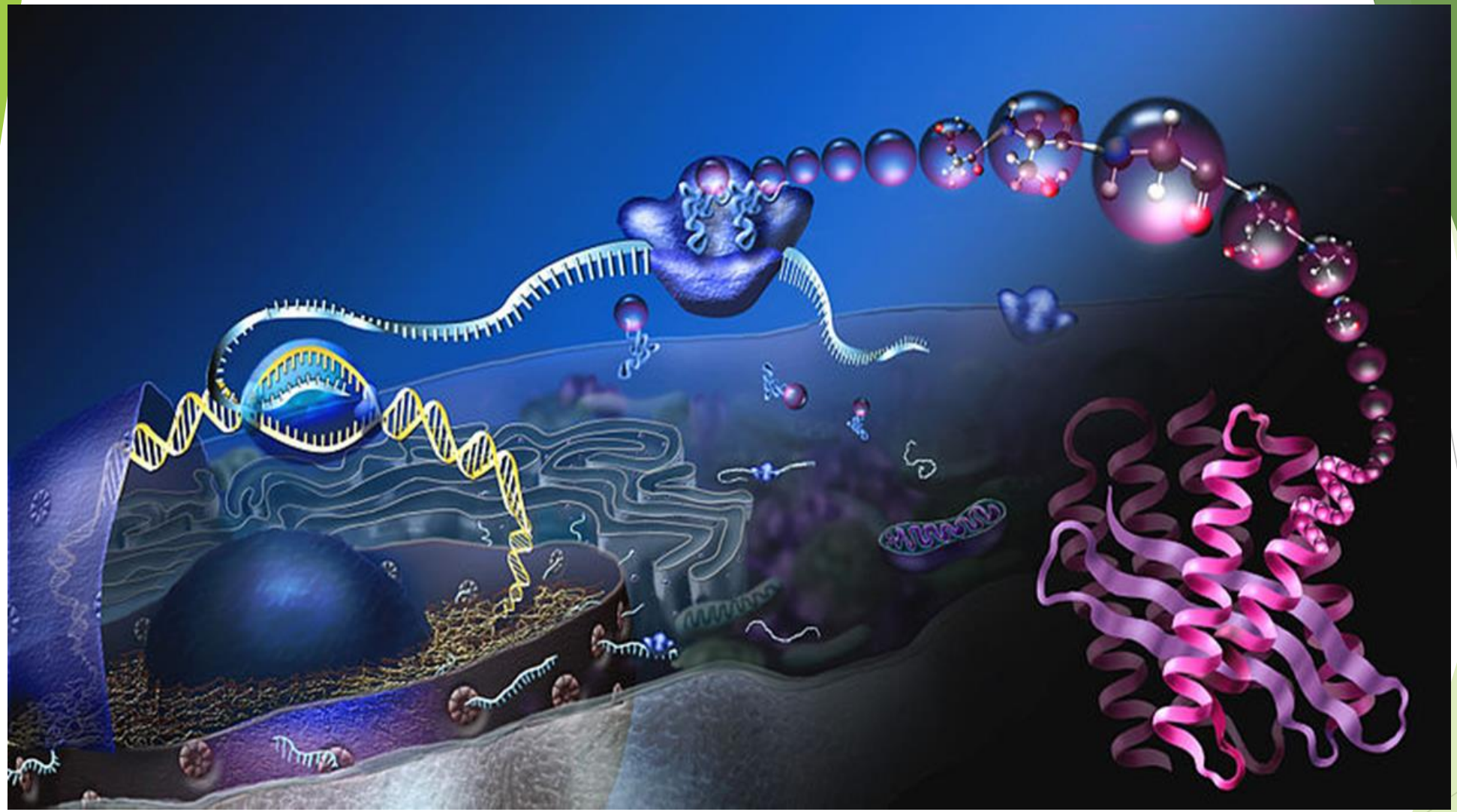


Prof.Dr.Galawezh Obaid

Protein synthesis

- **Protein synthesis** is the creation of proteins. In biological systems, it is carried out inside the cell. In prokaryotes, it occurs in the cytoplasm. In eukaryotes, it initially occurs in the nucleus to create a transcript (mRNA). The transcript leaves the nucleus and reaches the ribosomes for translation into a protein molecule with a specific sequence of amino acids.
- Not all amino acids are produced by the body; other amino acids are obtained from the diet

- In translation, the amino acids are linked together in a particular order based on the genetic code. After translation, the newly formed protein undergoes further processing, such as proteolysis, post-translational modification, and protein folding.

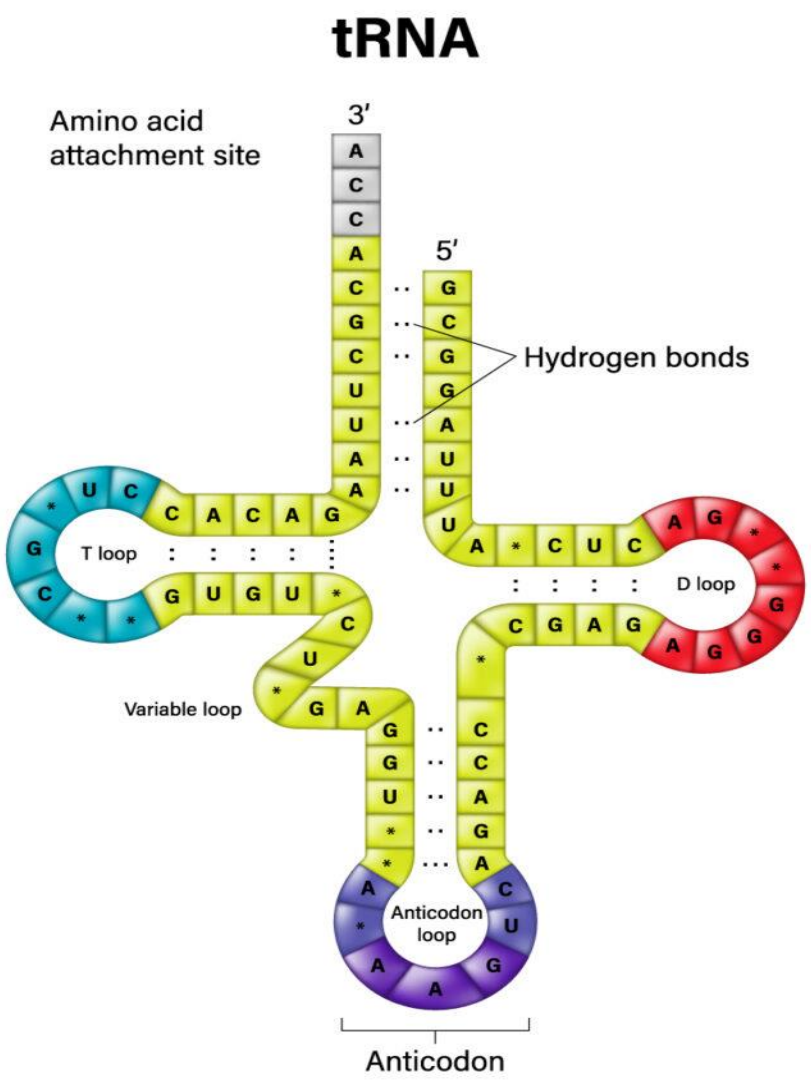
Protein Synthesis: Differences Between Prokaryotes and Eukaryotes	
Prokaryotic protein synthesis	Eukaryotic protein synthesis
Translation occurs even before the transcription of mRNA ends	Transcription occurs followed by translation
Except in archaebacterial, bacterial mRNA formation does not include the addition of a *cap* and a *poly A tail*	mRNA formation includes the addition of 5′ cap and a poly A tail at the 3′ end of mRNA transcript
Translation begins at AUG codon	Translation begins via the 5′ cap, binding the mRNA to the ribosomal unit at the first AUG codon
Initiating factors: PIF-1, PIF-2, PIF-3	Initiating factors: eIF1-6, eIF4B, eIF4C, eIF4D, eIF4F

- In biology, a codon refers to the trinucleotides that specify for a particular amino acid. For example, Guanine-Cytosine-Cytosine (GCC) codes for the amino acid alanine.
- The Guanine-Uracil-Uracil (GUU) codes for valine. Uracil-Adenine-Adenine (UAA) is a stop codon. The codon of the mRNA complements the trinucleotide (called anticodon) in the tRNA. **to be added to the growing chain of amino acid**

mRNA, tRNA, and rRNA

mRNA, tRNA, and rRNA are the three major types of RNA involved in protein synthesis. The mRNA (or messenger RNA) carries the code for making a protein.

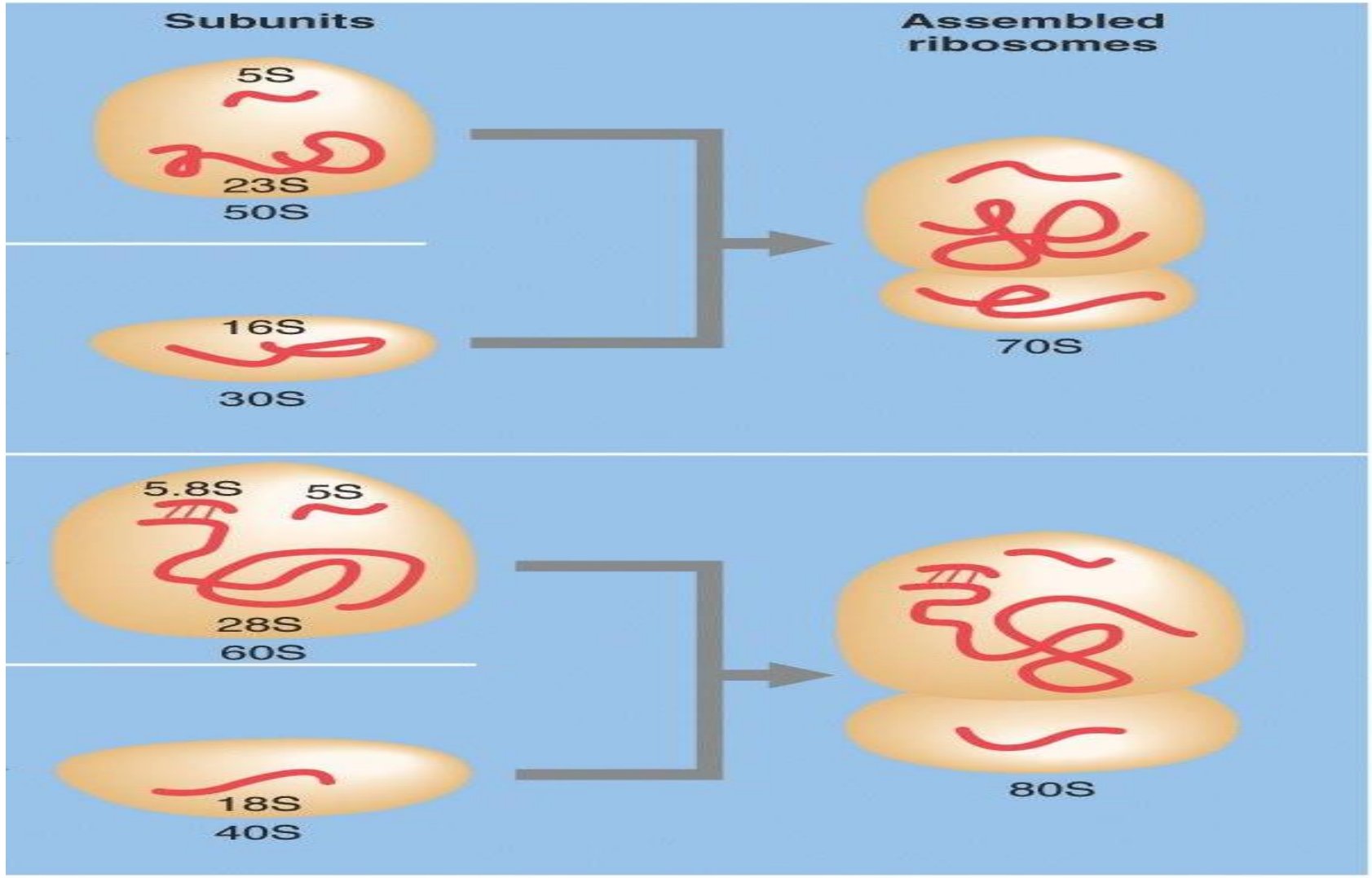
- . tRNA (or transfer RNA), as the name implies, transfers the specific amino acid to the ribosome It consists of two major sites: (1) anticodon arm and (2) acceptor stem. The anticodon arm contains the anticodon that complementary base pairs with the codon of the mRNA. The acceptor stem is the site where a specific amino acid is attached (in this case, the tRNA with amino acid is called aminoacyl-tRNA). A peptidyl-tRNA is the tRNA that holds the growing polypeptide chain.


tRNA
Amino acid attachment site
3′
5′
Hydrogen bonds
T loop
D loop
Variable loop
Anticodon loop
Anticodon

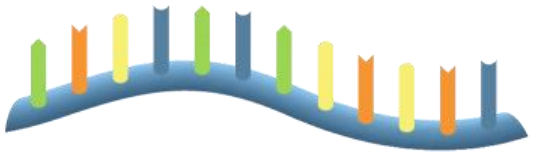
- Unlike the first two, rRNA (or ribosomal RNA) does not carry genetic information. Rather, it serves as one of the components of the ribosome. The ribosome is a cytoplasmic

  synthesis. The ribosomes can be used to determine a prokaryote from a eukaryote.

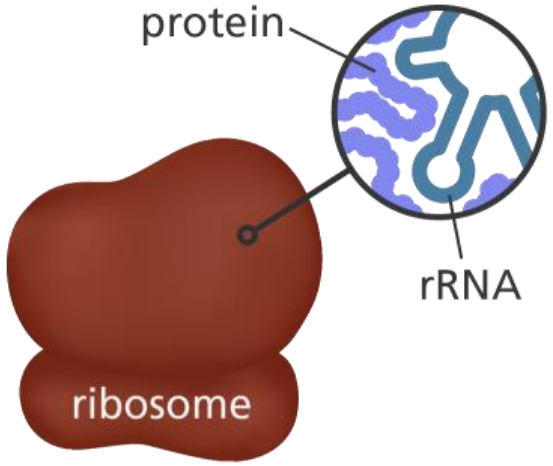
  Prokaryotes have 70S ribosomes whereas eukaryotes have 80S ribosomes. Both types,



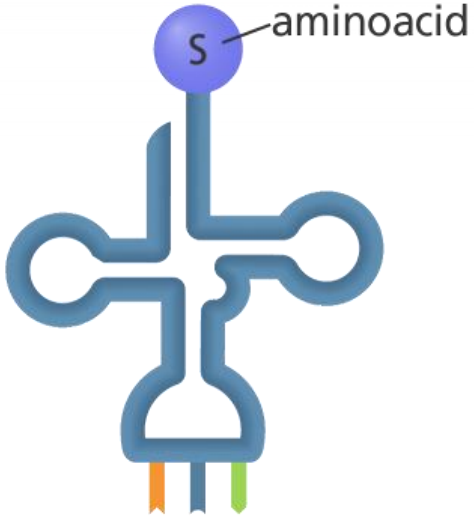
Structure of prokaryotic & eukaryotic ribosomes



messenger RNA
(mRNA)



ribosomal RNA
(rRNA)

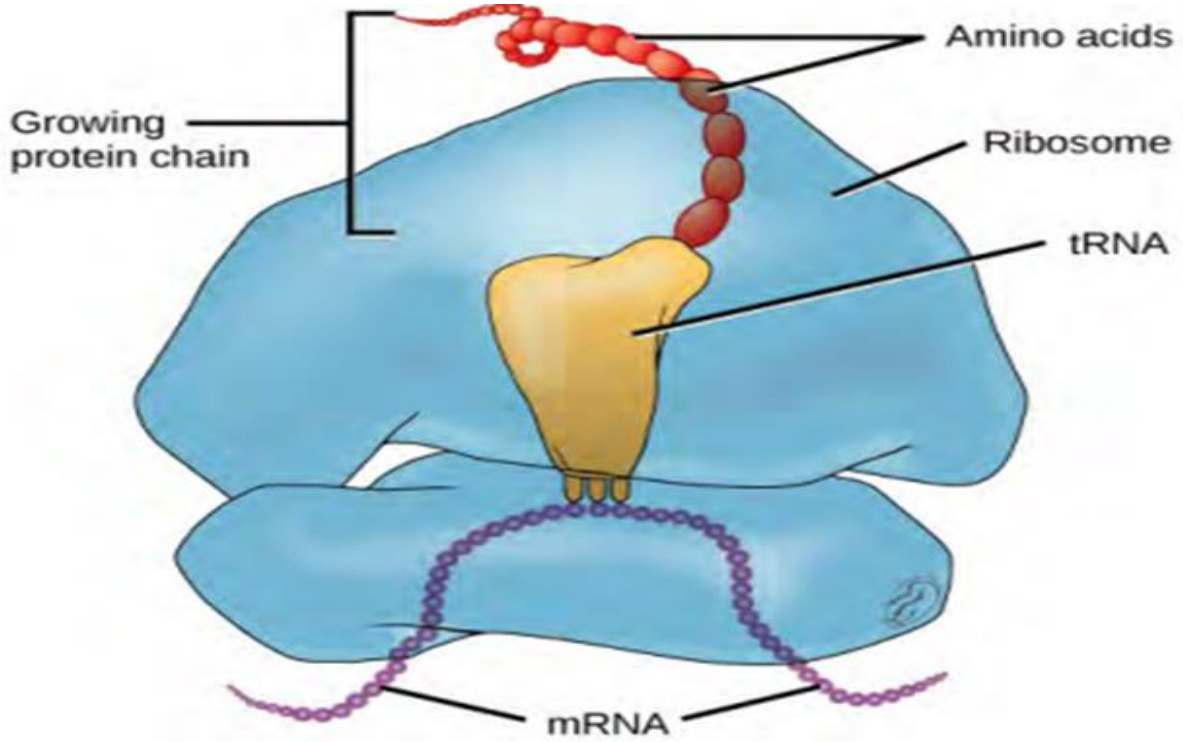


transfer RNA
(tRNA)

TRANSLATION

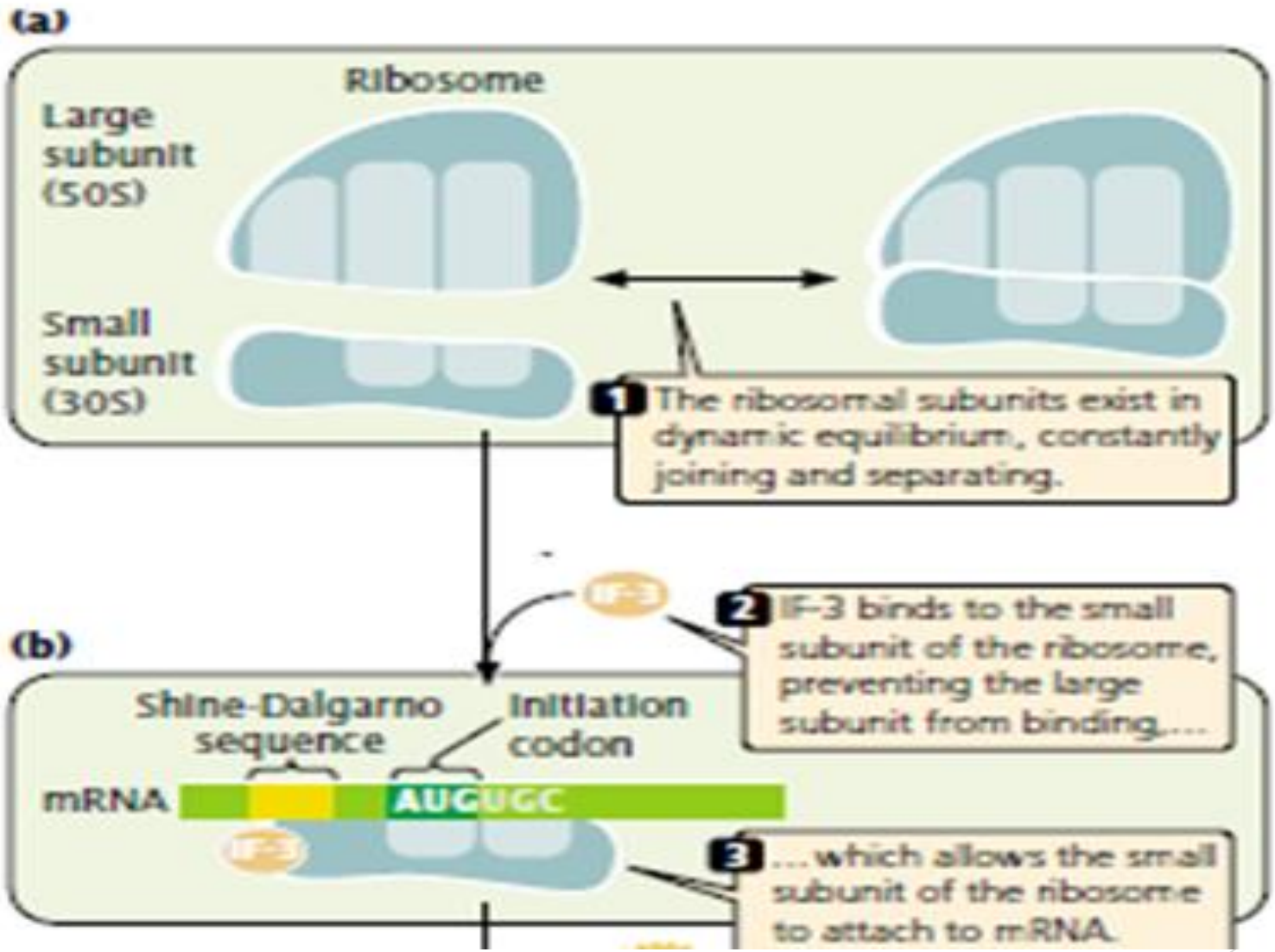
- Translation is the transmission of the genetic information from mRNA to form protein.
- In the cytoplasm, mRNA to form protein.
- In the cytoplasm, mRNA attaches to ribosomes, which is the site of protein production.
- During translation, smaller RNA molecules known as transfer RNA (tRNA) bind to the ribosome.
- The tRNA deliver amino acid to the ribosomes and synthesizes a linear chain of amino acids called a polypeptide (primary protein) and later forms proteins.

- The Initiation of Translation
- The first stage in the process of protein synthesis is initiation. During initiation, all the components necessary for protein synthesis assemble:
- (1) mRNA;
- (2) the small and large subunits of the ribosome;
- (3) a set of three proteins called initiation factors;
- (4) initiator tRNA with *N*-formylmethionine attached (fMet-tRNAfMet);
- (5) guanosine triphosphate (GTP).



The protein synthesis machinery includes the large and small subunits of the ribosome, mRNA, and tRNA.

- Initiation comprises three major steps. First, mRNA binds to the small subunit of the ribosome.
- Second, initiator tRNA binds to the mRNA through base pairing between the codon and anticodon.
- Third, the large ribosome joins the initiation complex.
- A functional ribosome exists as two subunits, the small 30S subunit and the large 50S subunit (in bacterial cells).
- An mRNA molecule can bind to the small ribosome subunit only when the subunits are separate. **Initiation factor 3** (IF-3) binds to the small subunit of the ribosome and prevents the large subunit from binding during initiation


(a)
Ribosome
Large subunit (50S)
Small subunit (30S)
1 The ribosomal subunits exist in dynamic equilibrium, constantly joining and separating.
2 IF-3 binds to the small subunit of the ribosome, preventing the large subunit from binding....
(b)
Shine-Dalgarno sequence
Initiation codon
mRNA
AUGUGC
3 ...which allows the small subunit of the ribosome to attach to mRNA.

- The sequence covered by the ribosome during initiation is from (30 to 40)nucleotides long and includes the AUG initiation codon. Within the ribosome-binding site is the Shine-Dalgarno consensus sequence ,which is complementary to a sequence of nucleotides at the 3` end of 16S rRNA (part of the small subunit of the ribosome).

- In E. coli, there are 200,000 ribosomes present in every cell at any given time. A ribosome is a complex macromolecule composed of structural and catalytic rRNAs, and many distinct polypeptides.
- In eukaryotes, the nucleolus is completely specialized for the synthesis and assembly of rRNAs. Ribosomes are located in the cytoplasm in prokaryotes and in the cytoplasm and endoplasmic reticulum of eukaryotes.

- In prokaryotes and eukaryotes, the basics of polypeptide elongation are the same
- tRNA keep bringing amino acids to the growing polypeptide according to complementary base pairing between the codons on the mRNA and the anticodons on the tRNA. As a tRNA moves into the ribosome, its amino acid is transferred to the growing polypeptide.
- , so we will review elongation from the perspective of E. coli. The large ribosomal subunit of E. coli consists of three compartments: the A site binds incoming charged tRNAs (tRNAs with their attached specific amino acids). The P site binds charged tRNAs carrying amino acids that have formed bonds with the growing polypeptide chain but have not yet dissociated from their corresponding tRNA.

- The E site releases dissociated tRNAs so they can be recharged with free amino acids.

The ribosome shifts one codon at a time, catalyzing each process that occurs in the three sites. With each step, a charged tRNA enters the complex, the polypeptide becomes one amino acid longer, and an uncharged tRNA departs. The energy for each bond between amino acids is derived from GTP, a molecule similar to ATP (Figure 9.21).

- Amazingly, the E. coli translation apparatus takes only 0.05 seconds to add each amino acid, meaning that a 200-amino acid polypeptide could be translated in just 10 seconds.
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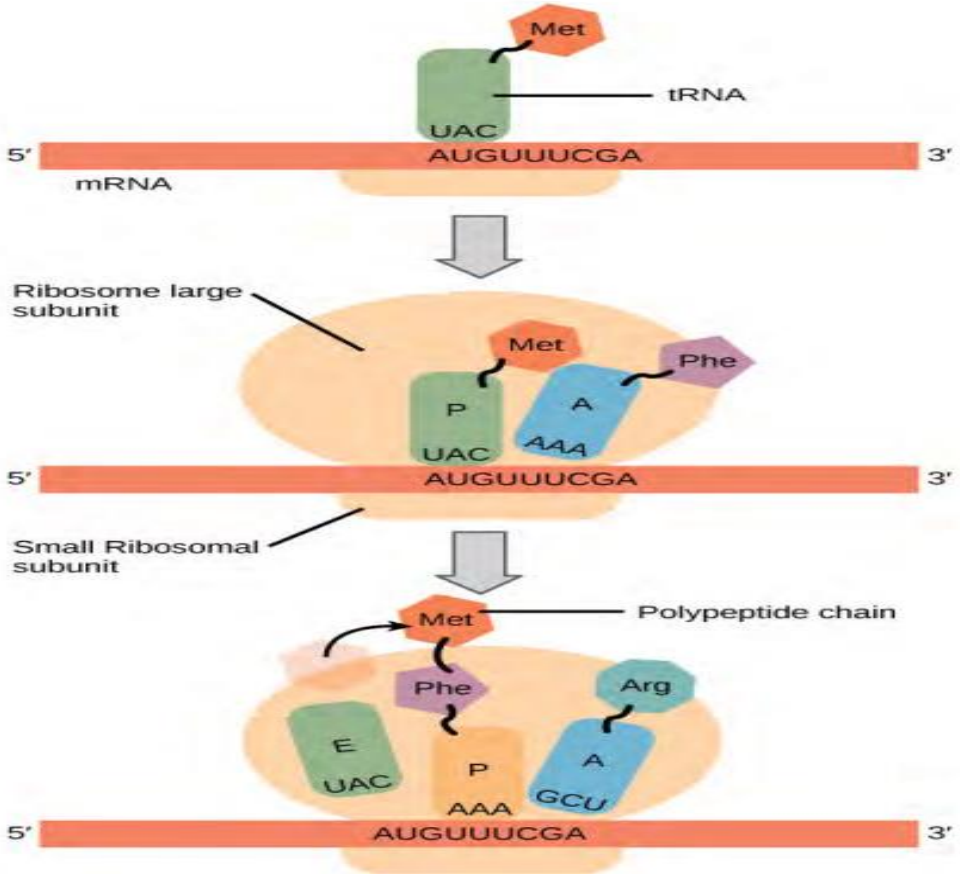
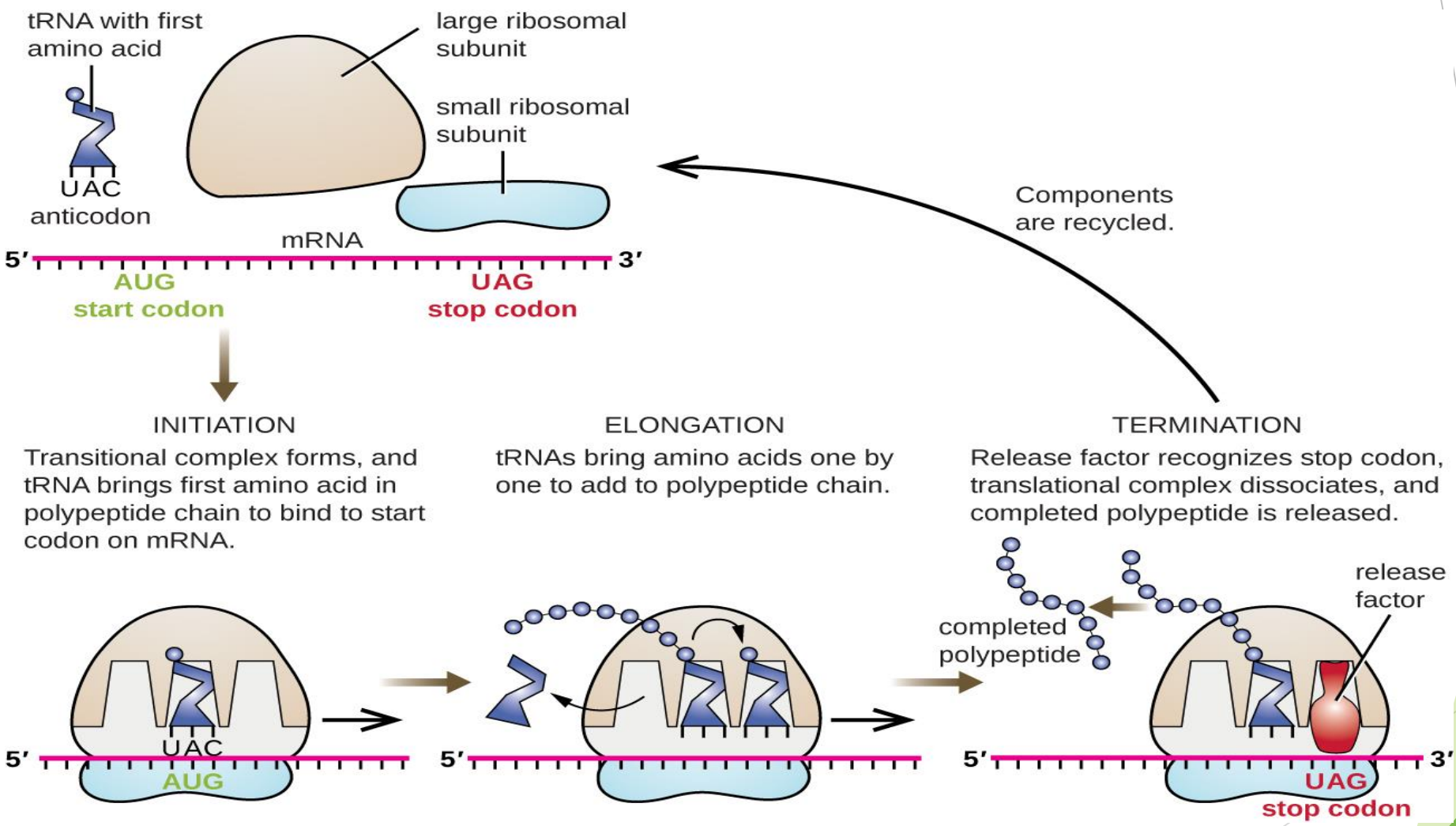
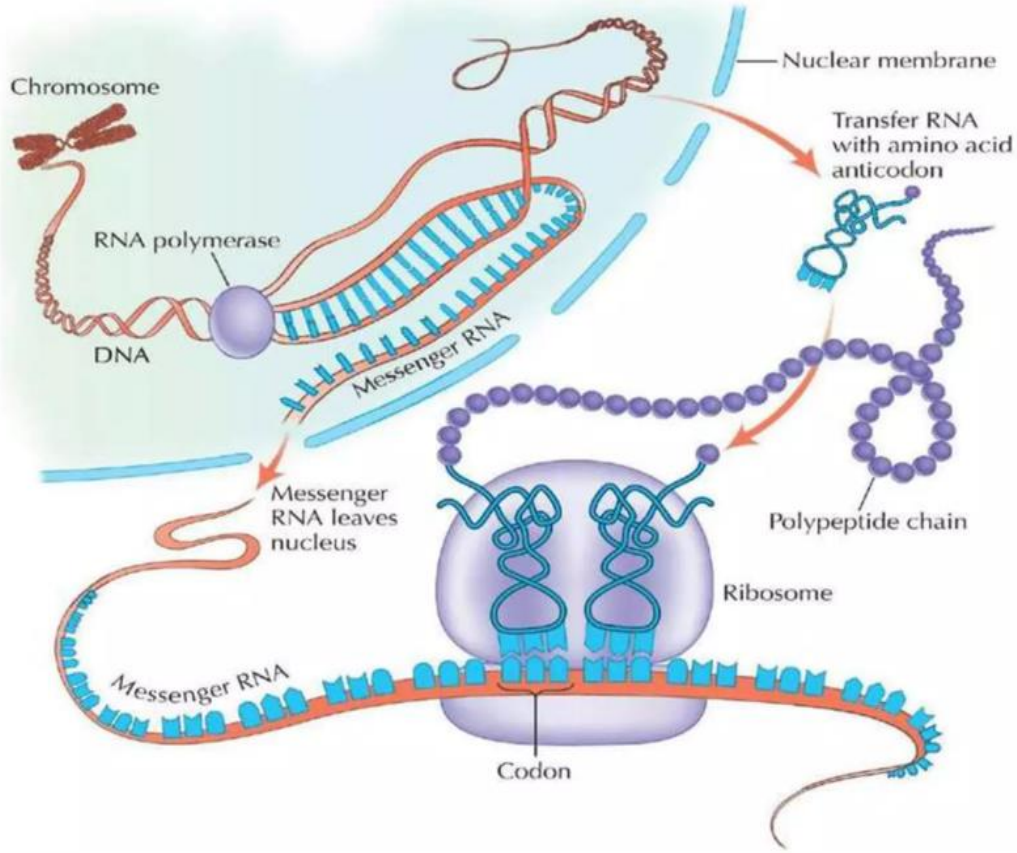


Figure 9.21 Translation begins when a tRNA anticodon recognizes a codon on the mRNA. The large ribosomal subunit joins the small subunit, and a second tRNA is recruited. As the mRNA moves relative to the ribosome, the polypeptide chain is formed. Entry of a release factor into the A site terminates translation and the components dissociate.


tRNA with first amino acid
large ribosomal subunit
small ribosomal subunit
UAC
anticodon
mRNA
5′
3′
AUG
start codon
UAG
stop codon
Components are recycled.
INITIATION
Transitional complex forms, and tRNA brings first amino acid in polypeptide chain to bind to start codon on mRNA.
ELONGATION
tRNAs bring amino acids one by one to add to polypeptide chain.
TERMINATION
Release factor recognizes stop codon, translational complex dissociates, and completed polypeptide is released.
release factor
completed polypeptide
UAC
AUG
UAG
stop codon

- Termination of translation occurs when a stop codon (UAA, UAG, or UGA) is encountered. When the ribosome encounters the stop codon, the growing polypeptide is released, and the ribosome subunits dissociate and leave the mRNA. After many ribosomes have completed translation, the mRNA is degraded so the nucleotides can be reused in another transcription reaction.
-

Translation and Proteins



DNA

↓

RNA

↓

PROTEIN