6.3 PROTEIN SYNTHESIS

TRANSCRIPTION AND TRANSLATION

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Learning outcomes

(a) Overview the roles of transcription and translation in flow of genetic information
(b) Explain transcription
(c) Describe the stages involved:
(i) initiation (ii) elongation (iii) termination
(d) State the formation of mRNA strand from 5' to 3'
(e) Describe the relationship between base sequences in codons with specific amino acids using genetic table

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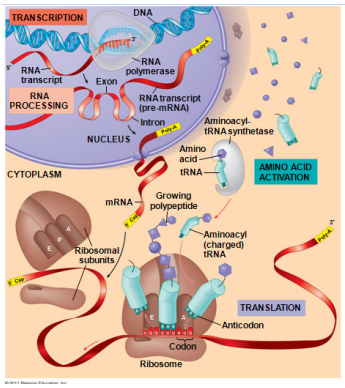
Roles of Transcription and Translation in gene flow

DNA directs protein synthesis in a two-step process

1. Information in a DNA gene is copied / transcribed into mRNA in the process of **transcription**
2. mRNA, together with tRNA, amino acids, and a ribosome, synthesize a protein in the process of **translation**



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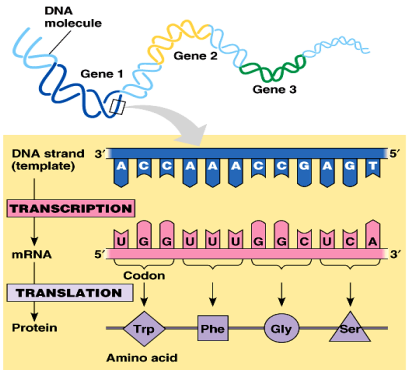
The roles of transcription and translation

From Gene to

Protein (e.g. : enzymes)



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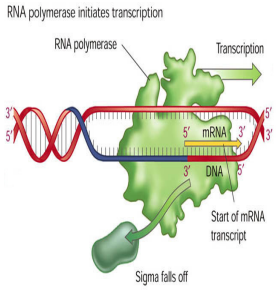
TRANSCRIPTION

- DNA - directs synthesis of RNA
- Transcription is the synthesis of mRNA molecule with a base complementary to a section of DNA (gene)
- The process is catalysed by RNA polymerase



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Importance of RNA Polymerase

1) RNA polymerase bind to a promoter region on the DNA
2) Unwind the DNA double helix
3) Initiates the transcription process
4) Able to start a chain from stratch; primer is not need to begin transcription
1) Adds DNA nucleotide from nucleoplasm to the growing RNA strand

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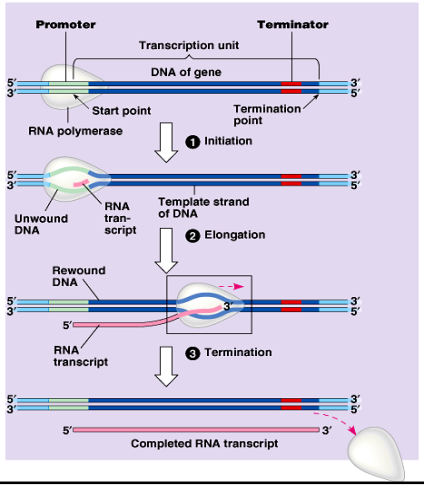
Transcription of a DNA gene into RNA has three stages

i. Initiation
ii. Elongation
iii. Termination



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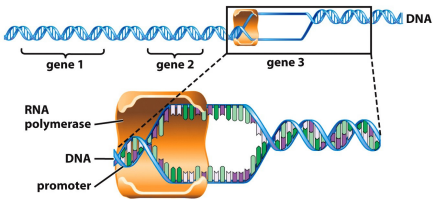
i. Initiation

- **RNA polymerase** bind to regions of DNA called **promoters.**
- It includes the **initiation site**, where the **transcription begins.**
- Certain regions within the promoter are important for recognition by RNA polymerase.
- Once active RNA polymerase is bound to a promoter region, the enzyme begins to **separate the two DNA strands** at the initiation site and transcription begins.



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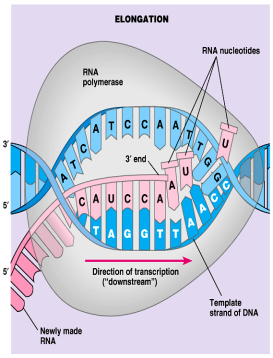
ii. Elongation

- After RNA polymerase binds to a promoter region, the DNA strands unwind separating the strands and exposing the DNA bases for pairing with RNA nucleotides.
- Only one DNA strand act as template
- The enzyme initiates RNA synthesis adding nucleotides to the 3' end of the growing RNA molecule as it continues along the double helix at the start point on the templates strand



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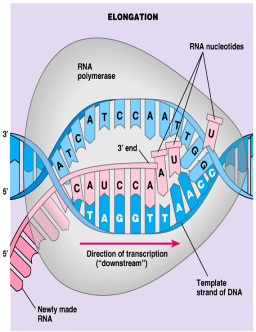
Elongation of RNA strand

- As RNA polymerase moves along the DNA, it untwists the double helix, 10 to 20 bases at time
- RNA nucleotide will be added complementary with the bases on the template DNA strand

✓ Adenine (DNA) - Uracil (RNA)
✓ Thymine (DNA) - Adenine (RNA)
✓ Guanine (DNA) - Cytosine (RNA)
✓ Cytosine (DNA) - Guanine (RNA)



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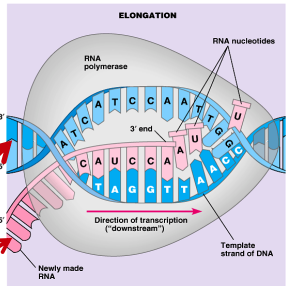
Elongation of RNA strand

- The enzyme adds RNA nucleotides to the 3' end of the growing strand
- Behind the point of RNA synthesis, the double helix re-forms and the RNA molecule peels away



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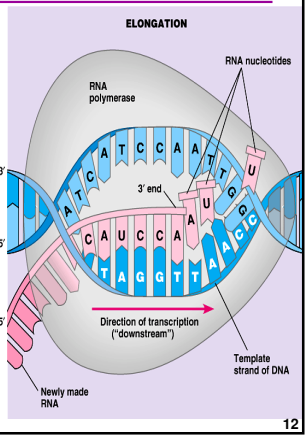
Elongation of RNA strand

- RNA polymerase moves along the template strand of the DNA in the 5' to 3' direction
- The RNA molecule grows in the 3' end direction
- Transcription progresses at the rate of about 60 nucleotides per second.



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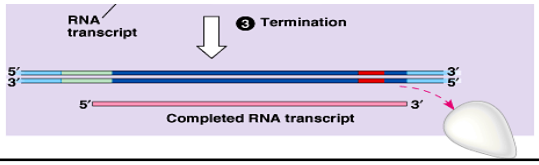
Termination

- Transcription proceeds until the RNA polymerase reaches a termination site on the DNA
- The sequence of bases that marks this site signals RNA polymerase to stop adding nucleotides to the RNA strand
- Then, the RNA strand and RNA polymerase are released
- Each time only a single gene is transcribed.
  - A single gene can be transcribed simultaneously by several molecules of RNA polymerase.



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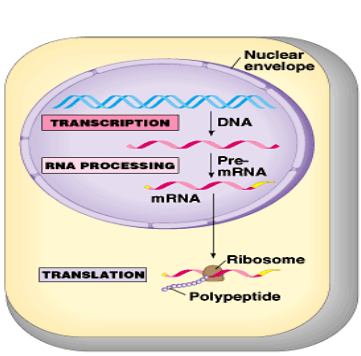
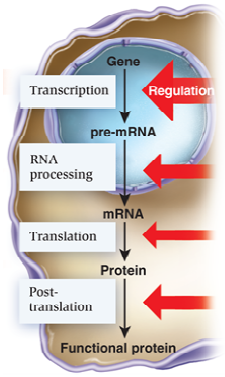
Eukaryotic gene regulation





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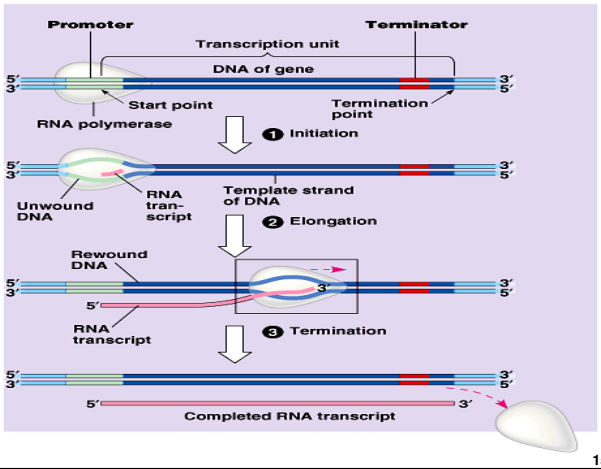

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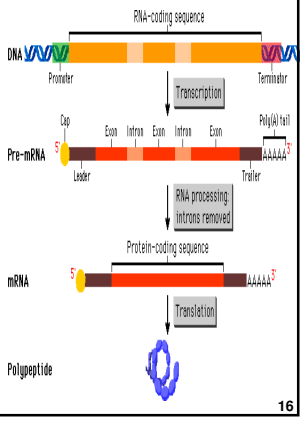
RNA processing

- Eukaryotic cells modify RNA after transcription
- Certain interior sections of the molecule are cut out and the remaining parts spliced together
- These modifications help form an mRNA that is ready to be translated



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- Most eukaryotic genes and their RNA transcripts have long sequence of nucleotides
- The mRNA transcript includes :-
  - Introns - Non-coding segments that are not translated into amino acid sequences
  - Exons - Coding region, that are translated into amino acid sequences
- In RNA processing, introns are cut out and exons are spliced together

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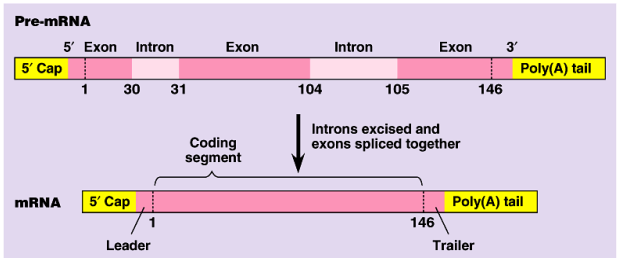

- RNA splicing removes introns and joins exons to create an mRNA molecule with a continuous coding sequence.

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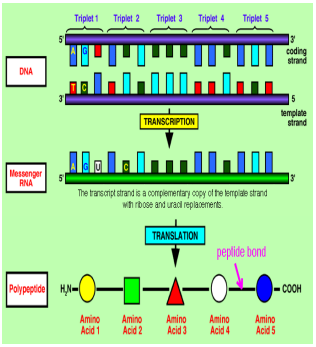
Genetic code

- Base triplet in DNA provides a template for ordering the complementary triplet in mRNA molecule
- Every base triplet will code an amino acid
- Three bases of an mRNA → are called codon



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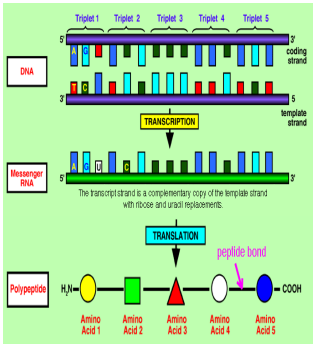
Importance of codons and anticodons

- CODON is a base triplet on mRNA that code for one specific amino acid
- It will complementary paired with anticodon on tRNA
- The flow of information from gene to protein is based on a **triplet code on the DNA**
- The three-nucleotide words of mRNA are then translated into a chain of amino acids, forming a **polypeptide** in protein synthesis



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GENETIC CODE : 64 codon

First base (5' end)	Second base U	Second base C	Second base A	Second base G	Third base (3' end)
U	UUU Phe	UCU Ser	UAU Tyr	UGU Cys	U
	UUC Phe	UCC Ser	UAC Tyr	UGC Cys	C
	UUA Leu	UCA Ser	UAA Stop	UGA Stop	A
	UUG Leu	UCG Ser	UAG Stop	UGG Trp	G
C	CUU Leu	CCU Pro	CAU His	CGU Arg	U
	CUC Leu	CCC Pro	CAC His	CGC Arg	C
	CUA Leu	CCA Pro	CAA Gln	CGA Arg	A
	CUG Leu	CCG Pro	CAG Gln	CGG Arg	G
A	AUU Ile	ACU Thr	AAU Asn	AGU Ser	U
	AUC Ile	ACC Thr	AAC Asn	AGC Ser	C
	AUA Ile	ACA Thr	AAA Lys	AGA Arg	A
	AUG Met or start	ACG Thr	AAG Lys	AGG Arg	G
G	GUU Val	GCU Ala	GAU Asp	GGU Gly	U
	GUC Val	GCC Ala	GAC Asp	GGC Gly	C
	GUA Val	GCA Ala	GAA Glu	GGA Gly	A
	GUG Val	GCG Ala	GAG Glu	GGG Gly	G

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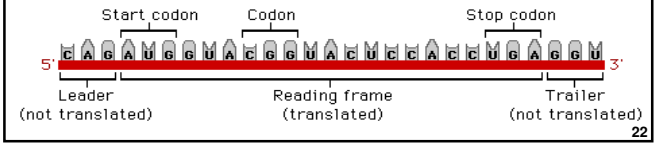
Two importances of codons in protein synthesis

Initiation codon

- Codon AUG
- a start signal
- code for amino acid methionine

Termination codon

- Three triplet bases of stop signal: UAA, UAG, UGA
- Stop signal marking the end of a genetic code
- Does not code for any amino acid



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Importance of Anticodon

- ANTICODON is a base triplet on tRNA that carry one specific amino acid
- It will complementary paired with codon on mRNA

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