8.5: Translation-Protein Synthesis

Learning Objectives

- Define and understand the mechanism of biological translation.

Translation

Translation in biology is the process of protein synthesis using the information encoded in mRNA.

Translation process

The process starts when the ribosome binds to mRNA in the cytoplasm, as illustrated in Figure $8.5.1$. The ribosome moves along the mRNA from 5' to 3" direction until it reaches the stats codon AUG. The AUG is also the codon for methionine. So, the methionine-tRNA (methionine-loaded aminoacyl-tRNA) with the complementary anticodon UAC arrives and aligns opposite the codon AUG. The aminoacyl-tRNA with a complementary anticodon to the codon next to AUG on the mRNA arrives and aligns opposite the codon.

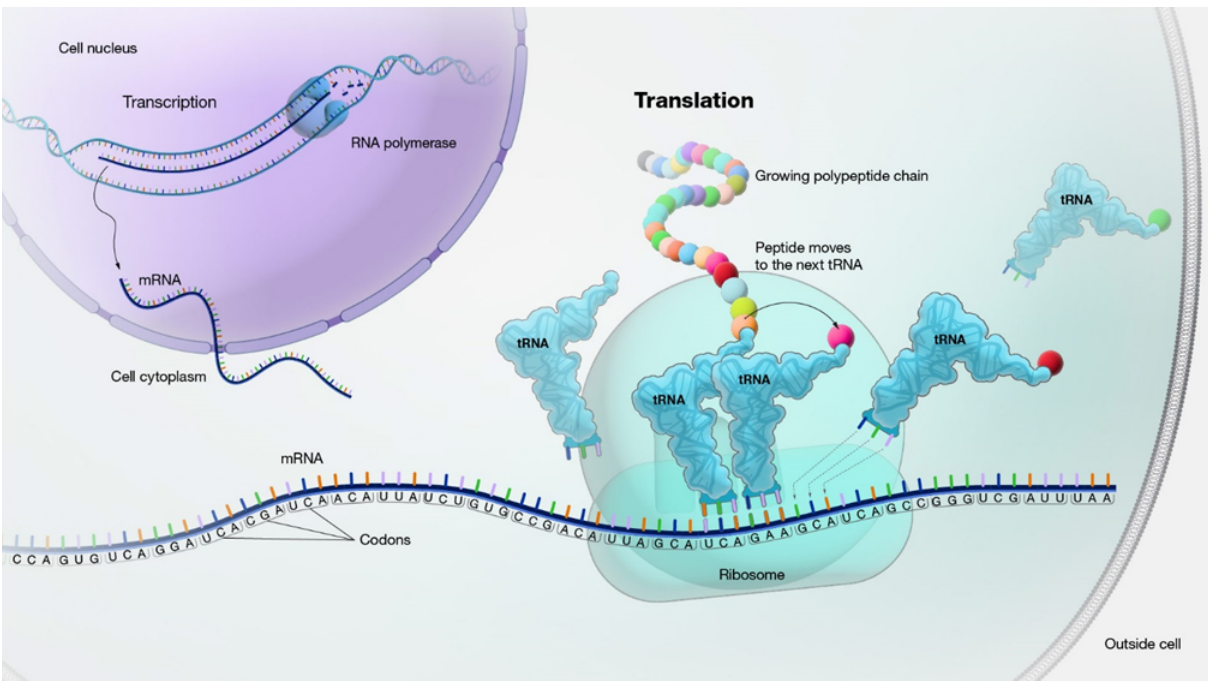


Figure $8.5.1$: An illustration of the translation process. (Copyright; National Human Genome Research Institute, Public domain)

Ribosome catalyzes a peptide bond formation between $-\mathrm{NH_2}$ group of the amino acid on the second tRNA with the carboxylate group of the first by nucleophilic acyl substitution mechanism. The first tRNA becomes empty, and the second tRNA becomes peptidyl-tRNA. The ribosome moves on to the next codon -a process called **translocation**. The empty-tRNA leaves and a new aminoacyl-tRNA with a complementary anticodon to the third codon align on the mRNA and repeat the above process, as illustrated in Figure $8.5.2$. The cycle repeats, and the peptide keeps elongating until the ribosome reaches a stop codon. The translation process stops at this point, and the newly formed peptide is released. The first methionine is usually removed from the peptide. The empty tRNA are re-loaded with the amino acid later on, as illustrated in Fig. 8.4.2. The hydrogen bonding and the other intramolecular interaction, like salt bridges, disulfide bonds, etc., make peptides acquire the secondary, tertiary, and sometimes quaternary structure. This is how functional proteins with the appropriate forms are synthesized.

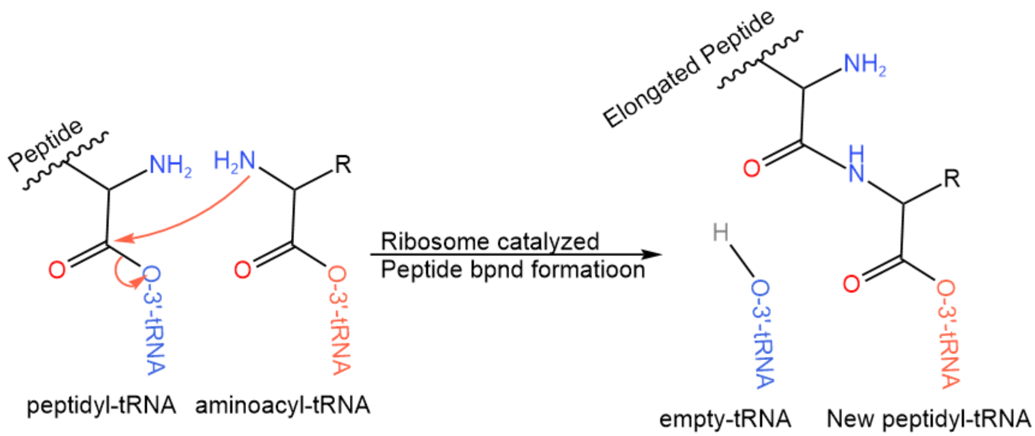
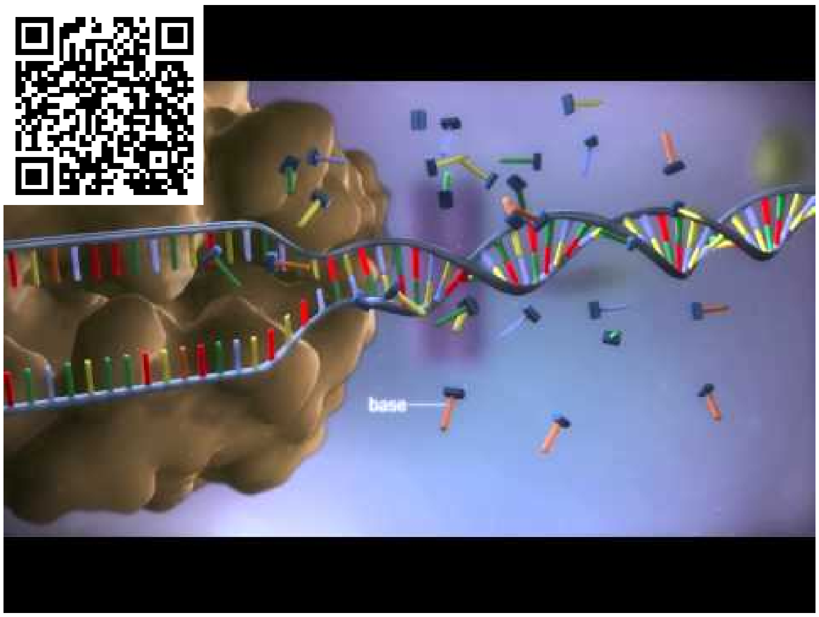


Figure 8.5.2: Illustration of the process of peptide elongation. (Copyright; author via source)

Figure 8.5.3 presents a simulation that summarizes the process of transcription and translation and the trinucleotide codons in DNA, mRNA, anticodons on tRNA, and the corresponding amino acids in the polypeptide that are shown in the simulation. Watch the DNA and RNA video summary by clicking this link or the video below.



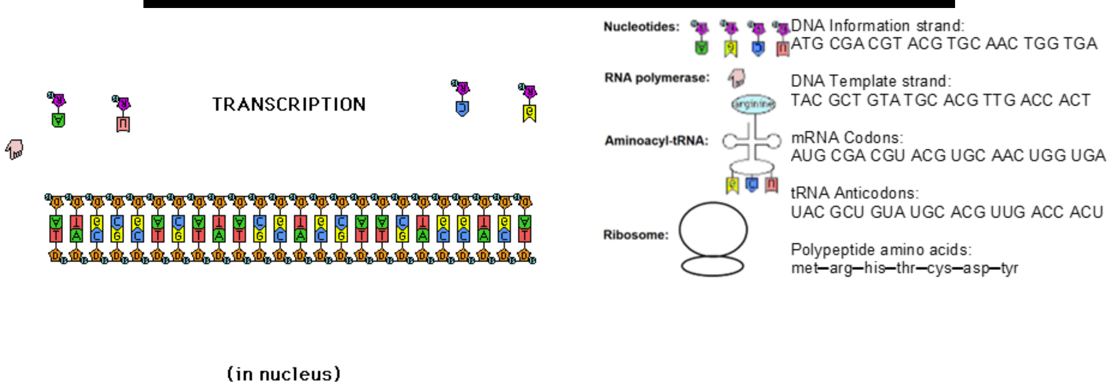


Figure 8.5.3: Simulation of the processes of transcription and translation (left), the corresponding ligands (middle), the corresponding codons, anticodon, and amino acids in DNA, mRNA, tRNA, and the polypeptide synthesized (rights). (Copyright; Steven Kuensting, CC BY-SA 4.0, via Wikimedia Commons)

Antibiotics that interrupt protein synthesis in bacteria

Antibiotics that interrupt protein synthesis in bacteria but not in humans are clinically useful. Some examples and their actions are shown in Table 1.

Table 1: Some antibiotics act by interrupting protein synthesis in bacteria but not in humans.

Antibiotic	Effect on protein synthesis in bacteria
Tetracycline	Prevents the aminoacyl-tRNA from binding to the ribosome
Erythromycin	Prevent the translocation of the ribosome along the mRNA
Streptomycin	Inhibits the initiation of protein synthesis
Chloramphenicol	Prevents the new peptide bond from being formed