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RNA polymerase III

In eukaryote cells, **RNA polymerase III** (also called **Pol III**) transcribes DNA to synthesize ribosomal 5S rRNA, tRNA and other small RNAs.

The genes transcribed by RNA Pol III fall in the category of "housekeeping" genes whose expression is required in all cell types and most environmental conditions. Therefore, the regulation of Pol III transcription is primarily tied to the regulation of cell growth and the cell cycle, thus requiring fewer regulatory proteins than RNA polymerase II. Under stress conditions however, the protein Maf1 represses Pol III activity.^[1] Rapamycin is another Pol III inhibitor.^[2]

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Transcription

The process of transcription (by any polymerase) involves three main stages:

- Initiation, requiring construction of the RNA polymerase complex on the gene's promoter
- Elongation, the synthesis of the RNA transcript
- Termination, the finishing of RNA transcription and disassembly of the RNA polymerase complex

Initiation

Initiation: the construction of the polymerase complex on the promoter. Pol III is unusual (compared to Pol II) by requiring no control sequences upstream of the gene, instead normally relying on internal control sequences - sequences within the transcribed section of the gene (although upstream sequences are occasionally seen, e.g. U6 snRNA gene has an upstream TATA box as seen in Pol II Promoters).

Class I

Typical stages in 5S rRNA (also termed class I) gene initiation:

- TFIIIA (**T**ranscription **F**actor for polymerase **III A**) binds to the intragenic (lying within the transcribed DNA sequence) 5S rRNA control sequence, the C Block (also termed box C).
- TFIIIA serves as a platform that replaces the A and B Blocks for positioning TFIIIC in an orientation with respect to the start site of transcription that is equivalent to what is observed for tRNA genes.
- Once TFIIIC is bound to the TFIIIA-DNA complex, the assembly of TFIIIB proceeds as described for tRNA transcription.

Class II

Typical stages in a tRNA (also termed class II) gene initiation:

- TFIIIC (**T**ranscription **F**actor for polymerase **III C**) binds to two intragenic (lying within the transcribed DNA sequence) control sequences, the A and B Blocks (also termed box A and box B).
- TFIIIC acts as an assembly factor that positions TFIIIB to bind to DNA at a site centered approximately 26 base pairs upstream of the start site of transcription. TFIIIB (**T**ranscription **F**actor for polymerase **III B**), consists of three subunits: TBP (**T**ATA **B**inding **P**rotein), the Pol II transcription factor TFIIIB-related protein, BRF1 (or Brf2 for transcription of a subset of Pol III-transcribed genes in vertebrates) and BDP1.
- TFIIIB is the transcription factor that assembles Pol III at the start site of transcription. Once TFIIIB is bound to DNA, TFIIIC is no longer required. TFIIIB also plays an essential role in promoter opening.

TFIIIB remains bound to DNA following initiation of transcription by Pol III (unlike bacterial σ factors and most of the basal transcription factors for Pol II transcription). This leads to a high rate of transcriptional reinitiation of Pol III-transcribed genes.

Class III

Typical stages in a U6 snRNA (also termed class III) gene initiation (documented in vertebrates only):

- SNAPc (**S**NRNA **A**ctivating **P**rotein complex) (also termed PBP and PTF) binds to the PSE (**P**roximal **S**equences **E**lement) centered approximately 55 base pairs upstream of the start site of transcription. This assembly is greatly stimulated by the Pol II transcription factors Oct1 and STAF that bind to an enhancer-like DSE (**D**istal **S**equences **E**lement) at least 200 base pairs upstream of the start site of transcription. These factors and promoter elements are shared between Pol II and Pol III transcription of snRNA genes.
- SNAPc acts to assemble TFIIIB at a TATA box centered 26 base pairs upstream of the start site of transcription. It is the presence of a TATA box that specifies that the snRNA gene is transcribed by Pol III rather than Pol II.
- The TFIIIB for U6 snRNA transcription contains a smaller Brf1 paralogue, Brf2.
- TFIIIB is the transcription factor that assembles Pol III at the start site of transcription. Sequence conservation predicts that TFIIIB containing Brf2 also plays a role in promoter opening.

Elongation

Termination

Polymerase III terminates transcription at small polyTs stretch (5-6). In eukaryotes, a hairpin loop is not required, as it is in prokaryotes.

Transcribed RNAs


The types of RNAs transcribed from RNA polymerase III include:


- Transfer RNAs^[3]
- 5S ribosomal RNA^[3]
- U6 spliceosomal RNA^[3]
- RNase P and RNase MRP RNA^[3]
- 7SL RNA (the RNA component of the signal recognition particle)^[3]
- Vault RNAs^[3]
- Y RNA^[3]
- SINEs (short interspersed repetitive elements)^[3]
- 7SK RNA^[3]
- Several microRNAs^[3]
- Several small nucleolar RNAs^[3]
- Several gene regulatory antisense RNAs^[4]

See also

- DNA polymerase III holoenzyme

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