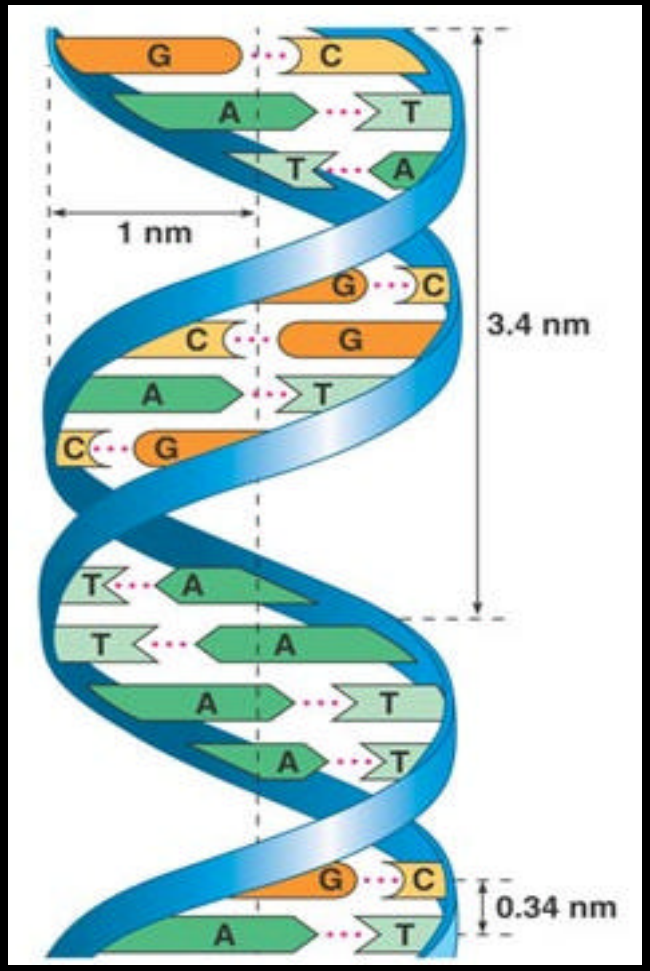
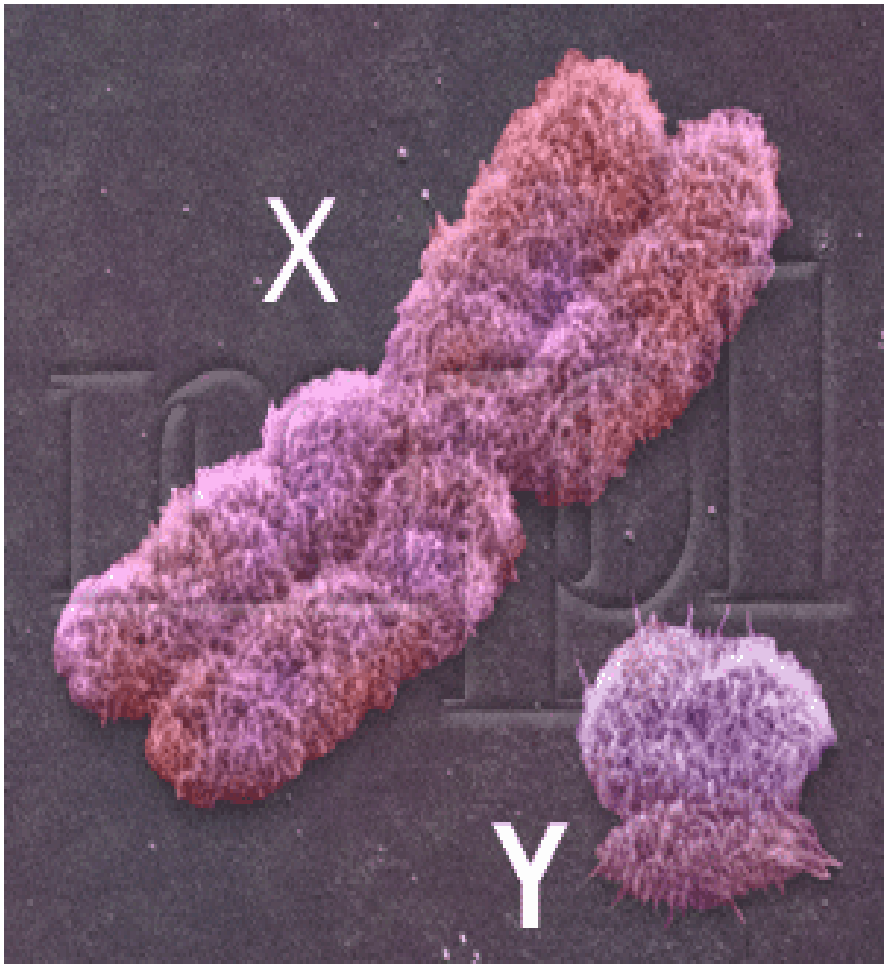
Protein Synthesis

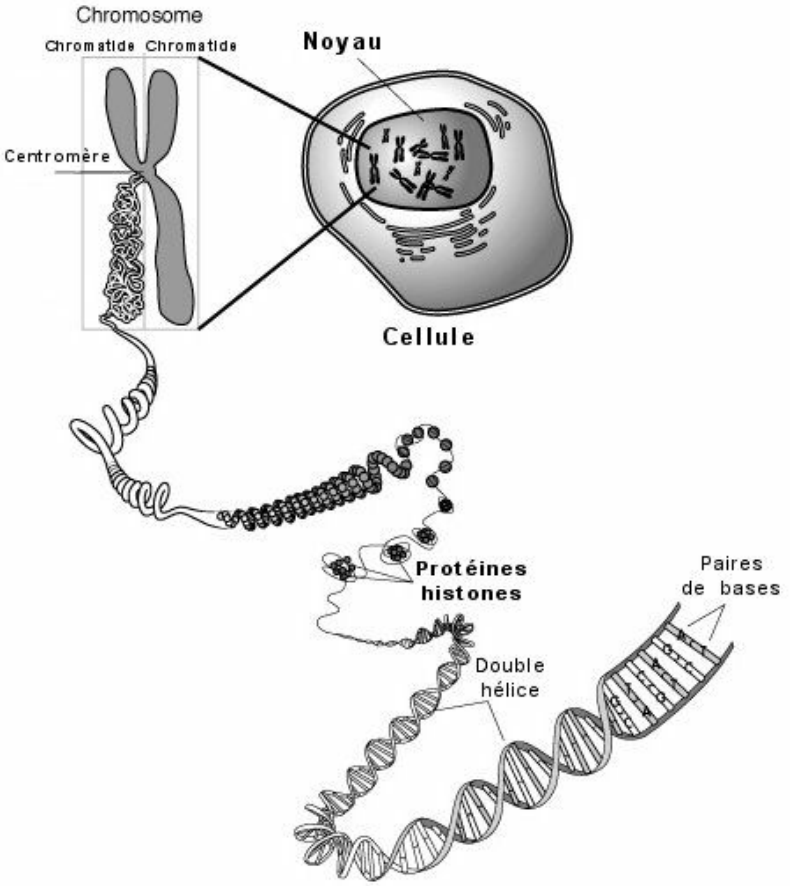


Protein Synthesis
How Genes Become Constituent Molecules

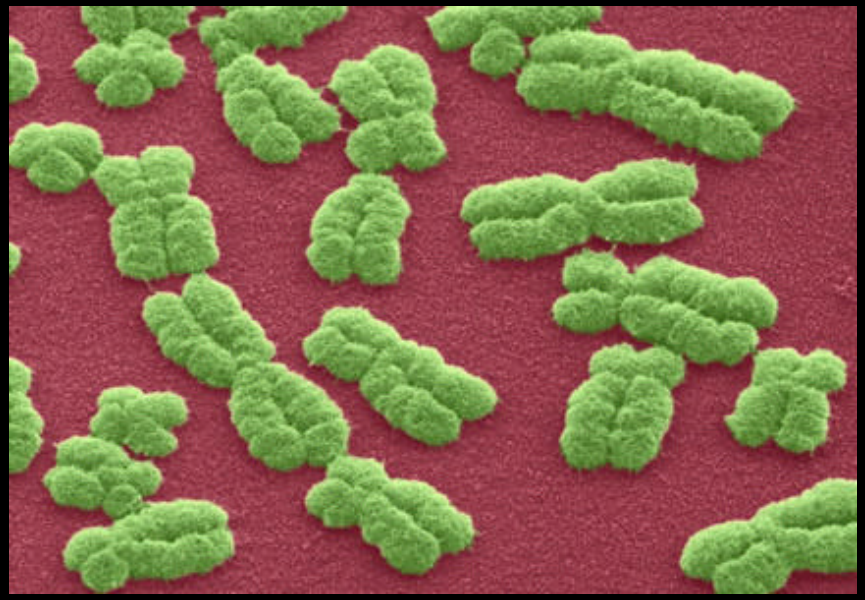
Mendel and The Idea of Gene

What is a Chromosome?

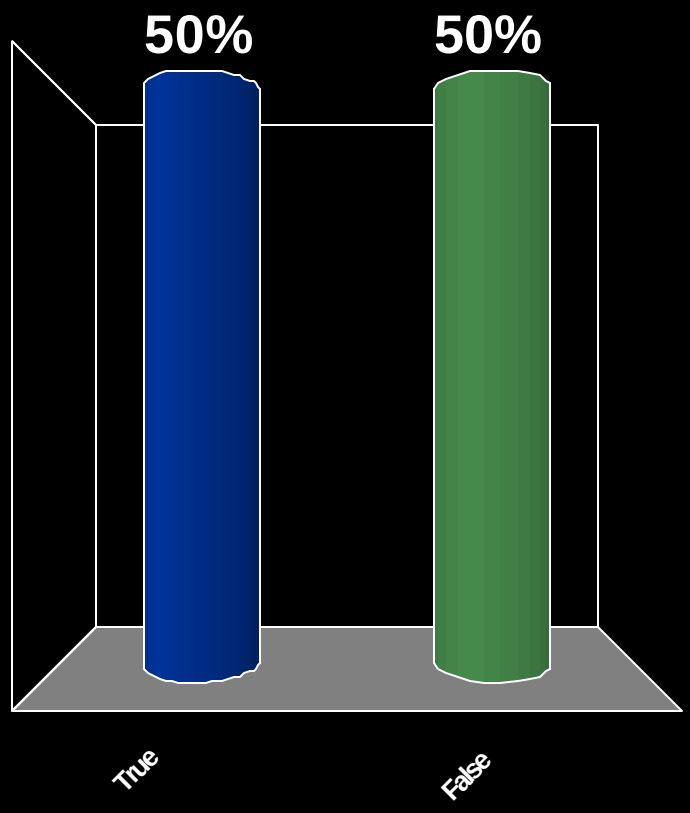




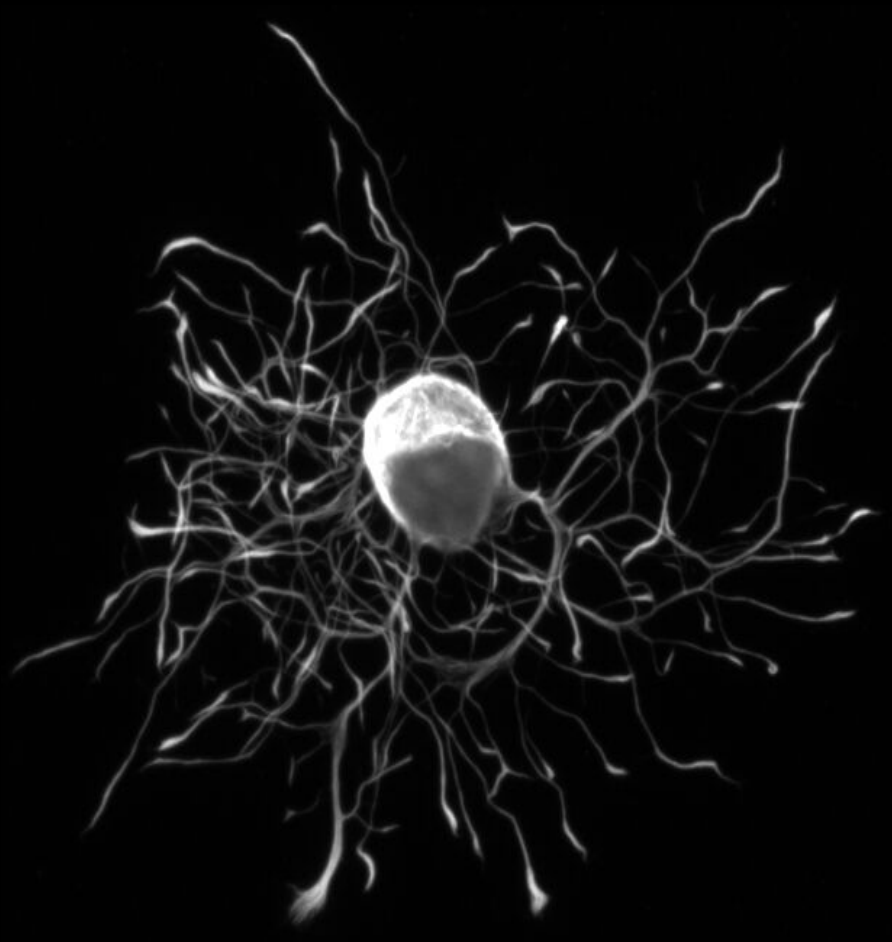
A chromosome is a molecule of DNA

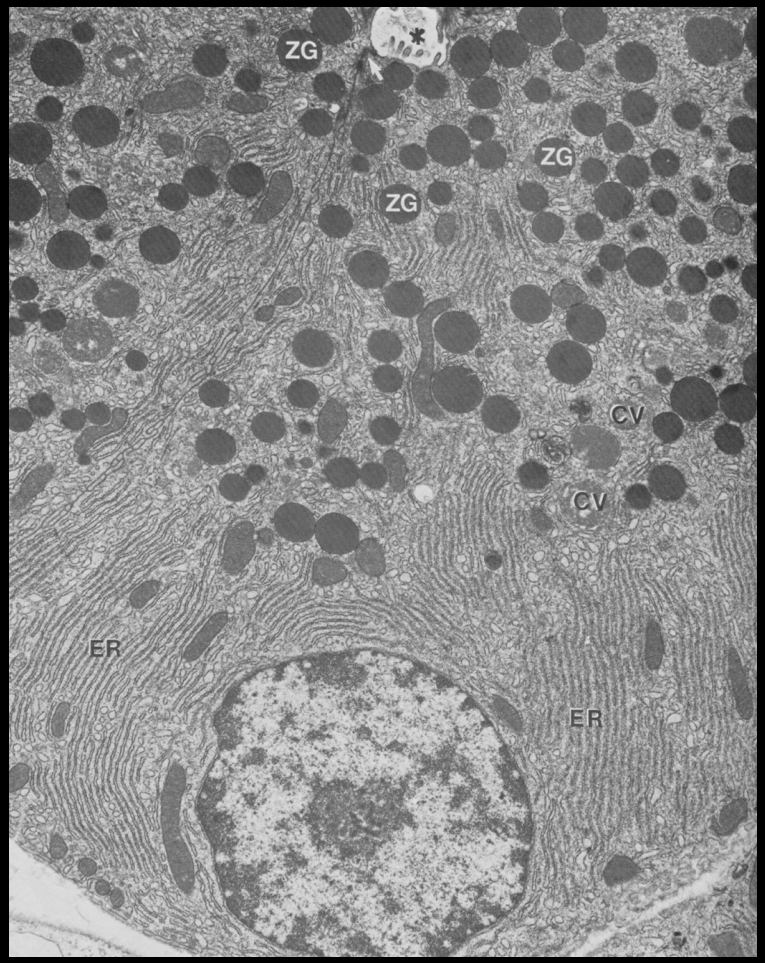


1. True
2. False



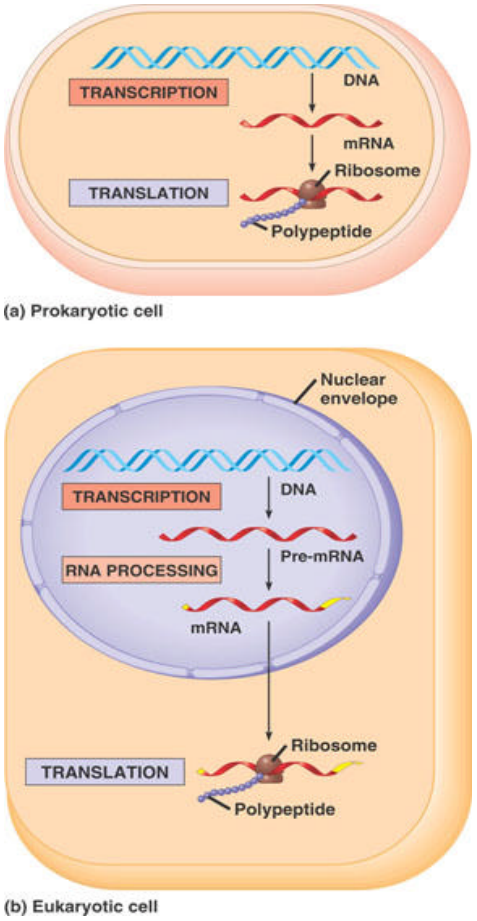
Protein Synthesis
How Genes Become Constituent Molecules





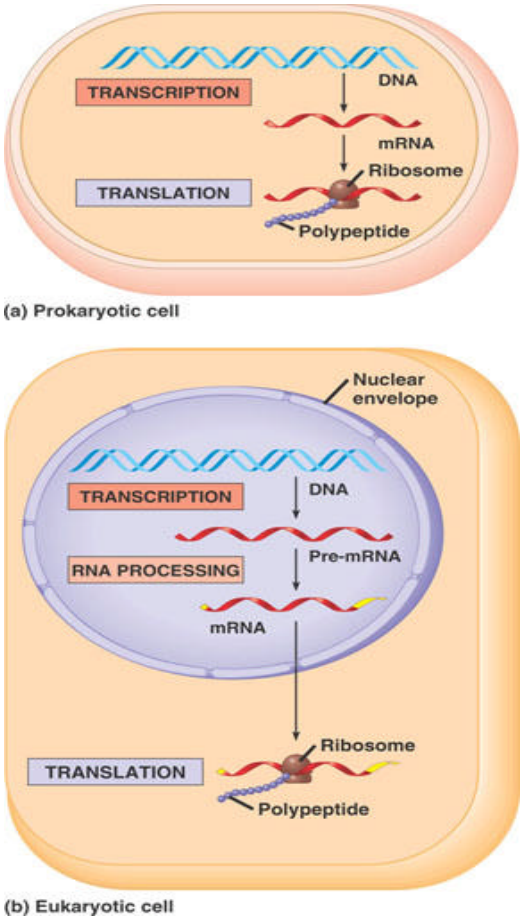
Protein Synthesis: What Is It?

- All proteins are synthesized according to instructions contained in the DNA nucleotide sequence, which is unique to every individual
- Protein synthesis is a two step process that consists of *transcription* and *translation.*



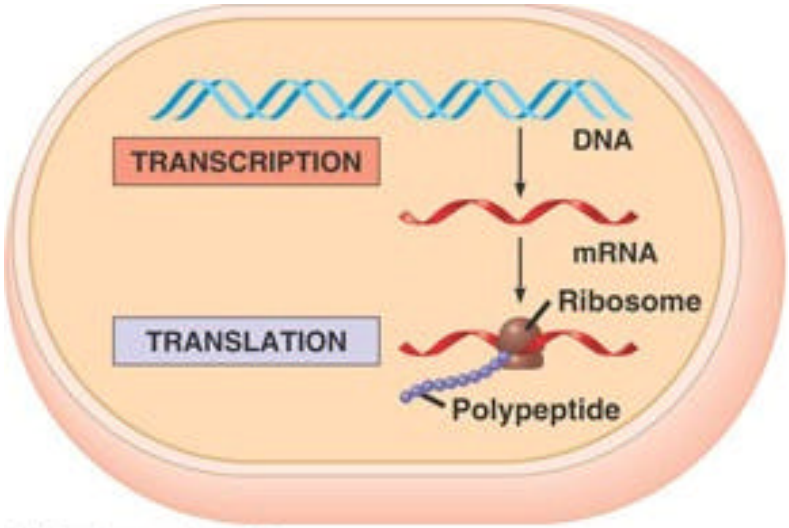
Protein Synthesis: What Is It?

- During transcription a molecule of messenger RNA (mRNA) is synthesized according to instructions provided by the DNA
- During translation, a polypeptide chain will be produced according to instructions provided by the mRNA



Protein Synthesis in Prokaryotes

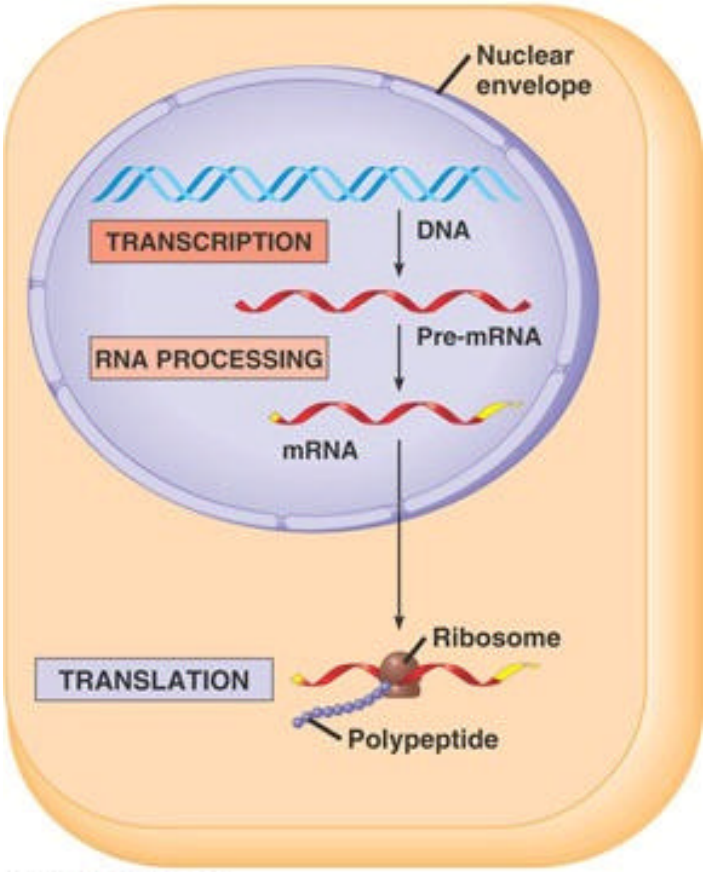
- In prokaryotes, transcription and translation occur in the same cellular compartment — the cytosol. Ribosomes are the site of translation



(a) Prokaryotic cell

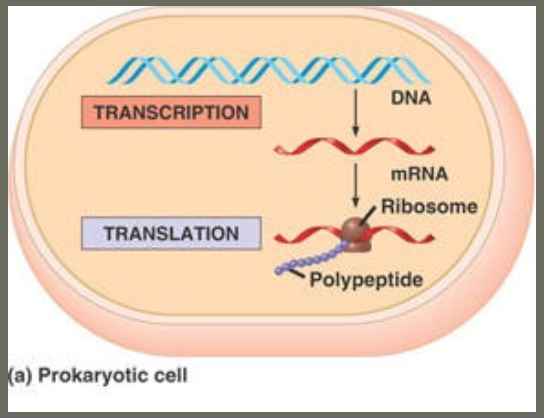
Protein Synthesis in Eukaryotes

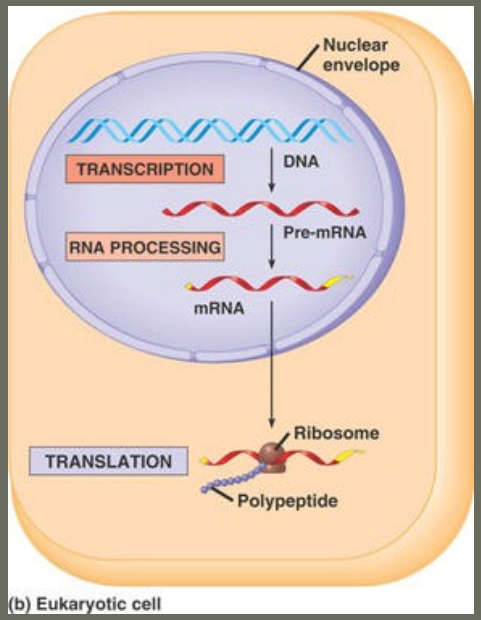
- In eukaryotes, mRNA is synthesized in the nucleus from pre-messenger RNA (pre-mRNA) molecules, and then shipped to the cytoplasm, where translation occurs
- RNA processing (or *post-transcriptional modification*) refers to the molecular mechanisms that lead to the production of mRNA from pre-mRNA.

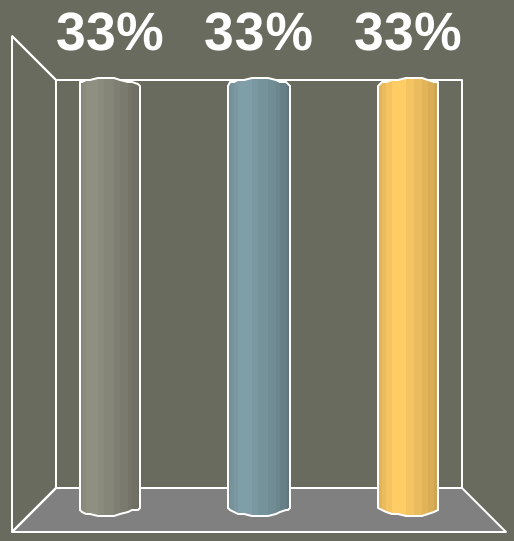


(b) Eukaryotic cell

The main difference between protein synthesis in eukaryotes and in prokaryotes is:

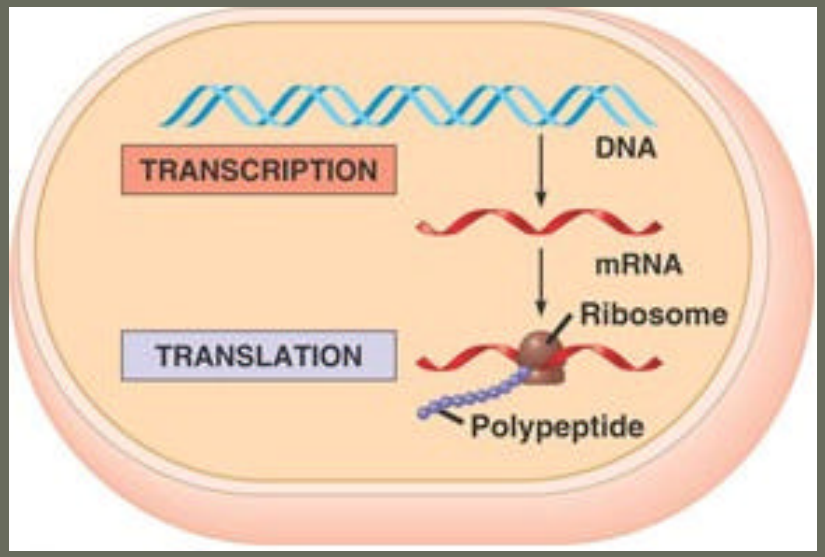


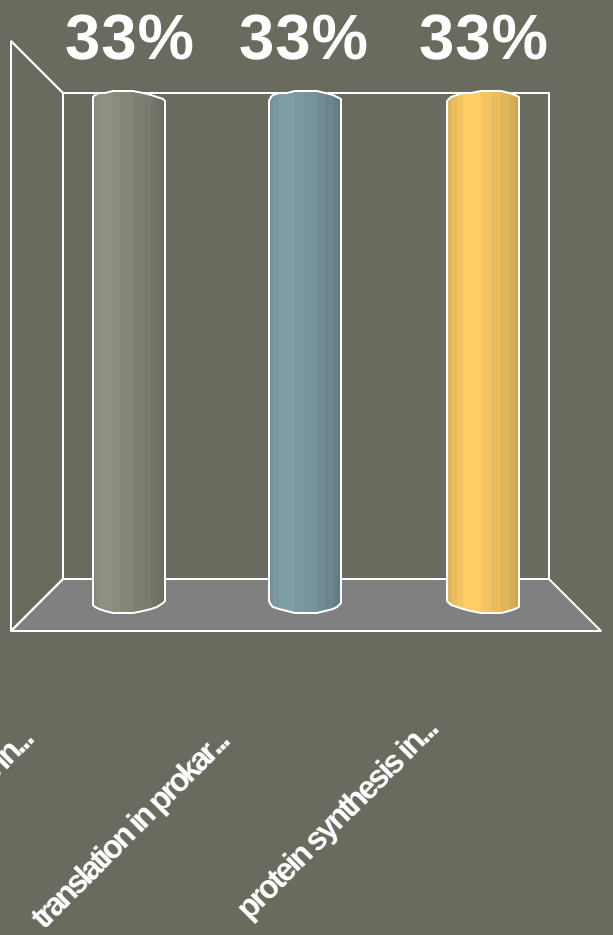




1. where the process happens
2. what the process produces
3. the participants in the process

This cartoon represents:

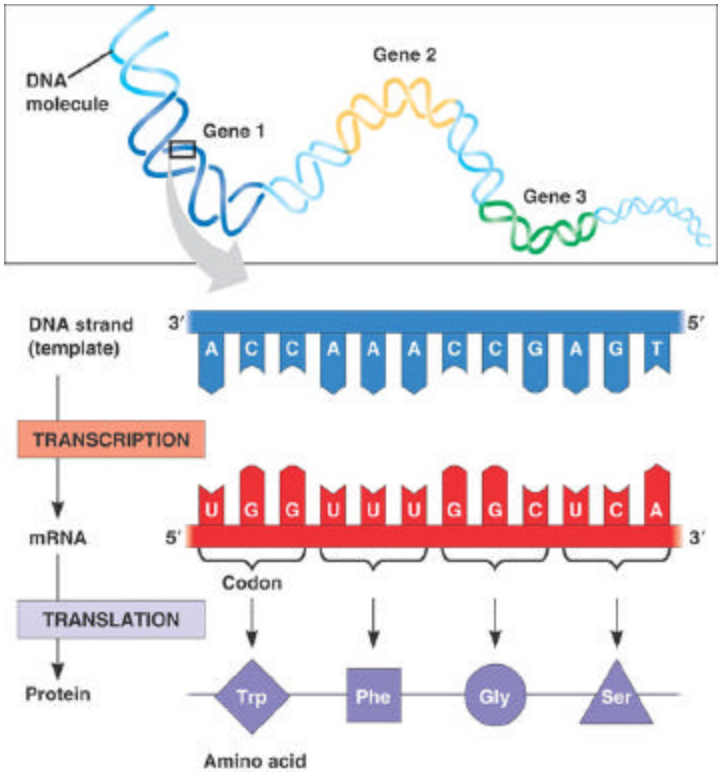




1. protein synthesis in eukaryotes
2. translation in prokaryotes
3. protein synthesis in prokaryotes

Protein Synthesis: From Gene to Protein

- Genes are stretches of nucleotides organized in *triplets*
- Different arrangements or DNA triplets encode for each one of the 20 amino acids that make proteins
- During transcription, a DNA triplet will produce an mRNA *codon.*
- During translation, a codon will constitute an amino acid



Protein Synthesis: From Gene to Protein

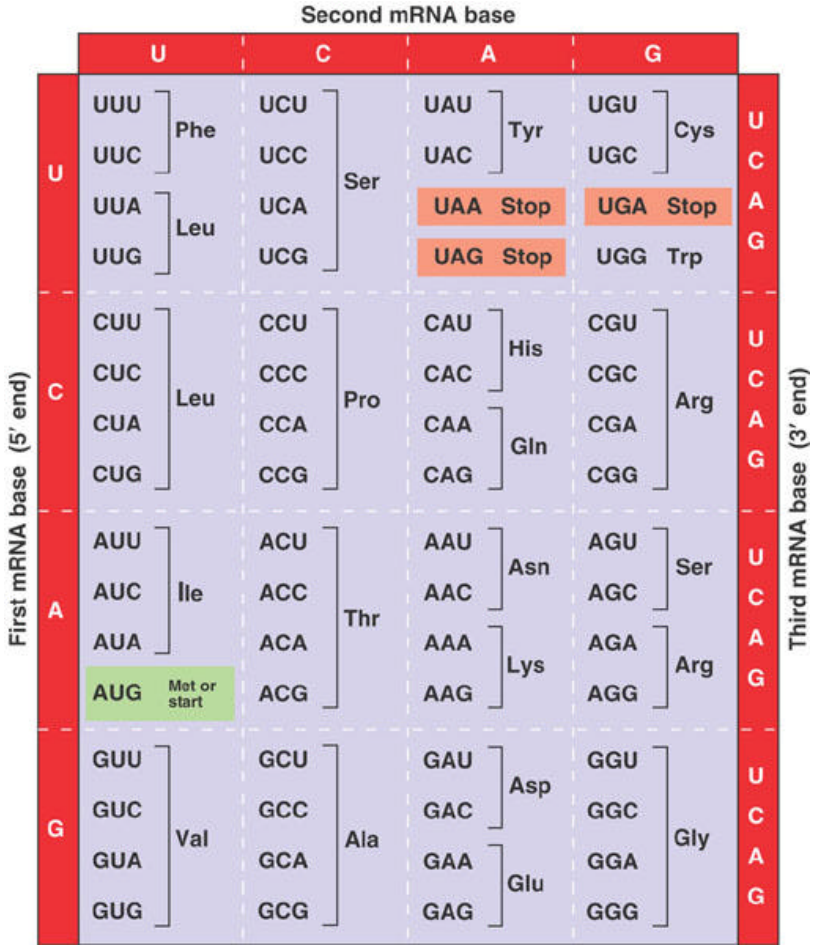
DNA

Transcription

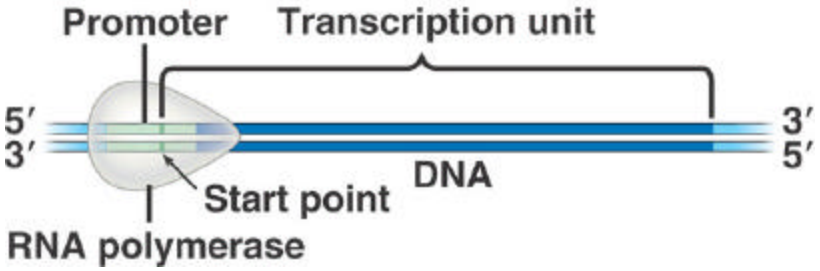
mRNA

Translation

Protein

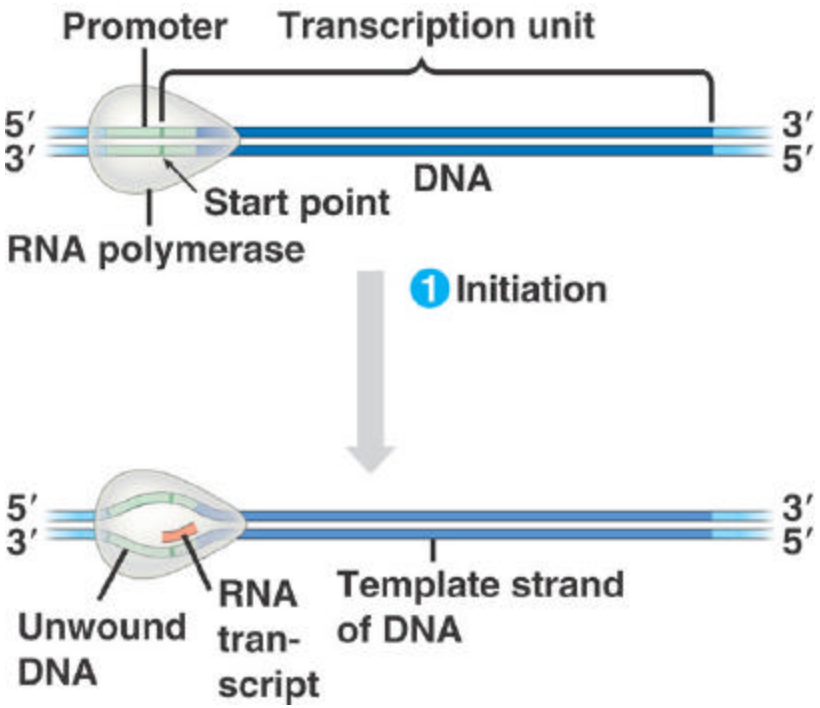


Transcription: What Is It Transcribed?



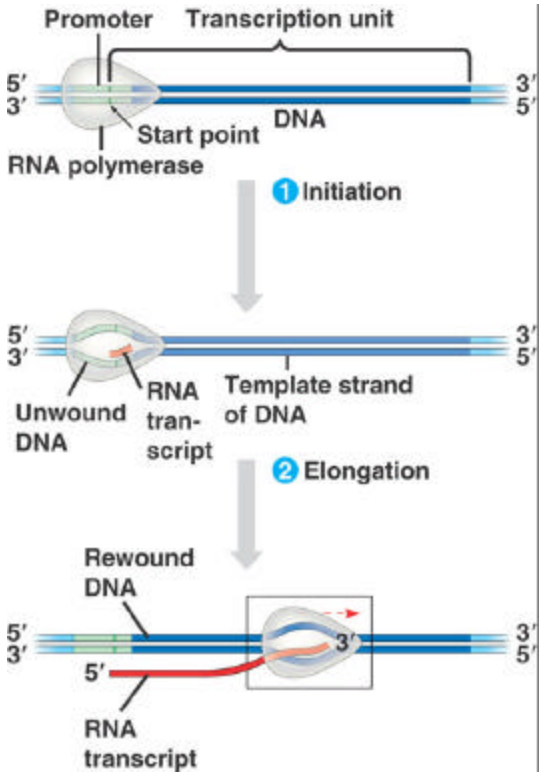
- RNA polymerase binds to the gene's promoter region and starts making a molecule of mRNA until it finds a "mark" in the gene or *termination sequence.*
- The term *transcription unit* refers to the segment of DNA between the sites of initiation and termination of transcription by RNA polymerase. More than one gene may reside in a transcription unit.

Transcription: Initiation



Nascent mRNA: RNA transcript

Transcription: Elongation



Transcription: Elongation

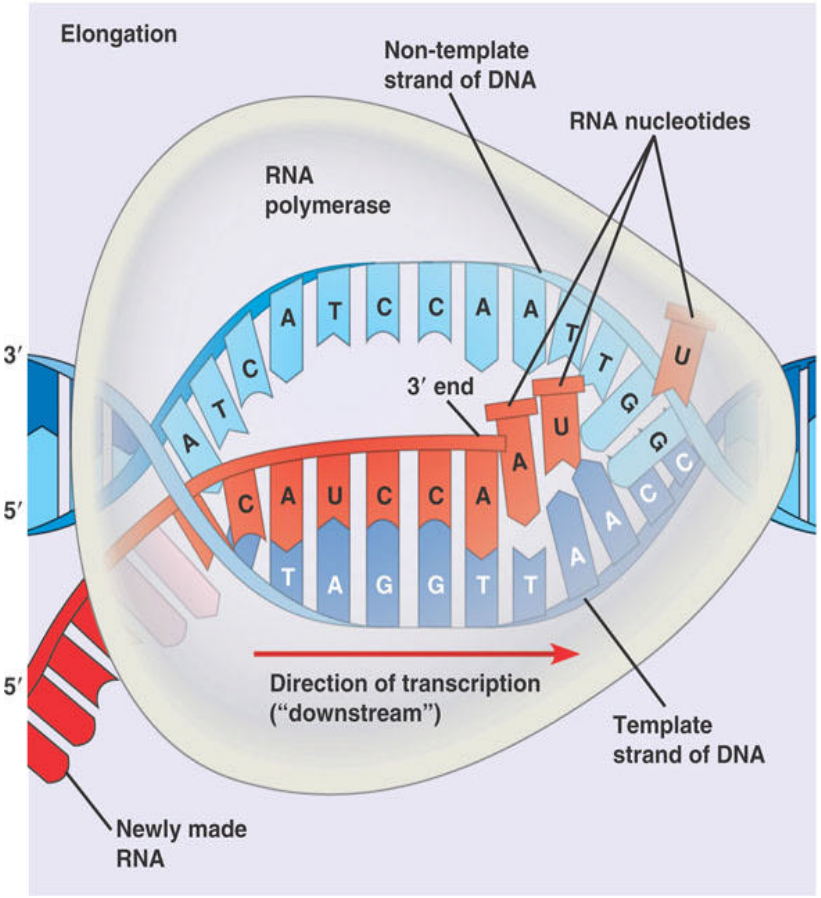
- RNA is synthesized according to DNA/RNA base pairing rules:

  A (DNA) — **U** (RNA)

  G (DNA) — **C** (RNA)

  T (DNA) — **A** (RNA)

  C (DNA) — **G** (RNA

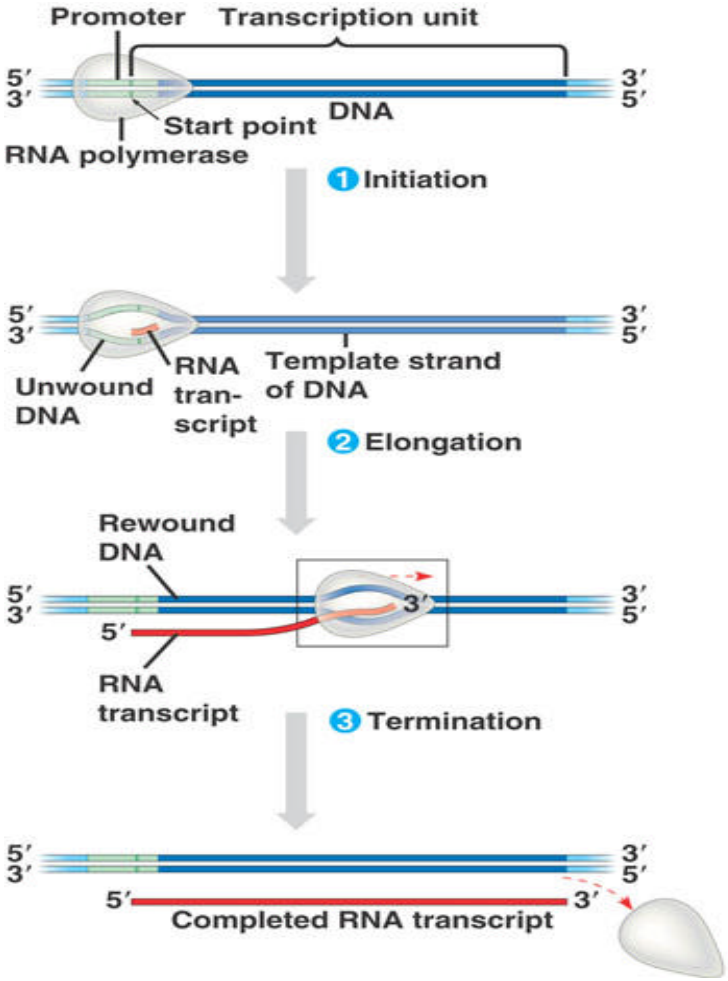


The Making of an mRNA

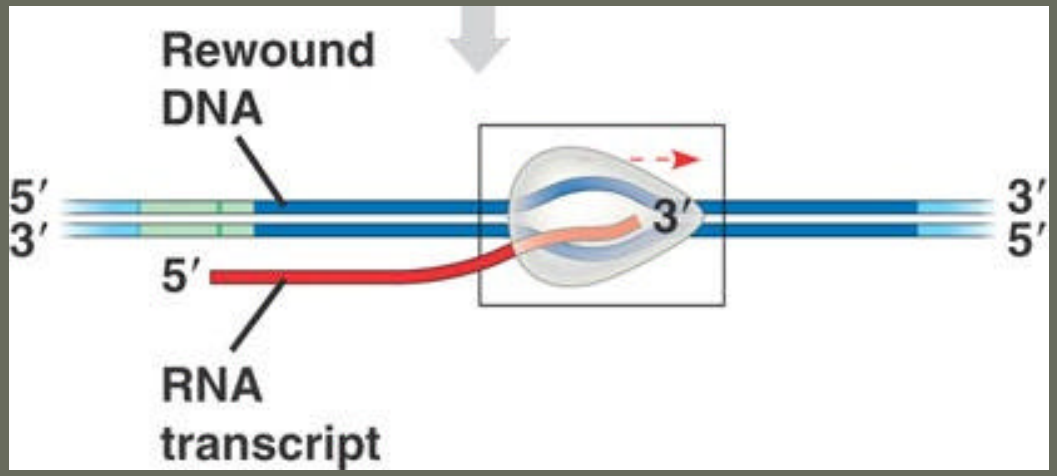
DNA 5’ ATTGCGTAGTGGGATTAT 3’

RNA

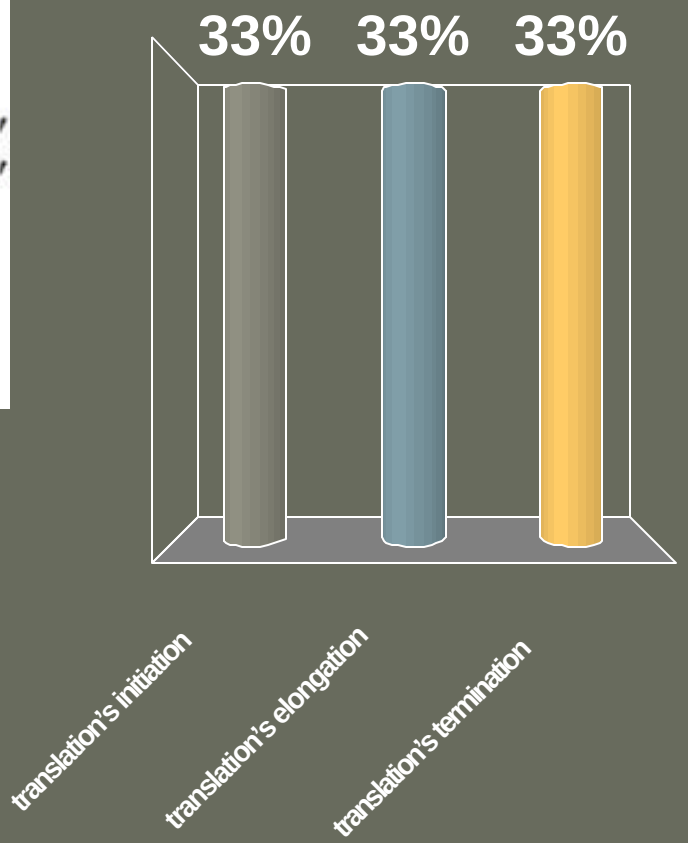
Transcription: Termination



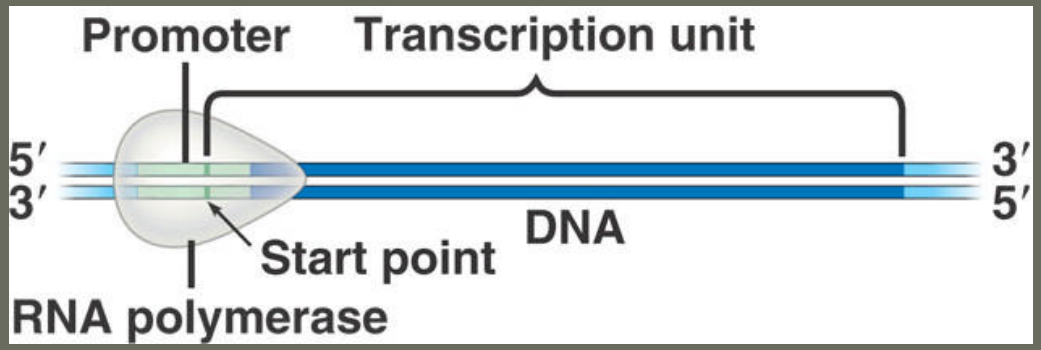
RNA polymerase : RNA transcript : unwound DNA

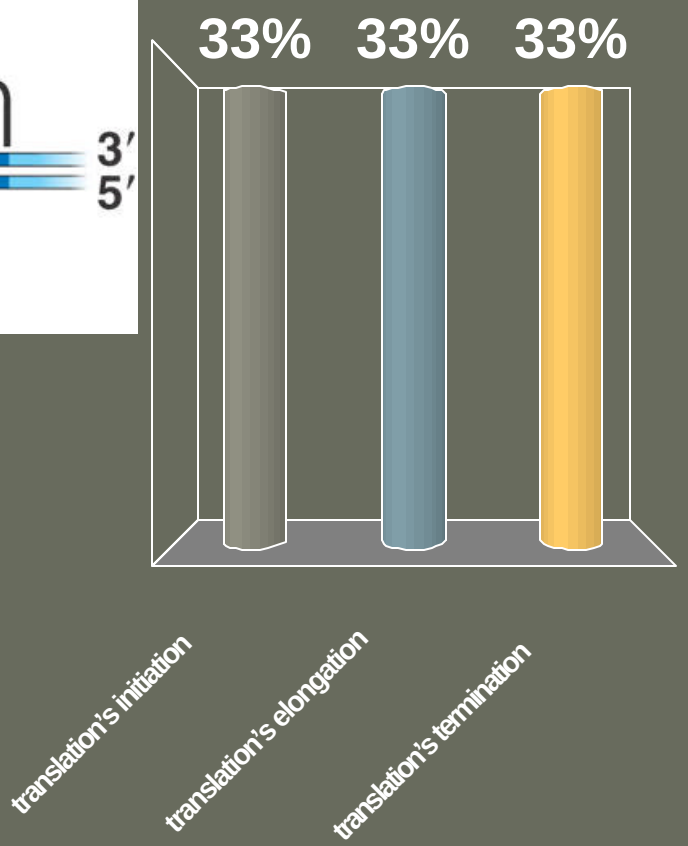


1. translation’s initiation
2. translation’s elongation
3. translation’s termination



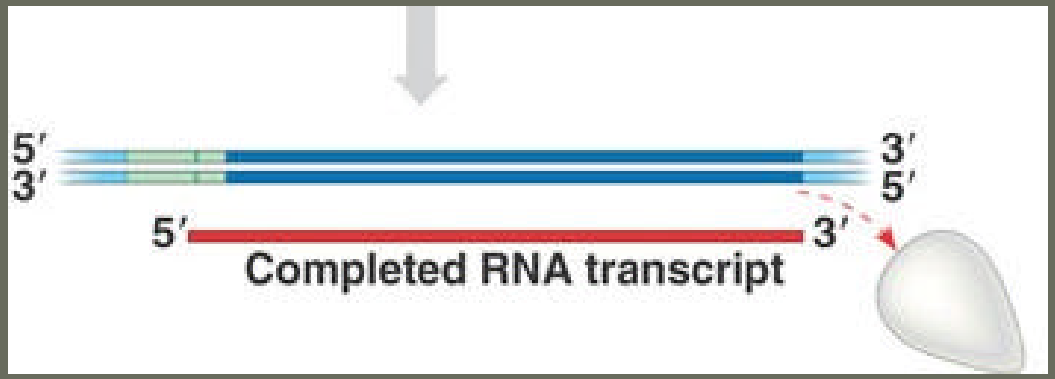
RNA polymerase : promoter : transcription unit

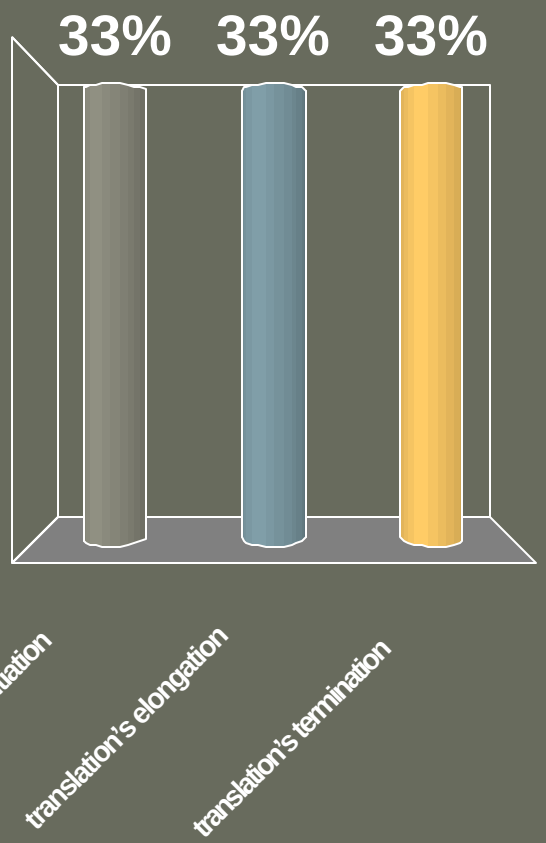




1. translation's initiation
2. translation's elongation
3. translation's termination

This cartoon illustrates:

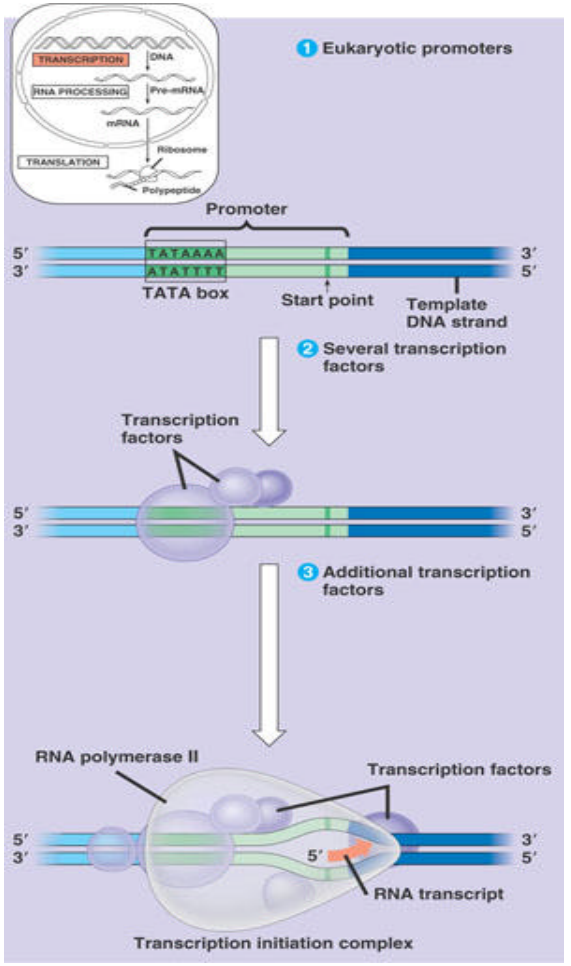




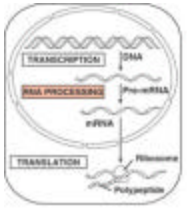
1. translation's initiation
2. translation's elongation
3. translation's termination

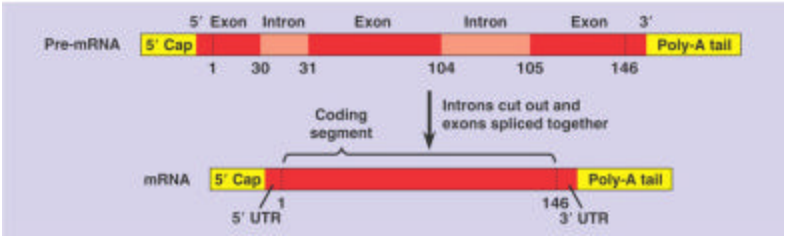
Transcription: Eukaryotic Promoters

- In eukaryotes, promoters are activated by DNA binding proteins or *transcription factors*
- TATA boxes are segments of about 30 base pairs to which RNA polymerase binds



Transcription in Eukaryotes: Splicing of pre-mRNA Molecules

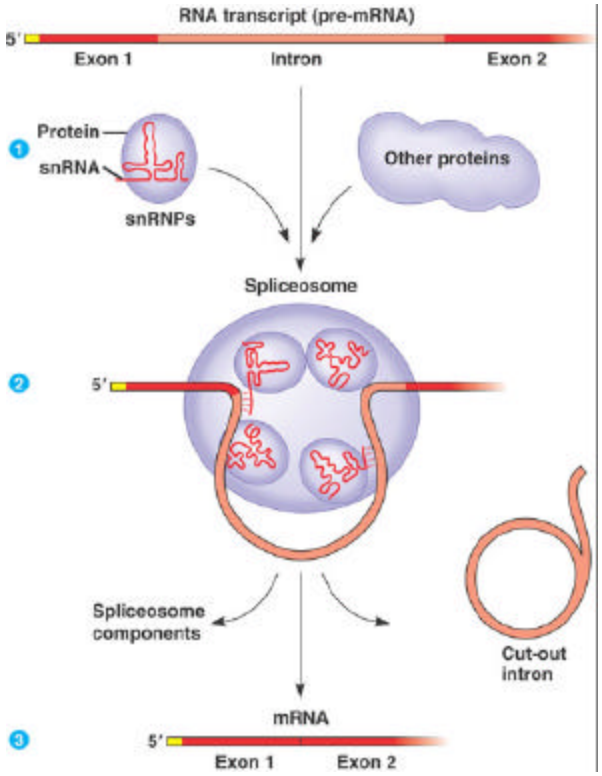




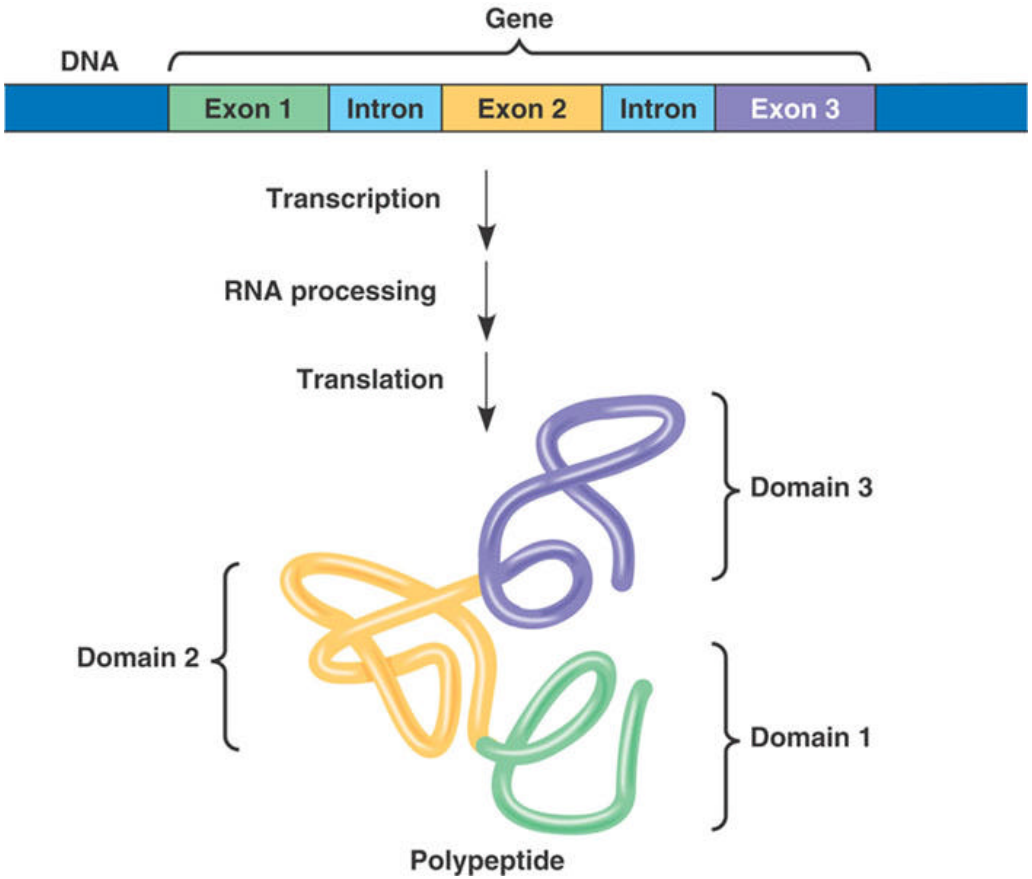
- Eukaryotic transcripts (pre-mRNA) contains *exons* (coding sequences) and *introns* (non coding sequences)
- Post-transcriptional modifications (i.e. splicing) remove introns before shipping the final mRNA to the cytoplasm

Transcription in Eukaryotes: Splicing of pre-mRNA Molecules

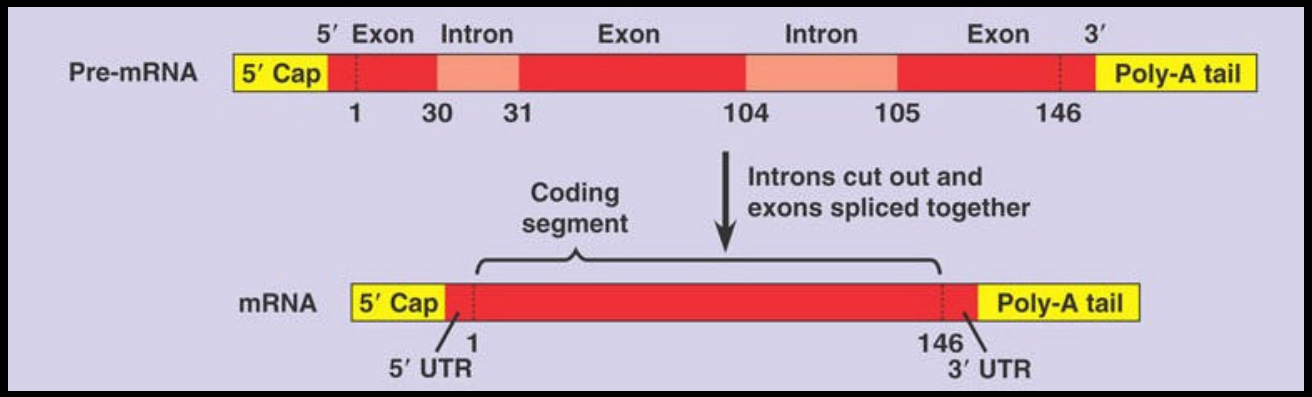
- Spliceosomes are organelles in which the excision and splicing reactions that remove introns from pre-mRNA occur
- Ribozymes and small nuclear RNAs (snRNA) are contained in spliceosomes



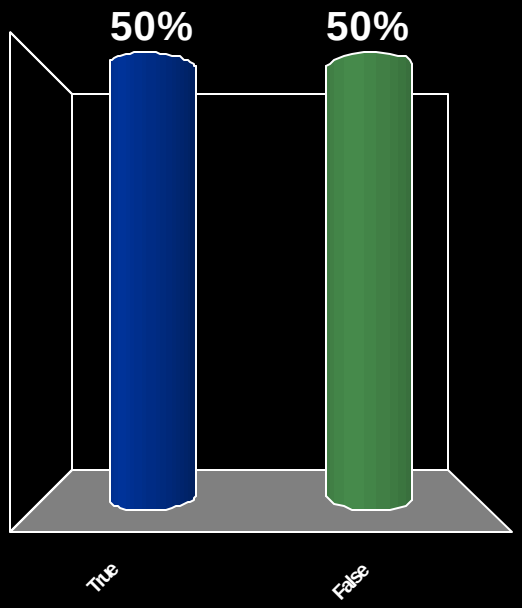
Transcription in Eukaryotes: Splicing of pre-mRNA Molecules



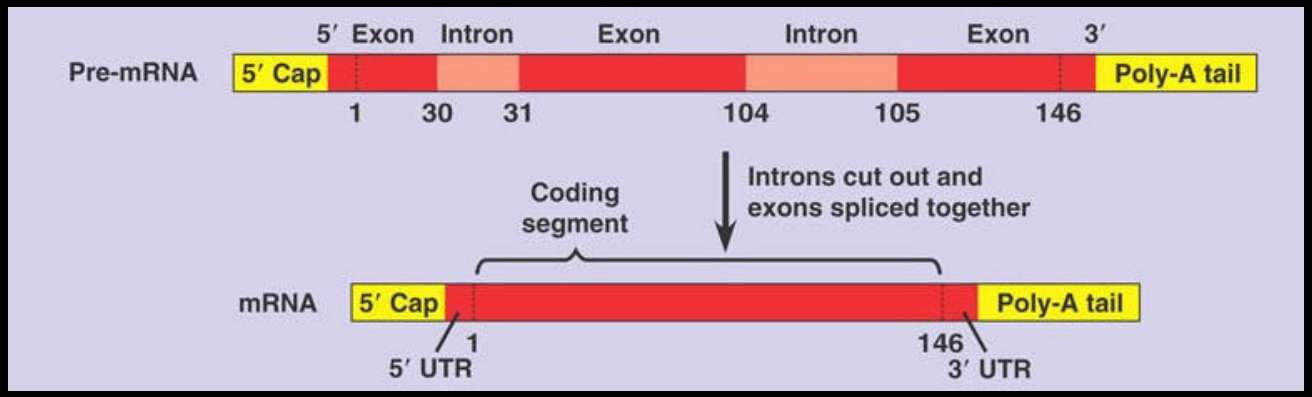
Introns are not translated.



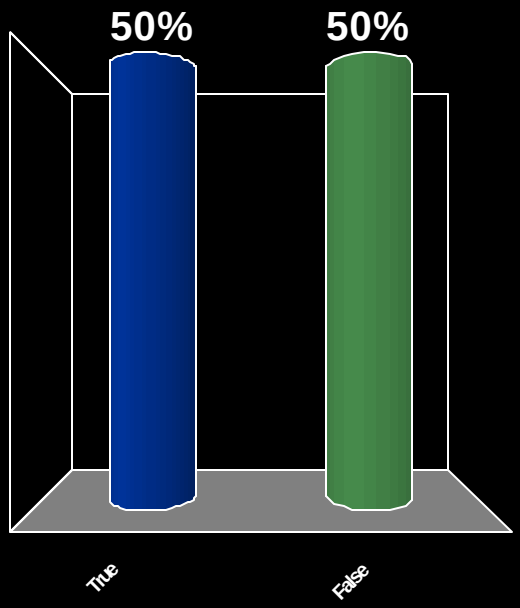
1. True
2. False



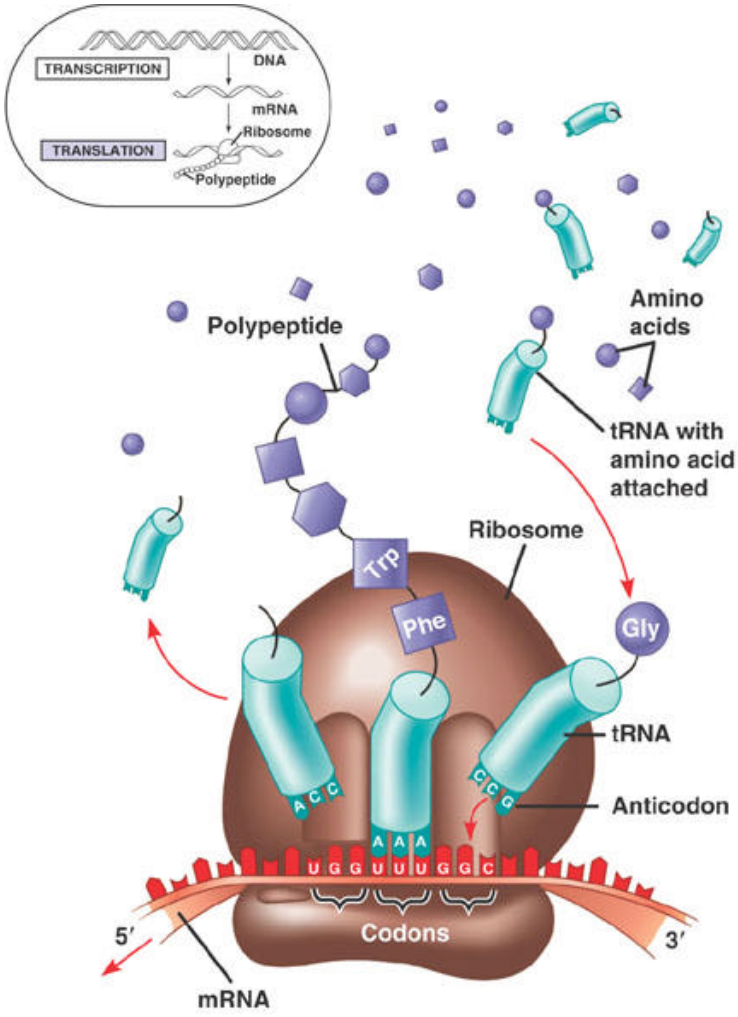
Splicing only occurs in eukaryotes.



1. True
2. False

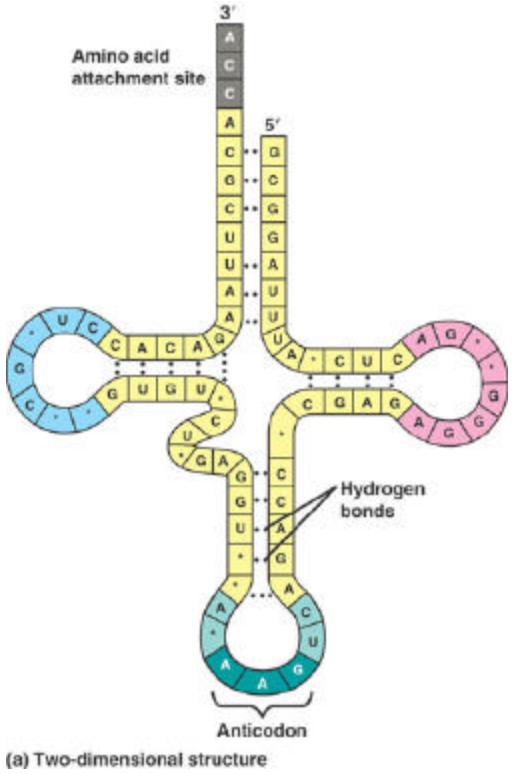


Translation: Production of Polypeptide Chains

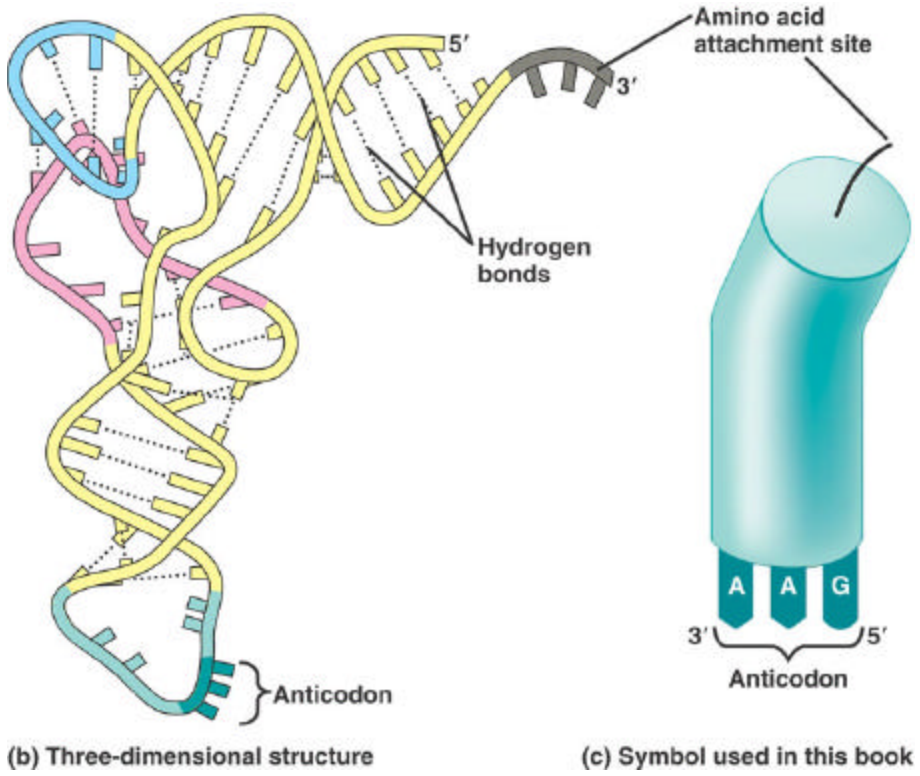


Translation: transfer RNA (tRNA)

- Every transfer RNA (tRNA) has a specific sequence of nucleotides, complementary to an mRNA codon — the *anticodon.*
- Opposite to the anticodon, there is an attachment site specific for each of the 20 amino acids.

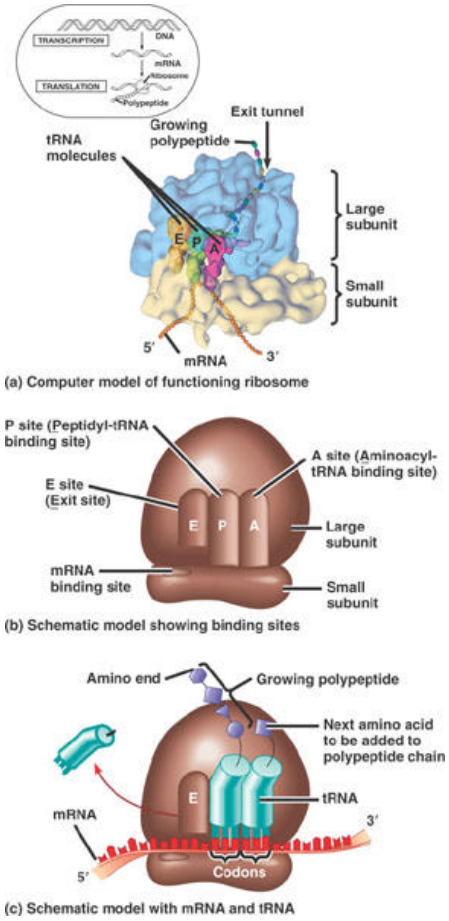


Translation: transfer RNA (tRNA)

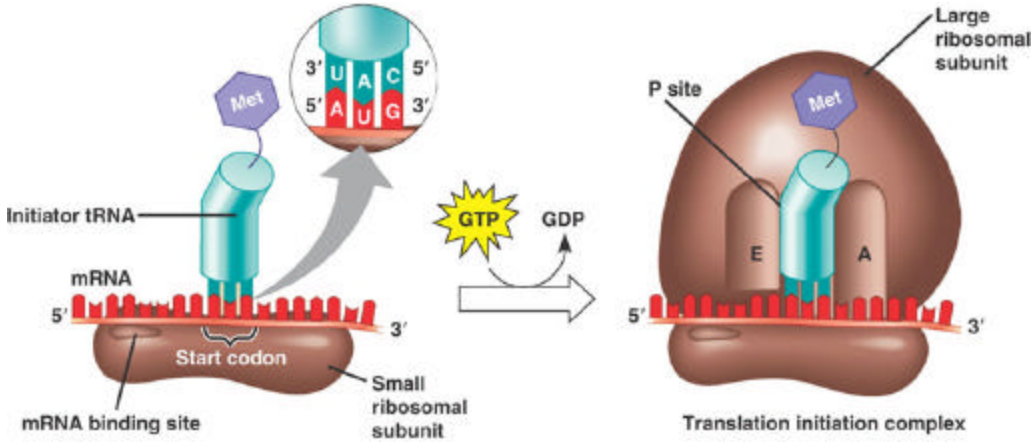


Translation: mRNA/tRNA Interaction

- The recognition of codon (mRNA) and anticodon (tRNA) occurs in the ribosomes.
- Ribosomes have sites of tRNA anchorage and exiting
- A growing polypeptide will be produced following instructions in the mRNA

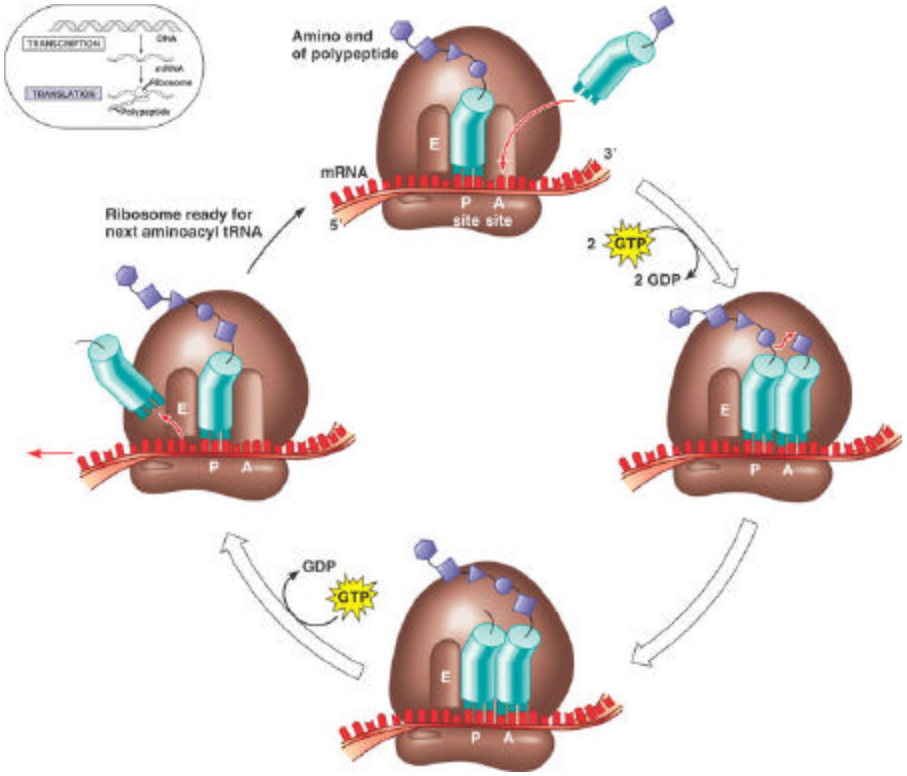


Translation: Initiation and Elongation of the Polypeptide Chain

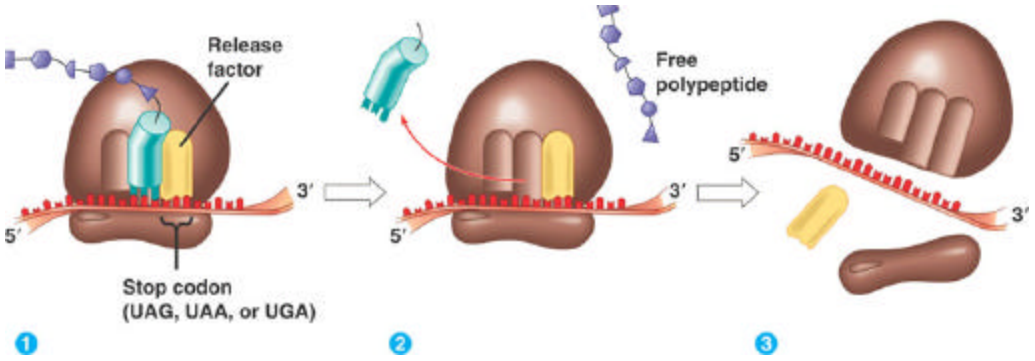


- A start codon (AUG) complements with the Methionine (Met) tRNA in the ribosome, constituting the *translation initiation complex*
- A new anticodon will land in the A site, and its amino acid will join Met. The tRNA will slide to the P site leaving the A site free for another anticodon

Translation: Initiation and Elongation of the Polypeptide Chain



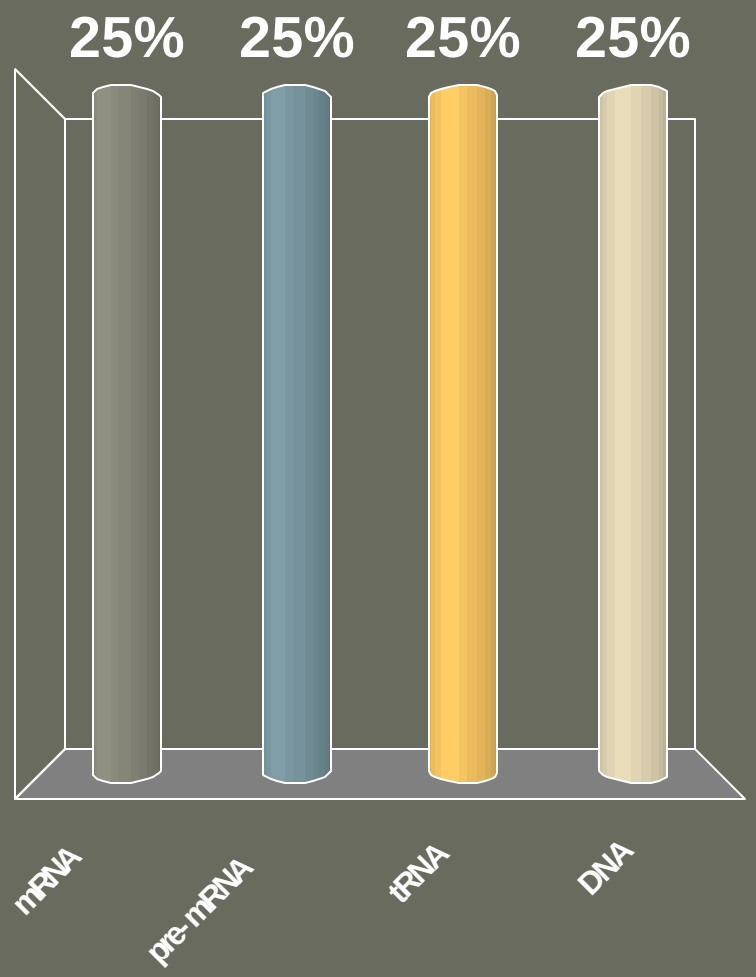
Translation: Termination



- A stop codon (UAG, UAA, or UGA) signals the end of the mRNA molecule. A release factor triggers the disassembling of the two ribosomal units and the mRNA molecule.

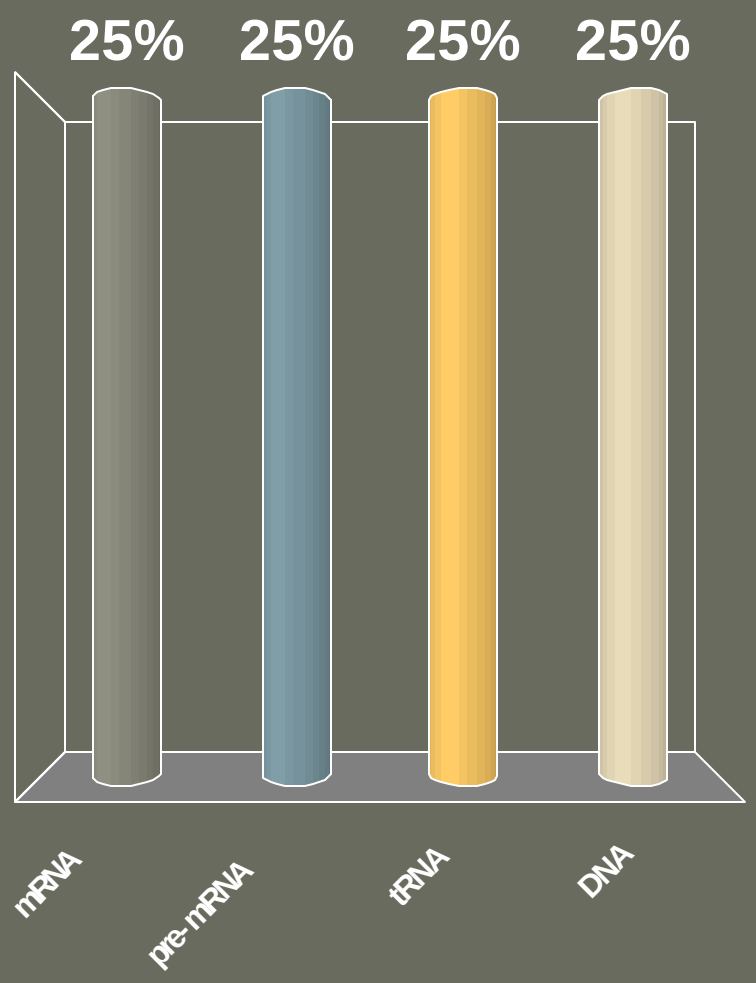
uracil : codon : transcription

1. mRNA
2. pre- mRNA
3. tRNA
4. DNA



uracil : anticodon : translation

1. mRNA
2. pre- mRNA
3. tRNA
4. DNA

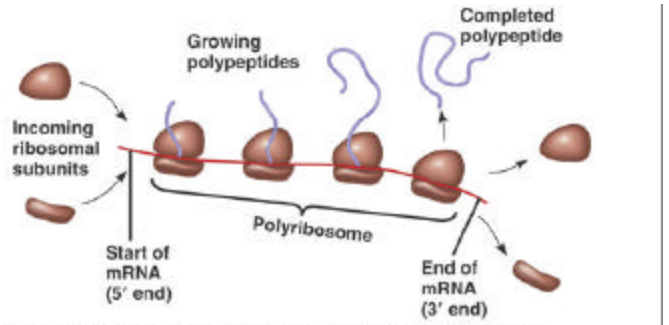


thymine : triplet : genetic message

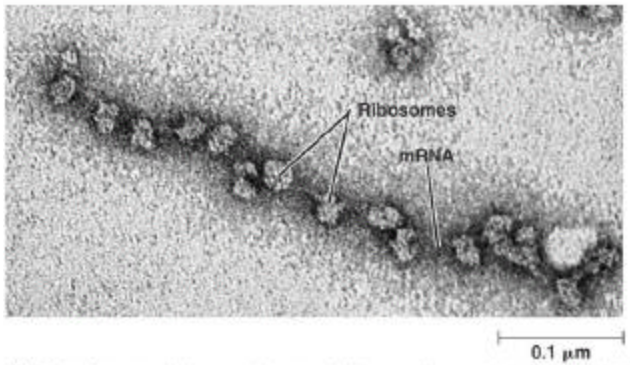
1. mRNA
2. pre- mRNA
3. tRNA
4. DNA

Polyribosomes

- An mRNA molecule is generally translated simultaneously by several ribosomes that constitute *polyribosomes*

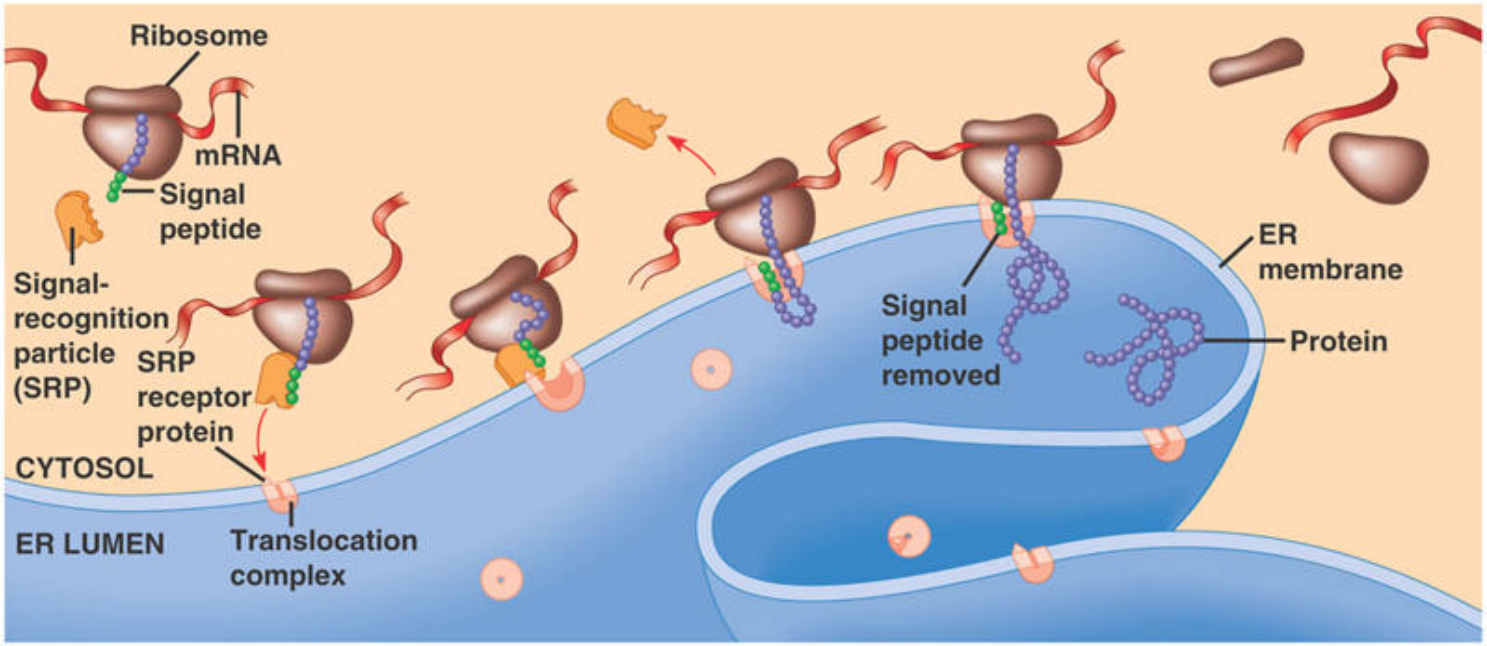


(a) An mRNA molecule is generally translated simultaneously by several ribosomes in clusters called polyribosomes.



(b) This micrograph shows a large polyribosome in a prokaryotic cell (TEM).

Anchorage of Proteins After Translation



Gene Expression