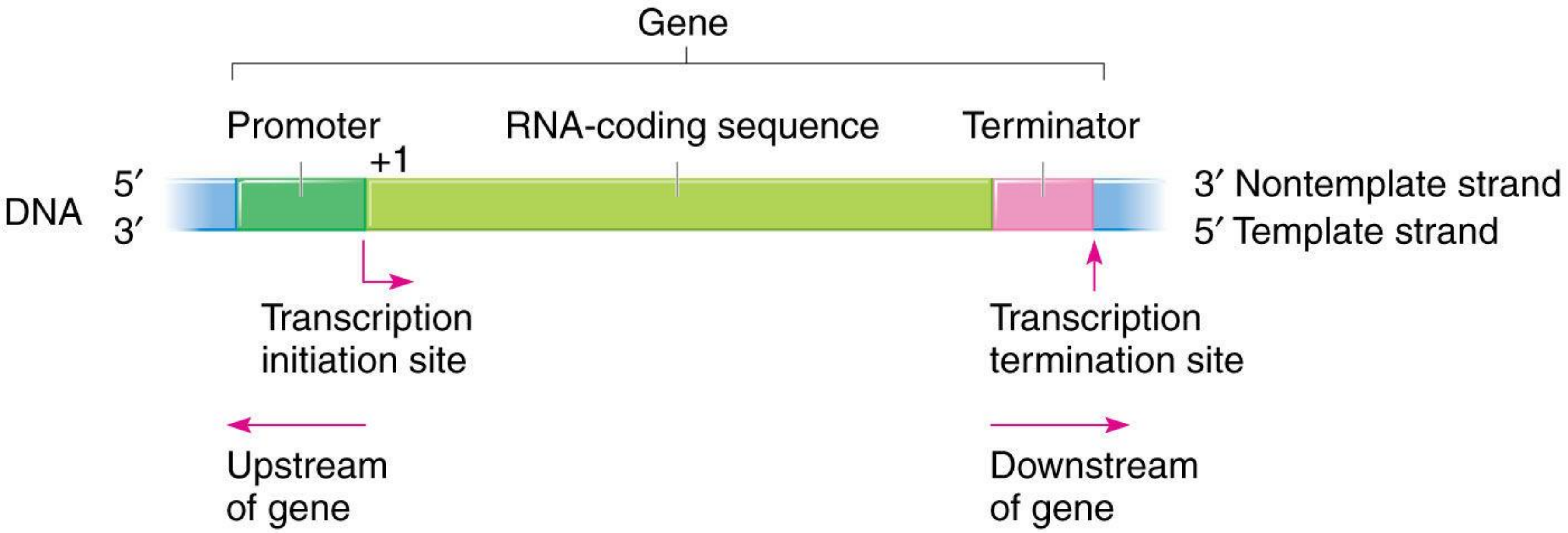
Transcription unit:

1. Initiation site/promoter
2. RNA coding DNA region
3. Termination site/terminator



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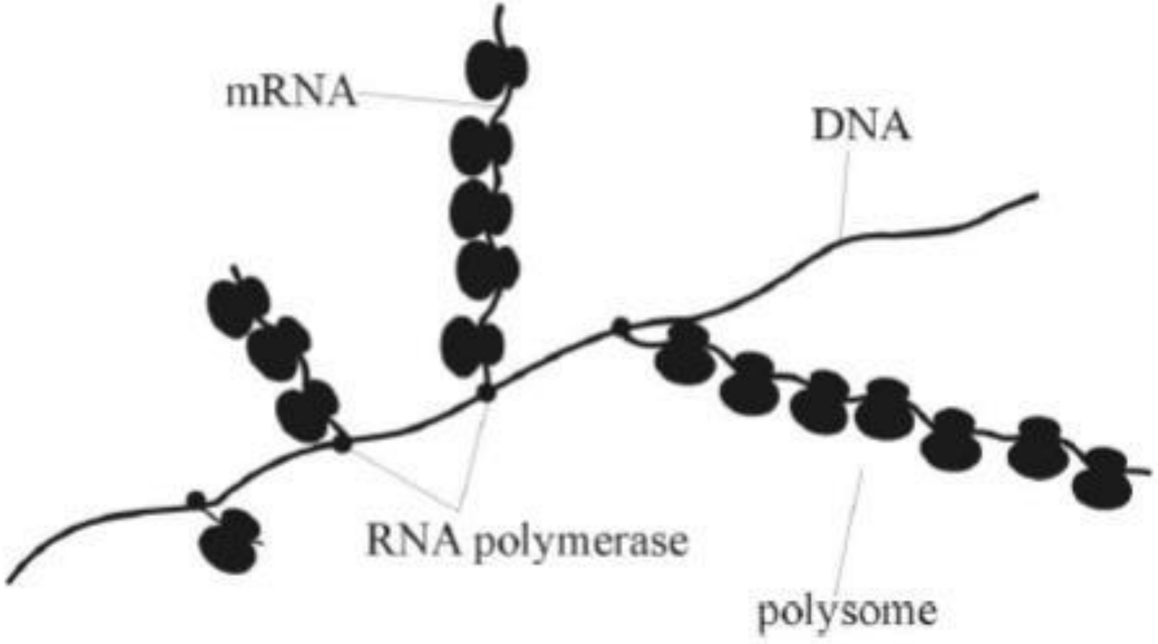
- **Asymmetrical:** only one strand transcribed, this is the active (antisense) strand. The other strand is inactive.(Except: E.g.: Mitochondria!!!)

Phases of transcirption

1. **Initiation**:
    - when the transcription starts (promoter region)
2. **Elongation**:
    - Starts from +1 site
    - 3’-5’ phosphodiester bonds are formed
    - 5’ triphosphate end
    - The 3’ end of the growing RNA molecule is attached to the template DNA strand
3. **Termination:**
    - end of RNA synthesis by different mechanisms in pro- and eukaryotes

Transcription in prokaryotes

- Occurs in the nucleoid region
- Coupled transcription- translation → **chromosome-polysome complex**
  - The direction of transcription and translation are the same from the point of view of the mRNA (5’-3’)
  - No processing in the case of the prokaryotic mRNA
  - No nuclear envelope



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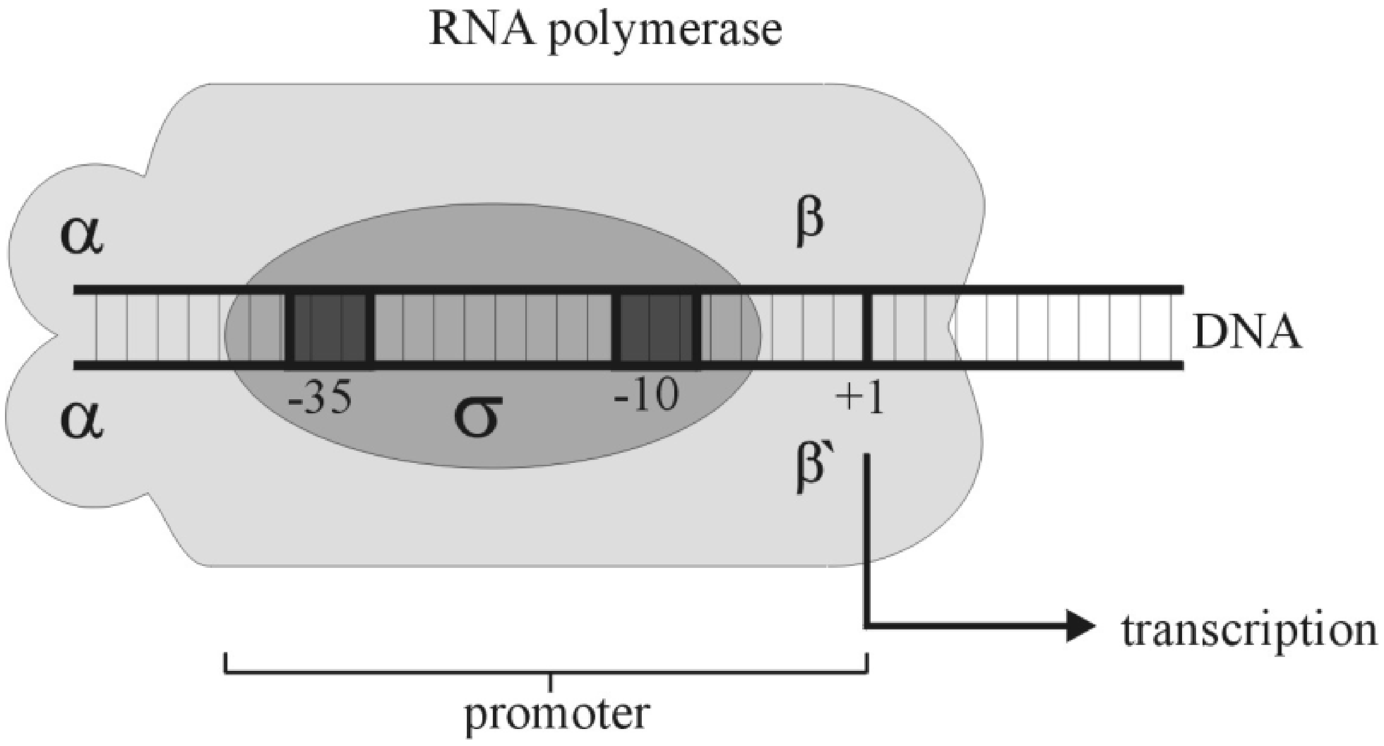
Initiation in prokaryotes:

- Promoter region: -35 and -10 (Pribnow box) sequences
- RNA polymerase: sigma factor+ core enzyme
- DNA denaturation happens ⟶ a small transcription bubble is formed, sliding toward the terminator



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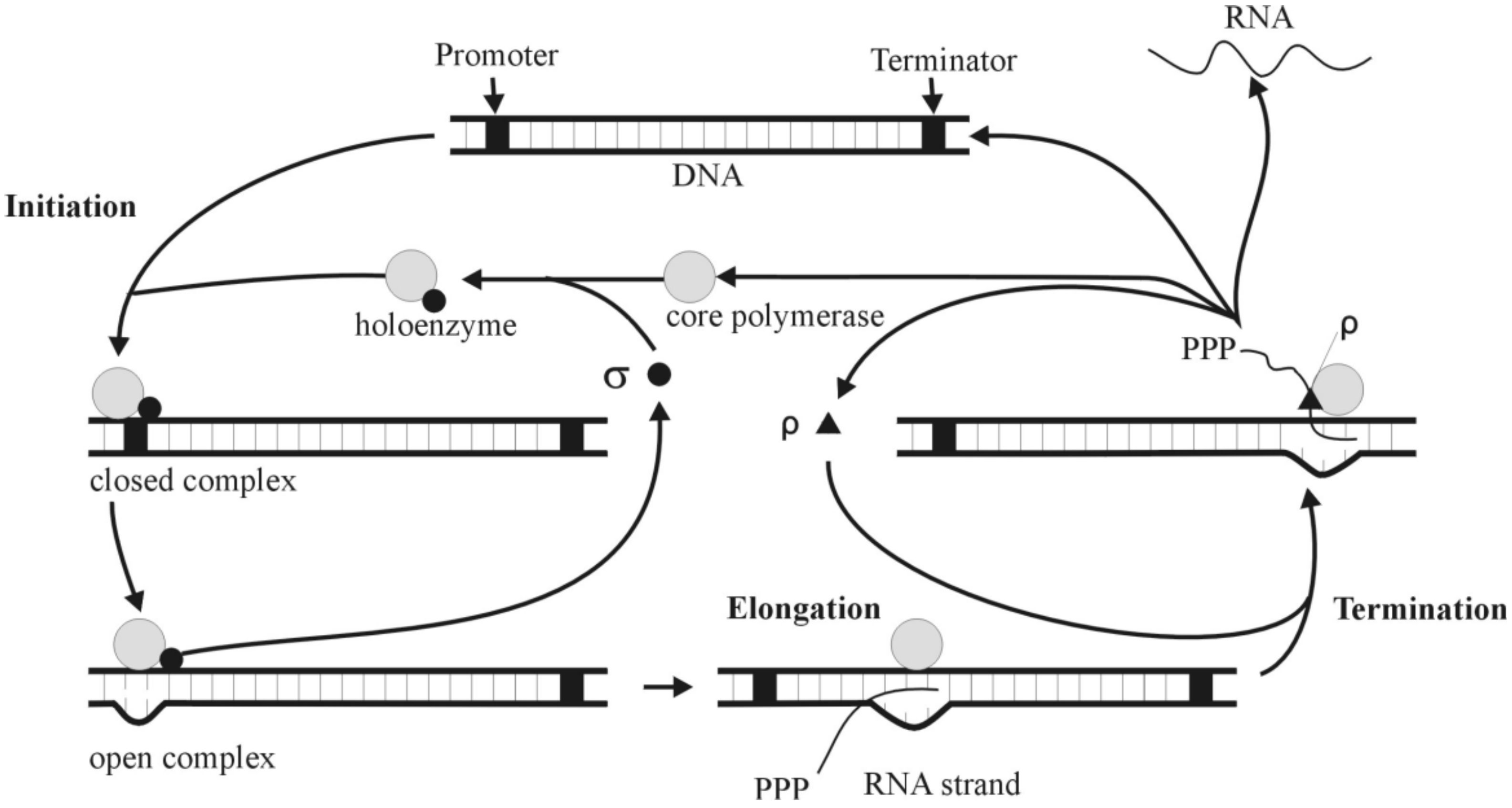
Elongation

- It is carried out by the core polymerase
- The direction of RNA synthesis is 5’-3’
- 5’ triphosphate end



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Termination

- **Rho dependent**: ρ factor binds to the polymerase, recognizes the terminator sequence and cuts off the RNA molecule from the DNA by its helicase activity

OR

- **Rho independent**: GC rich hairpin is formed by selfcomplementer basepairing and „tears off" the RNA from the DNA (there is a poly-U region after the hairpin structure)

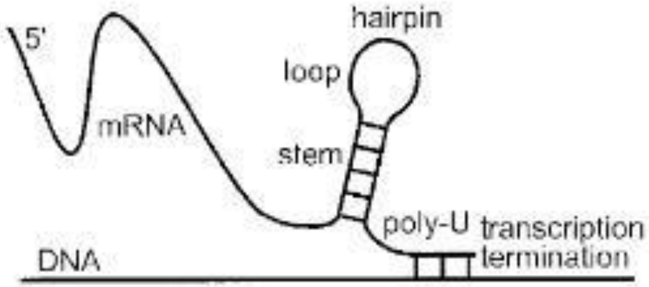


Figure 1. Model of a rho-independent transcription terminator.

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

RNA processing is prokaryotes

- The mRNA is mature, not processed ⟶ **chromosome-polysome complex**
- tRNAs and rRNAs are modified

A little help

- https://www.youtube.com/watch?v=1b-bRVgqof0

Transcription in eukaryotes

- Takes place in the nucleus (chromatin=DNA+proteins)
- Transcription and translation are separated
  - Nuclear membrane
  - mRNA processing
- 3 types of RNA polymerases

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

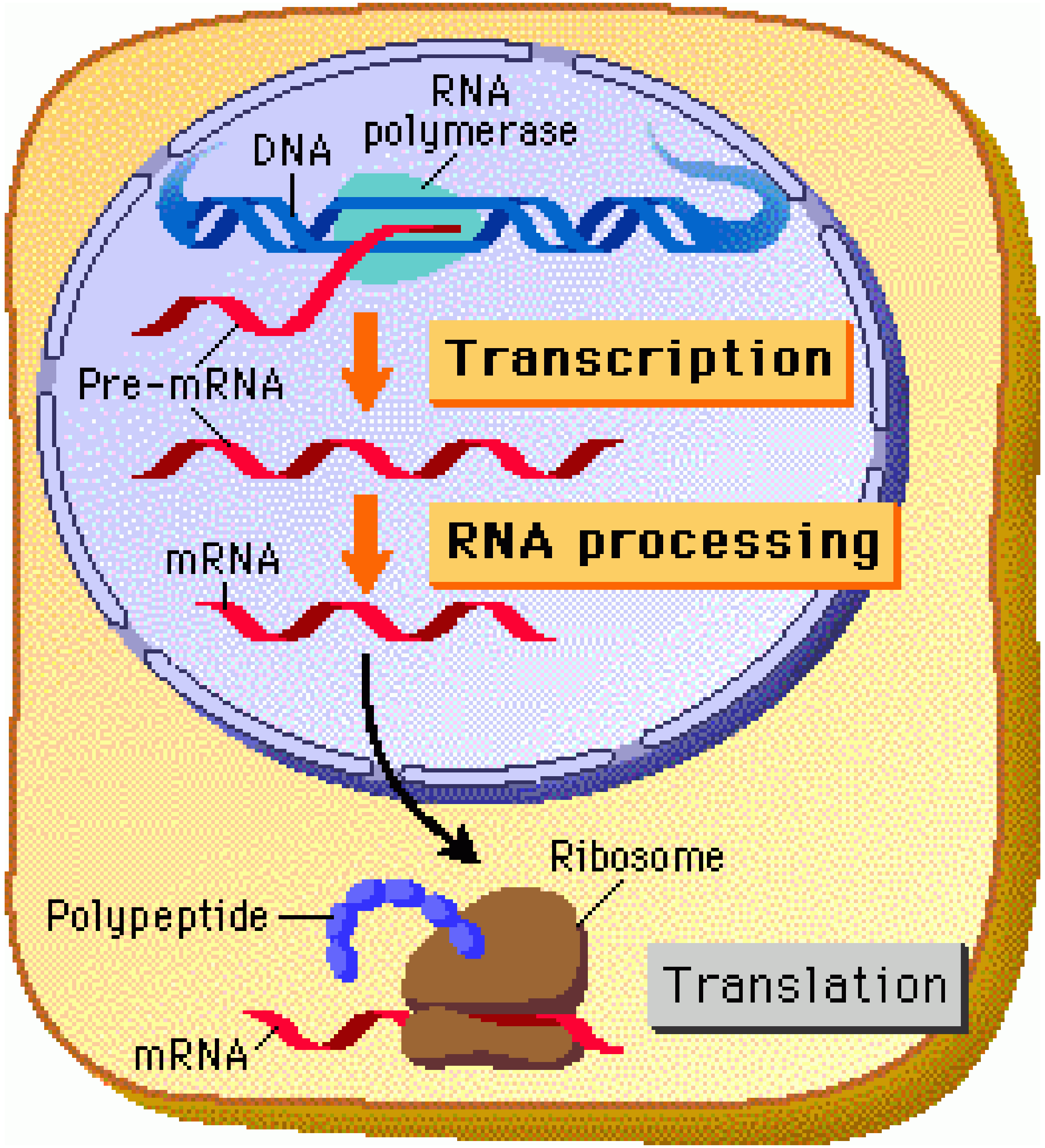
Promoter

- RNA polymerase cannot bind directly to the promoter

- Transcription factors!

- Core promoter:
  - Right before the coding region
  - Sequences : TATA-box and Initiator region

- Enhancer elements:
  - Can be far away from the coding region
  - Transcription can be influenced



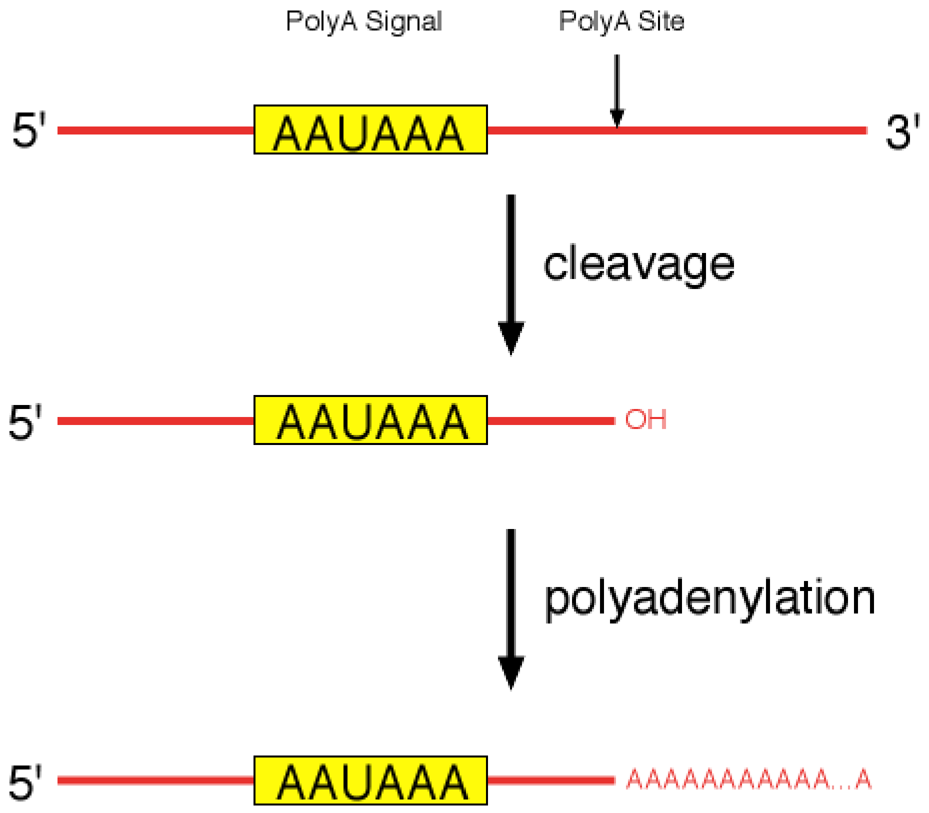
http://www.namrata.co/transcription-part-2-prokaryotic-vs-eukaryotic-transcription/

Elongation in eukaryotes

- Similar to the prokaryotic elongation mechanism
- Elongation and processing factors are attached to the RNA polymerase

Termination in eukaryotes

- A specific sequence (polyadenilation element) is transcribed by the RNA polymerase
- A protein complex binds to this sequence and cleaves the mRNA strand by its endunuclease activity

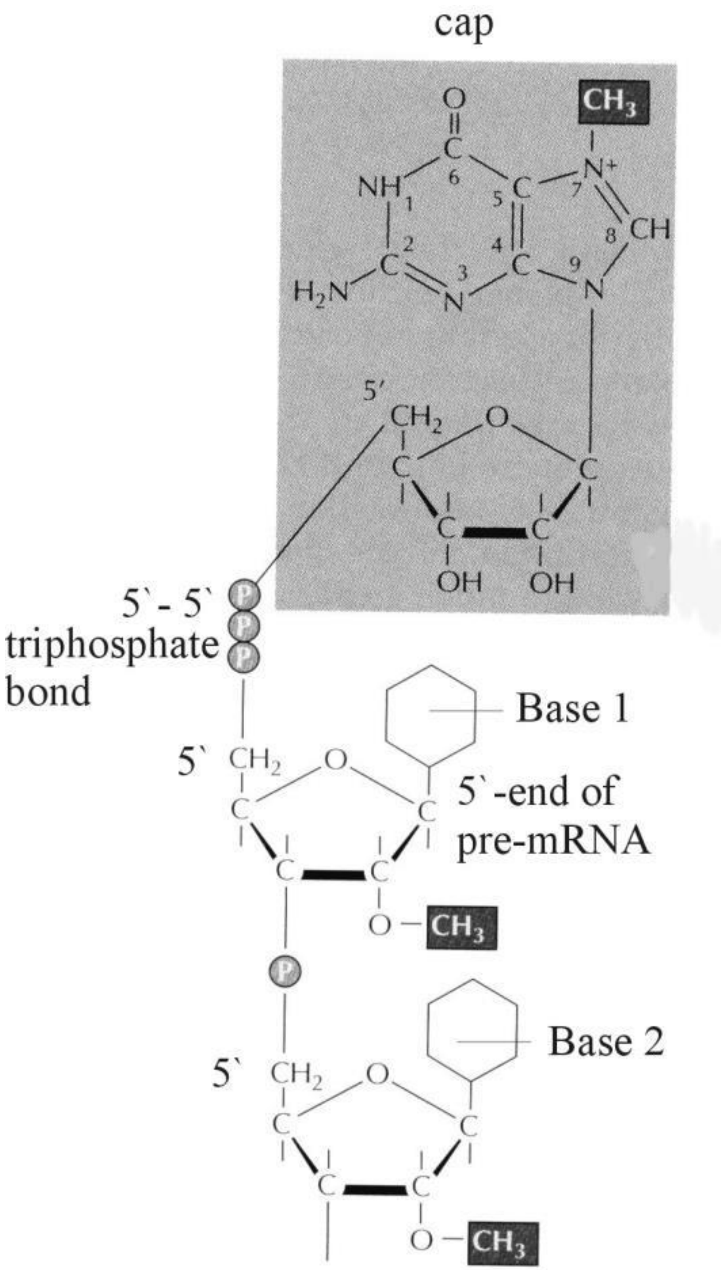


http://oregonstate.edu/instruction/bb331/lecture10/FigpolyA.html

Pre-mRNA processing in eukaryotes

- 5’ cap fromation:
  - Protection against nucleases
  - Ribosome binding

- 3’ poly(A) tail:
  - Poly(A) polymerase synthesizes it
  - Protection against degradation



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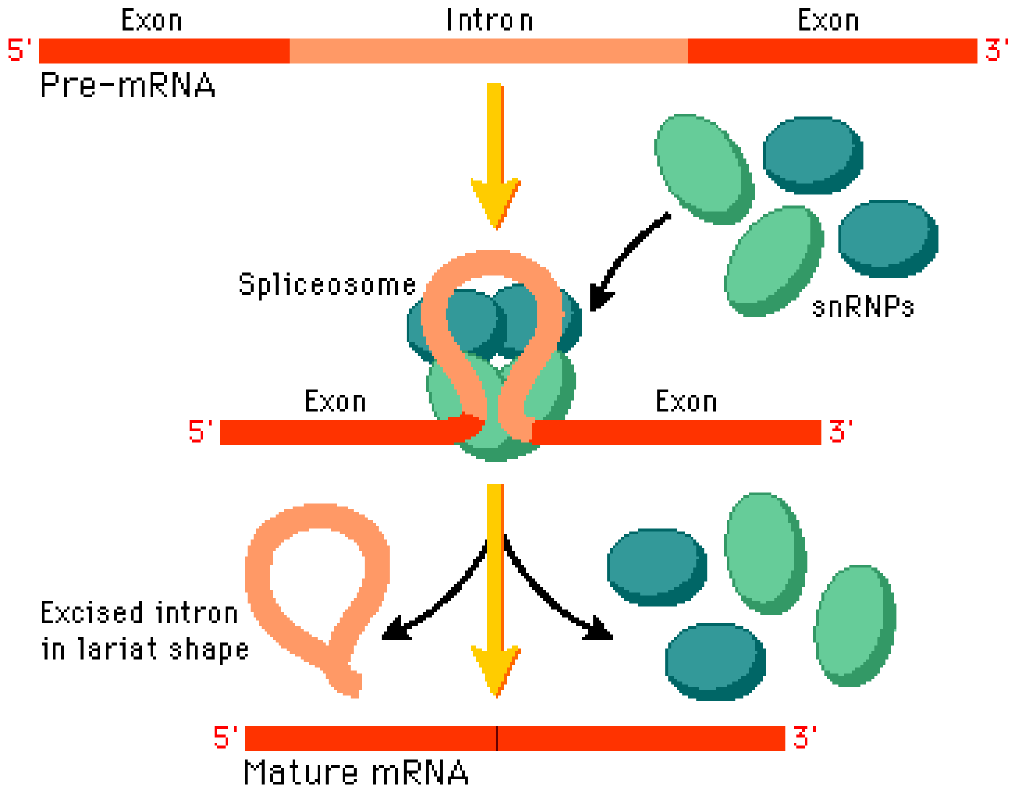
Pre-mRNA processing in eukaryotes

- Splicing
  - Eukaryotic pre-mRNA contains introns and exons
  - Introns are removed from the pre-mRNA
  - Joining of exons



http://www.phschool.com/science/biology_place/biocoach/transcription/premrna.html

A little help again

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

Thank you for your attention!