Difference Between Prokaryotic and Eukaryotic RNA Polymerase

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Key Difference - Prokaryotic vs Eukaryotic RNA Polymerase

RNA polymerase is the enzyme which is responsible for the process of transcription that takes place in all living organisms. RNA polymerase is a high molecular weight enzyme. The official name of RNA polymerase is the DNA-directed RNA polymerase. During the transcription, RNA polymerase opens the double-stranded DNA so that one DNA strand can be used as a template for the process of synthesizing a mRNA molecule. Generating RNA (**mRNA, rRNA, and tRNA**) molecules is an extremely important step in the protein synthesis (translation). Transcription factors and transcription mediated complexes are guiding the RNA polymerase enzyme to initiate the transcription in a living cell. RNA polymerase attaches to the promoter region of the gene (DNA) and starts the RNA polymerase-catalyzed transcription. Prokaryotic and eukaryotic transcription differs mainly due to the difference in RNA polymerase enzyme. The **key difference** between Prokaryotic and Eukaryotic RNA Polymerase is, **the prokaryotic transcription is performed by a single multi subunit type of RNA polymerase. On the contrary, the eukaryotic transcription is catalyzed by three different types of RNA polymerases named as RNA polymerase I (transcribe rRNA), RNA polymerase II (transcribe mRNA) and RNA polymerase III (transcribe tRNA).**

What is Prokaryotic RNA Polymerase?

The prokaryotic RNA polymerase is a multisubunit heavy enzyme. The RNA polymerase of *E coli* is extensively studied. This is a complex enzyme which is having a molecular weight of 450 KDa. The holoenzyme consists of two main components. They are core enzyme and transcription factors. The core enzyme component is having five subunits such as β', β, αI, αII and ω. The transcription factors are sigma factor (initiation), nusA (elongation).

Out of these factors, the β′ is having the function of DNA binding. And β factor has the catalytic site that carries out the RNA polymerization. The functions of factors α and ω are not discovered yet. Some say that the alpha factor (α) is responsible for chain initiation and interaction with regulatory proteins. The main function of the sigma factor is promoter recognition. Once the promoter in DNA is recognized by sigma factor, the coenzyme component of the RNA polymerase binds with promoter region and

initiates the RNA polymerization. Once transcription begins the sigma factor releases from the DNA. The elongation of RNA molecule is done by β subunit. In the chain termination, the “rho factor” releases the already-transcribed RNA molecule.

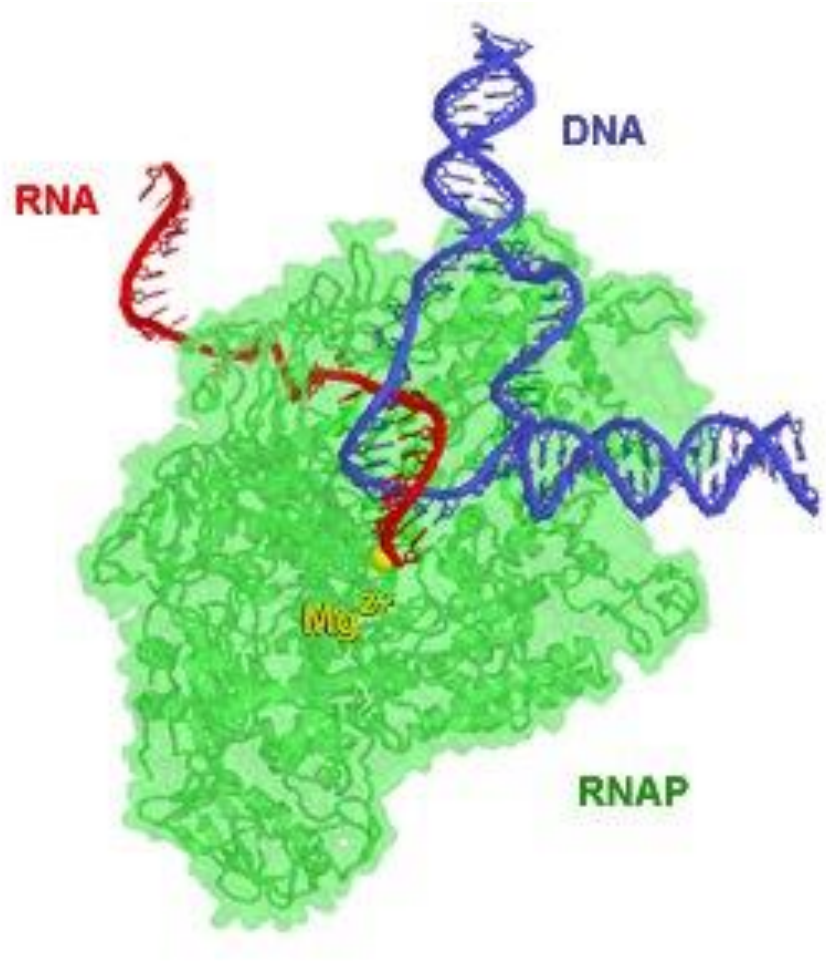

Figure 01: The Prokaryotic RNA Polymerase

The transcription terminates at the sites specified by the DNA template. The factor nusA is involved in the function of elongation as well as chain termination. The antibiotic rifampicin can bind with the beta subunit of the bacterial RNA polymerase.Thereby, it is preventing the enzyme from initiating bacterial RNA polymerization. Another antibiotic known as streptolydigin inhibits the elongation process of bacterial RNA polymerization. The prokaryotes mRNA is polycistronic, meaning it contains codons of a more than one cistron (more than one gene).

What is Eukaryotic RNA Polymerase?

The eukaryotic RNA polymerases are three different types. They transcribe different classes of genes. And also function under different conditions. The initiating and

terminating factors (sigma and rho factors) are completely different from prokaryotic RNA polymerase counterparts. The three different RNA polymerases are named as, RNA polymerase I (transcribes rRNA), RNA polymerase II (transcribes mRNA) and RNA polymerase III (transcribes tRNA). RNA polymerase I is located in the nucleolus and the enzyme is requiring Mg^{2+} for its activity. RNA polymerase II is in the nucleoplasm needs ATP for its activity. RNA polymerase III is also located in the nucleoplasm.

The promoters for these RNA polymerases are different. RNA polymerase I recognize the promoters in upstream between -45 to +25 regions in DNA. RNA polymerase II recognizes the promoters in upstream between -25 to -100 regions in DNA such as (TATA box, CAAT box, and GC box). RNA polymerase III recognizes the downstream internal promoters.

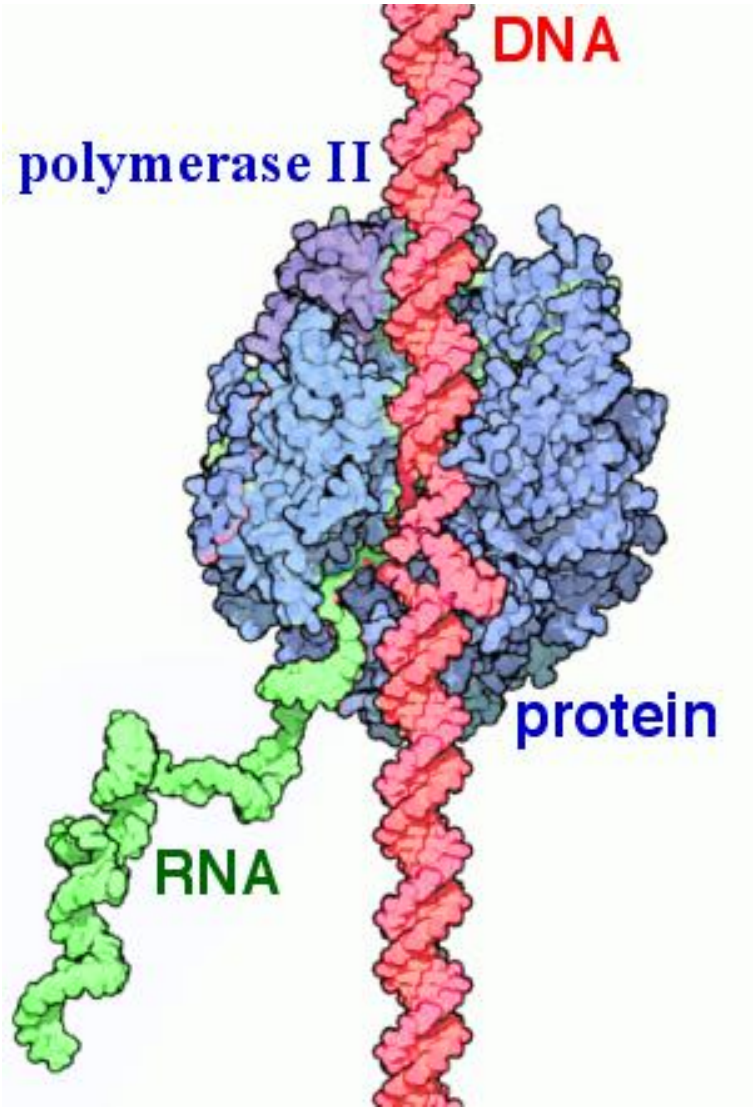

Figure 02: Eukaryotic RNA Polymerase

The eukaryotic RNA polymerases are large complex that made up of multi subunits proteins of 500 kDa or more. They have different transcription factors for initiation process and elongation process like, TFIIA, TFIIB, TFIID, TFIIE, TFIIF, TFIIH, TFIIJ. RNA polymerization terminates by RNA polymerase I after recognizing Sal box. RNA polymerization termination by RNA polymerase II happens after recognizing downstream signals known as polyA tail. And RNA polymerase III recognizes deoxyadenylate residues on the template and terminate the transcription. Eukaryotic mRNA is always monocistronic.

What are the Similarities Between Prokaryotic and Eukaryotic RNA Polymerase?

- Both are involved in RNA synthesizing.
- Both are using DNA as the template.
- Both are large proteins.
- Both have sigma factor that initiates transcription.
- Both have transcription factors that regulate the steps (initiation and elongation) of RNA polymerization.

What is the Difference Between Prokaryotic and Eukaryotic RNA Polymerase?

Prokaryotic vs Eukaryotic RNA Polymerase	
The prokaryotic RNA polymerase is a single multi subunits type enzyme which is responsible for prokaryotic transcription.	The Eukaryotic RNA polymerases are different types of enzymes which carry out the eukaryotic transcription.
Molecular Weight	
The prokaryotic RNA polymerase molecular weight is approximately 400 KDa.	The Eukaryotic RNA polymerases molecular weight is more than 500kD.

Transcription Factors	
The prokaryotic RNA polymerase has transcription factors such as sigma factor and nusA.	The Eukaryotic RNA polymerases have different transcription factors for initiation and elongation such as ; TFIIA, TFIIB, TFIID, TFIIE, TFIIF, TFIIH, TFIIJ
Termination Factor	
The prokaryotic RNA polymerase has “rho factor” for termination.	The Eukaryotic RNA polymerases have different termination sequences like sal box, poly A tail and deoxyadenylate residues.
Promoters	
The prokaryotic RNA polymerase recognizes promoter in -10 to -35 region in DNA known as TATA box.	The Eukaryotic RNA polymerases have different promoters like; RNA polymerase I recognizes the promoters in upstream between -45 to +25 regions in DNA. RNA polymerase II recognizes the promoters in upstream between -25 to -100 regions in DNA such as (TATA box, CAAT box, and GC box). RNA polymeraseIII recognizes the downstream internal promoters.
Nature of mRNA	
The prokaryotic RNA polymerase produces polycistronic mRNA.	The Eukaryotic RNA polymerase II produces monocistronic mRNA.

Summary - Prokaryotic vs Eukaryotic RNA Polymerase

RNA polymerase is the enzyme responsible for RNA polymerization known as transcription in the living cell. The RNA polymerase is also named as DNA-directed RNA polymerase as it uses DNA as the template. In transcription RNA polymerase normally opens the double-stranded DNA so that one DNA strand can be used as a template for the process of synthesizing RNA molecule. RNA polymerase can give rise to mRNA, rRNA, and tRNA. Transcription factors and transcription mediated complex are guiding the RNA polymerase in the transcription process. The transcription has three

steps; initiation, elongation, and termination. This can be highlighted as the difference between Prokaryotic and Eukaryotic RNA Polymerase.

Reference:

1.Nature News, Nature Publishing Group. Available here
2.“RNA polymerase.” Wikipedia, Wikimedia Foundation, 11 Dec. 2017. Available here

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2.'Label RNA pol II' By JWSchmidt, (Public Domain) via Commons Wikimedia

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