CONCEPT: RNA TRANSLATION

Translation Overview

● **Translation** is the process of changing a mRNA transcript to a protein

□ The **ribosome** is the main _____ of translation

- Contains two subunits: small and large

- Made up of a combination of rRNA (ribozymes) and protein

- RNA makes up 2/3s of the ribosome by weight

□ The **ribosome** binds to *tRNAs* in three _____: The *A, P,* and *E sites*

- A (aminoacyl) **site:** Site where tRNA recognizes the codon

- P (peptidyl) **site:** Site where the amino acid is linked to the polypeptide chain

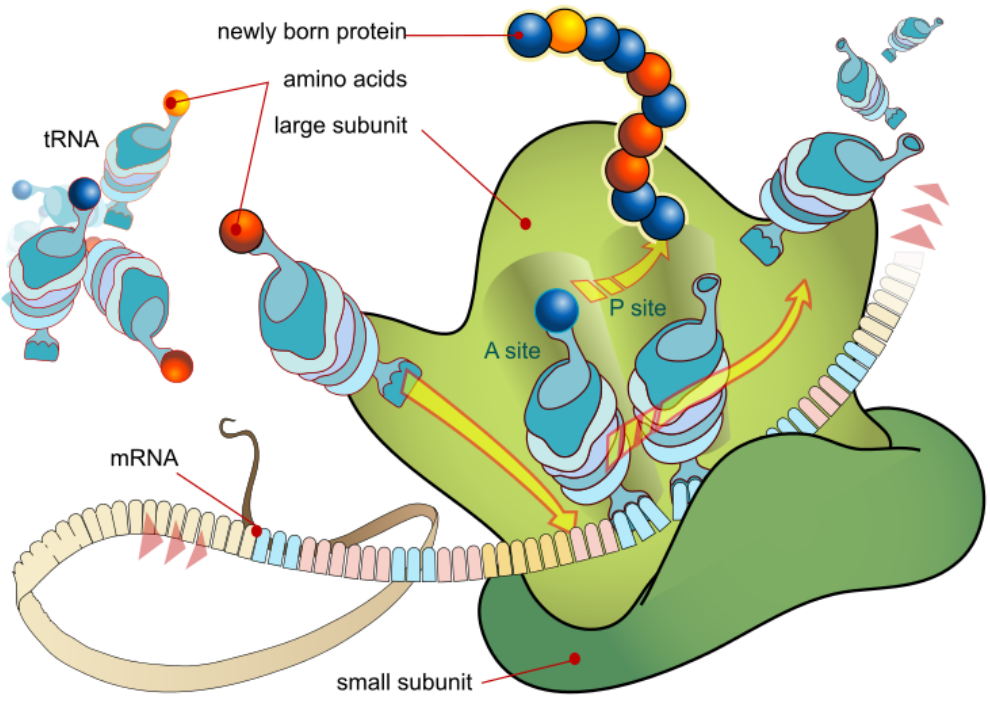
- E (exit) **site:** Site where the tRNA exists the ribosome

□ An **initiator tRNA** bound to a methionine amino acid initiates translation

- In prokaryotes it is bound to a modified methionine called *N-formylmethionine*

- Binds to the start codon AUG

EXAMPLE: Overview of ribosomal sites and mRNA translation

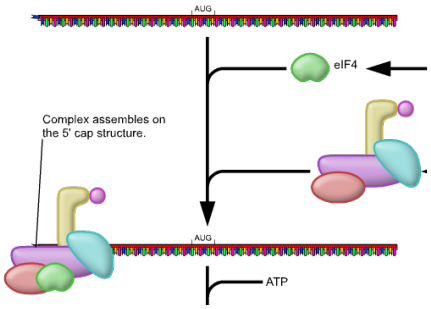


7 Translation Steps in Eukaryotes

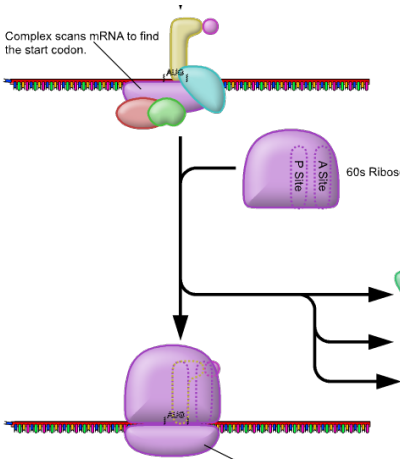
1. The initiator tRNA binds to the small subunit of the ribosome and other translation initiation factors (IFs/eIFs)

    - Binds to the P site – only the initiator tRNA can bind here if the large subunit isn't attached

2. This complex binds to the 5' end of the mRNA transcript and scans it until it reaches AUG



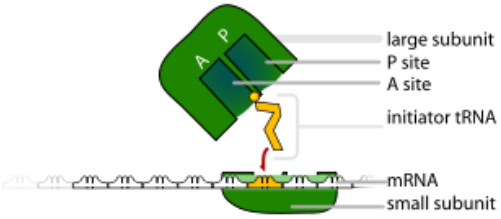
3. The large subunit is recruited to the AUG site - translation initiation proteins dissociate from complex



4. The amino acid is cleaved from the initiator tRNA in the P site, while the second tRNA is brought to the A site

    - Large subunit: contains peptidyl trasnferase (23S rRNA) which bonds the amino acids together

    - Small subunit: responsible for matching tRNAs to appropriate mRNA codons



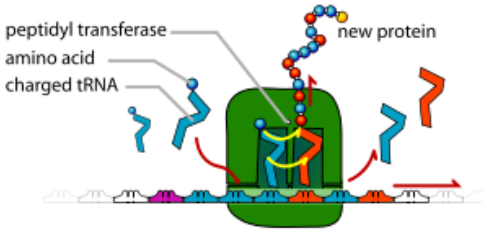
4. After linking amino acids, the ribosome moves three nucleotides (1 codon) moving the tRNA from P to E site

- Elongation factors (EFs) assist in translation elongation by hydrolyzing GTP

- Common ones include EF-tu – which promotes binding of tRNAs to mRNAs (prokaryotes)

5. The tRNA exits the ribosome and the process continues for the length of the mRNA

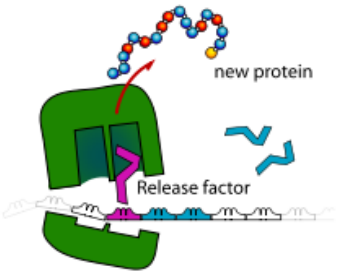
- The mRNA is pulled through the ribosome in a 5' to 3' direction



6. Translation is terminated when it reaches a stop codon: UAA, UAG, or UGA

- This causes the accumulation of *release factors* that signal the ribosome to hydrolyze a water molecule

7. The protein and ribosome are released from the mRNA – which can then start again



□ These steps can occur quickly and require lots of ribosomes

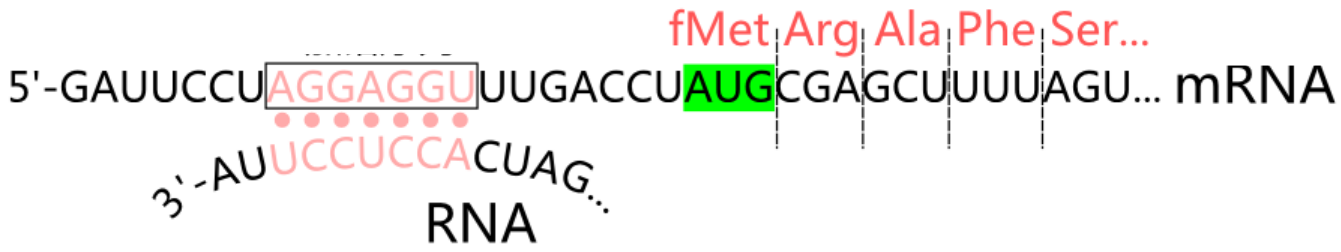
- 25% of *E.coli* weight is from ribosomes

- Mammals contain 10 million ribosomes

Prokaryotic Translation

- Translation in prokaryotes _____ because there is no 5' cap for the ribosome to bind
  - □ The **Shine-Dalgamo** sequences is where the prokaryotic ribosome binds upstream of start codon
  - □ The prokaryotic ribosome is slightly smaller than the bacterial ribosome
  - □ Antibiotics work by targeting prokaryotic ribosomes and leaving eukaryotic ribosomes alone

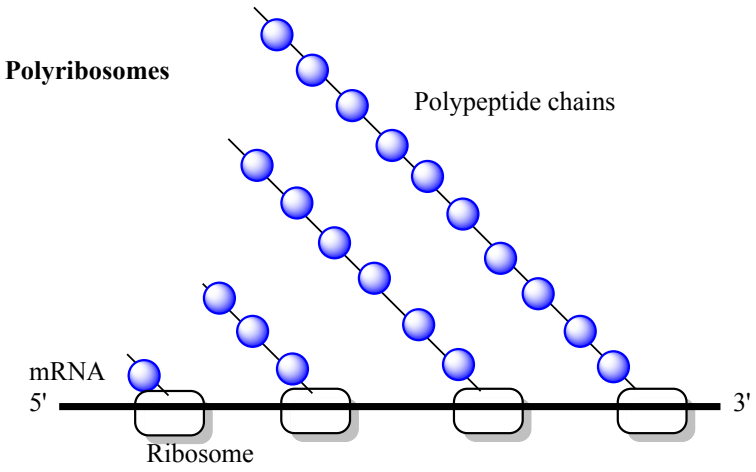
EXAMPLE: The shine-dalgamo sequence upstream of the AUG start codon



Polyribosomes

- **Polyribosomes** _____ on a single transcript so multiple mRNA copies can be translated at the same time
  - □ Saves time, as it can take several minutes to copy a single transcript
  - □ Each ribosome can begin when the proceeding on has translated around ~80 nucleotides
    - Contains two subunits: small and large
    - Made up of a combination of rRNA (ribozymes) and protein
      - RNA makes up 2/3s of the ribosome by weight

EXAMPLE: Example of polyribosomes on a single mRNA transcript



PRACTICE

1. Which of the following is not true regarding translation?
    a. Only the initiator tRNA can initiate translation
    b. Only one ribosome can translate a gene at a time
    c. Each tRNA must be passed through three sites on the ribosome
    d. The large subunit is responsible for bonding amino acids together to form the polypeptide chain

2. Which ribosomal site of protein synthesis does the initiator tRNA bind to initiation translation?
    a. A site
    b. P site
    c. E site

3. Before translation initiation, which subunit of the ribosome is recruited to the mRNA first?
    a. Small subunit
    b. Large subunit
    c. Both subunits are recruited to the mRNA at the same time

4. Elongation factors get the energy to elongate the polypeptide chain through which of the following processes?
    a. ATP hydrolysis
    b. Break down of H_2O
    c. Formation of H_2O
    d. GTP hydrolysis

5. What sequence does the prokaryotic ribosome bind in order to initiate translation?
    a. Shine dalgamo sequence
    b. Start codon: AUG
    c. Start codon: UGA
    d. Peptidyl sequence

6. True or False: Only one copy of a protein can be synthesized at one time.
    a. True
    b. False