BIO102-Foundations of Biology (I)

Translation: RNA to Protein

INDRAPRASTHA INSTITUTE *of*
INFORMATION TECHNOLOGY **DELHI**

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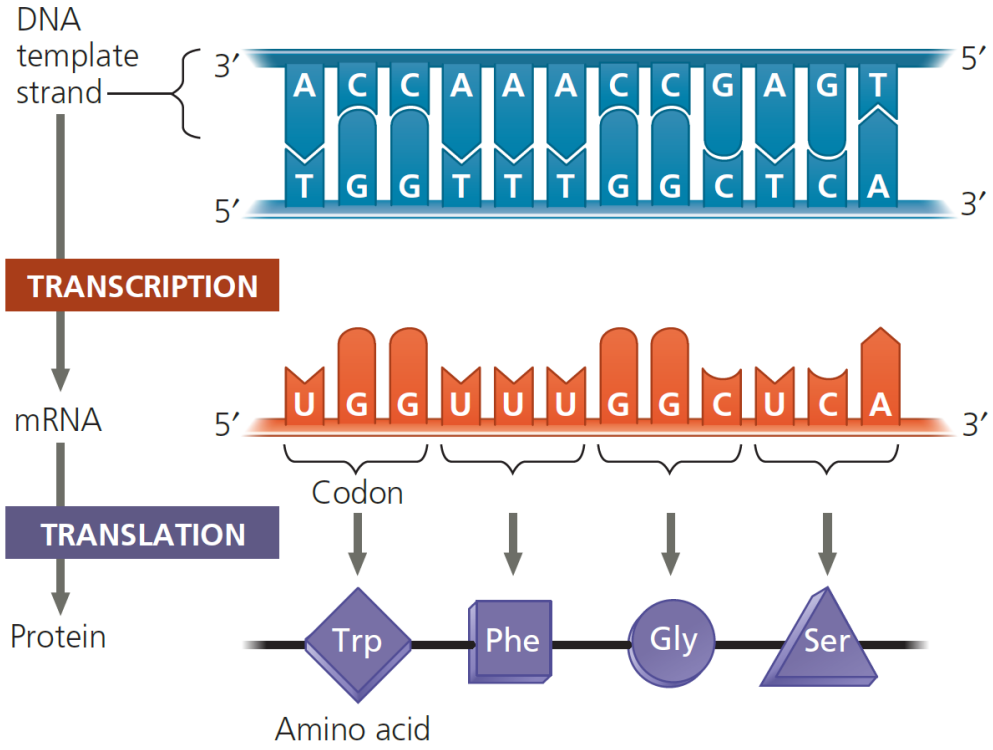
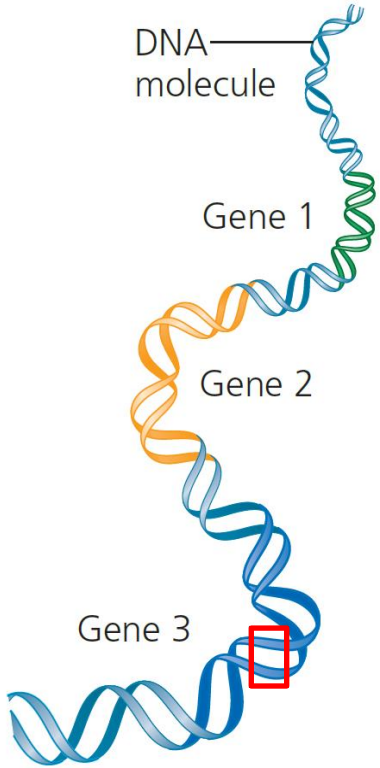
Central Dogma

Flow of genetic information



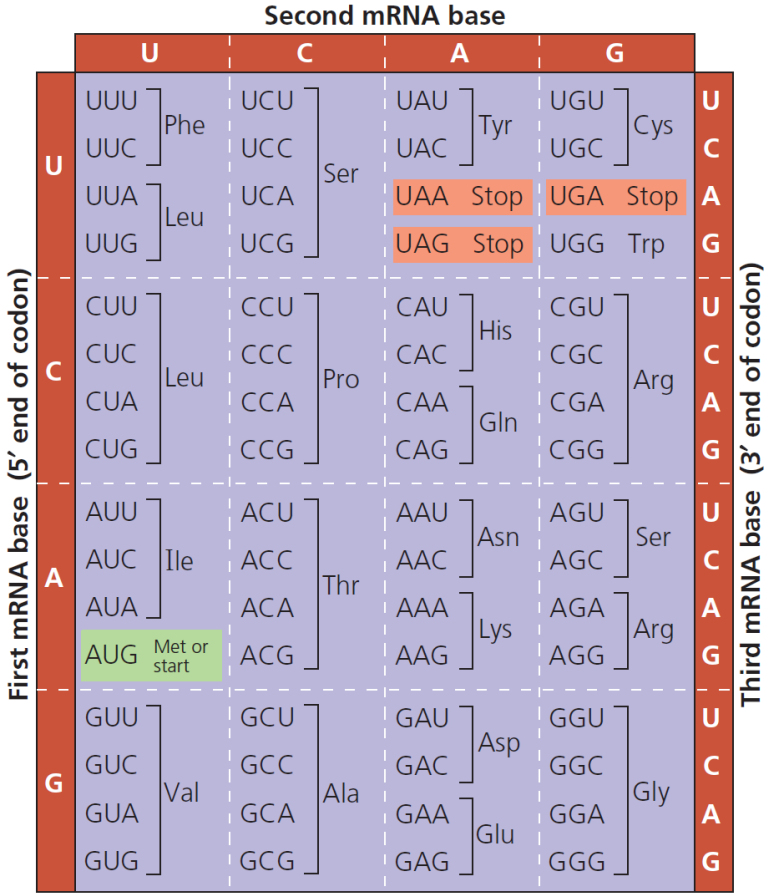


DNA → RNA → Protein

- Information encoded in DNA is copied first into RNA and then into protein.
- DNA and RNA are chemically and structurally similar, and DNA can act as a direct template for the synthesis of RNA through complementary base pairing.
- How is the information in a linear sequence of nucleotides in an RNA molecule translated into the linear sequence of a chemically quite different set of subunits—the amino acids in a protein? This process is called translation.
- The rules by which the nucleotide sequence of a gene, through an intermediary mRNA molecule, is translated into the amino acid sequence of a protein are known as the genetic code.

Genetic code

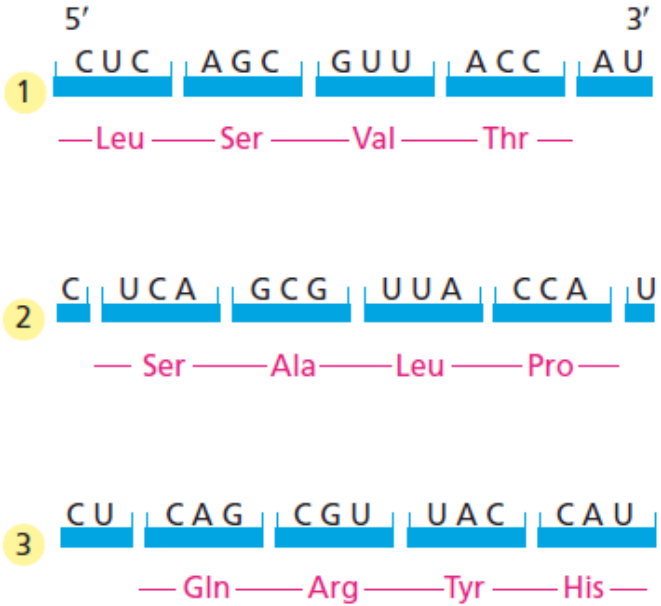
- Sequence of nucleotides in an mRNA molecule is read consecutively in groups of three.
- RNA is made of 4 different nucleotides, therefore 64 combinations (4 × 4 × 4) of three nucleotides are possible. Eg. AAA, AUA, AUG, and so on.
- Each group of three consecutive nucleotides in RNA is called a codon, and each codon specifies one amino acid. Some amino acids being specified by more than one triplet.



RNA can be read in three different frames

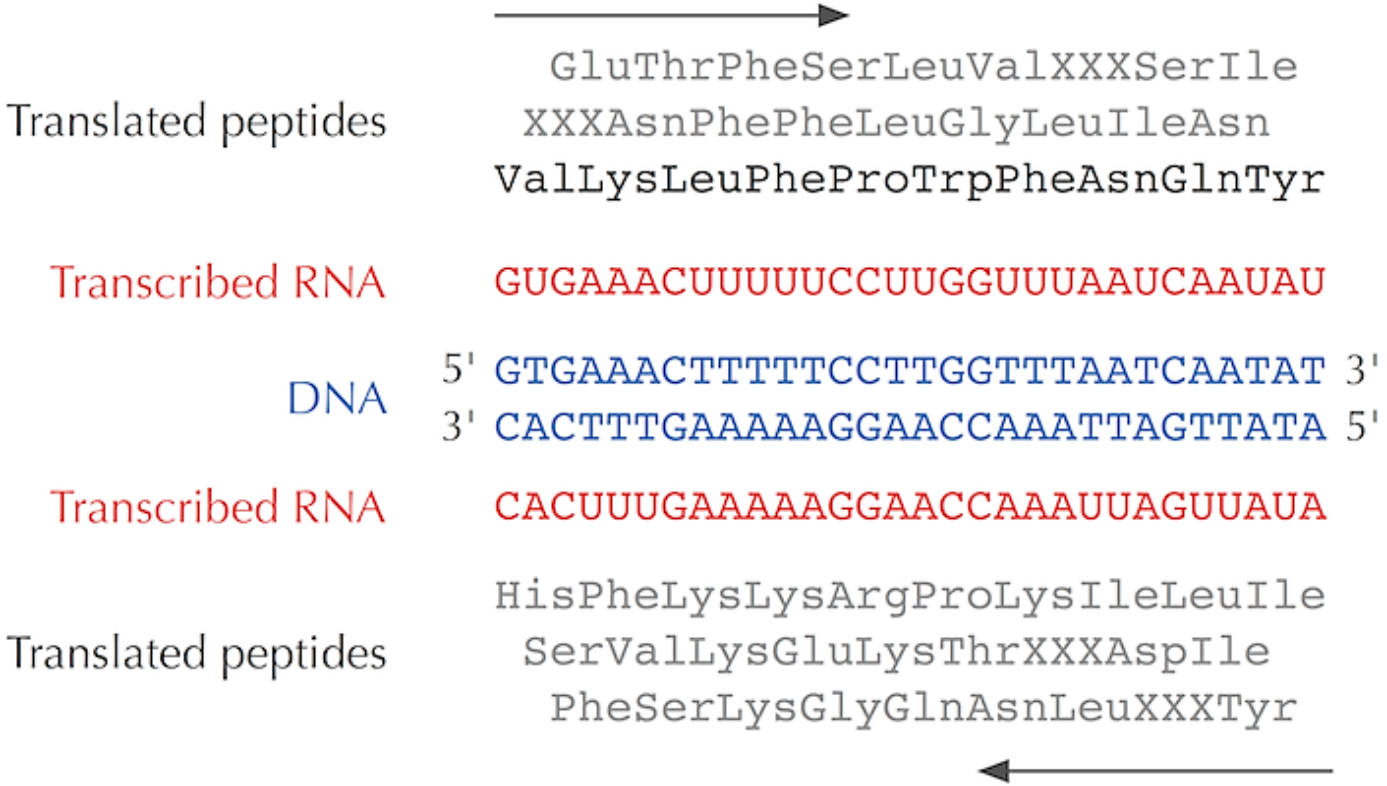
An mRNA molecule can be translated in three possible reading frames.

mRNA sequence: CUCAGCGUUACCAU



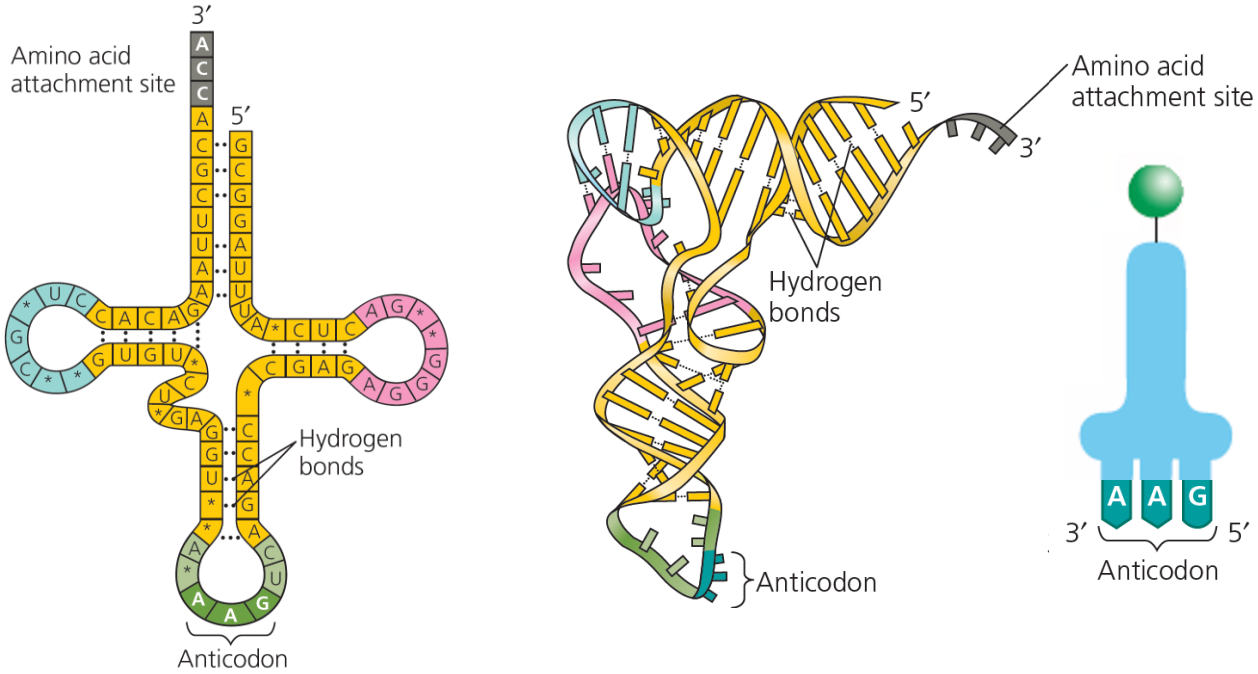
DNA can be read in six different frames

A DNA molecule can be read in six reading frames.



tRNA molecules match amino acids to codons

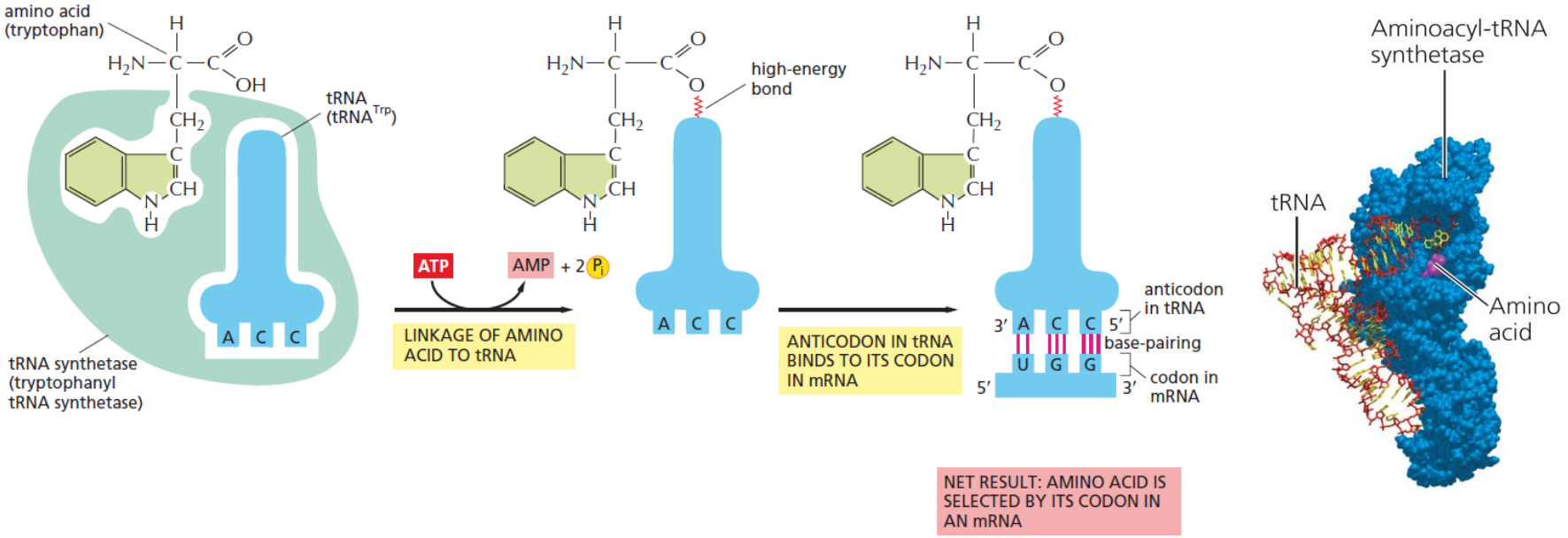
tRNA (transfer RNA) molecules are molecular adaptors that link amino acids to codons



The asterisks mark (*) bases that have been chemically modified, a characteristic of tRNA.

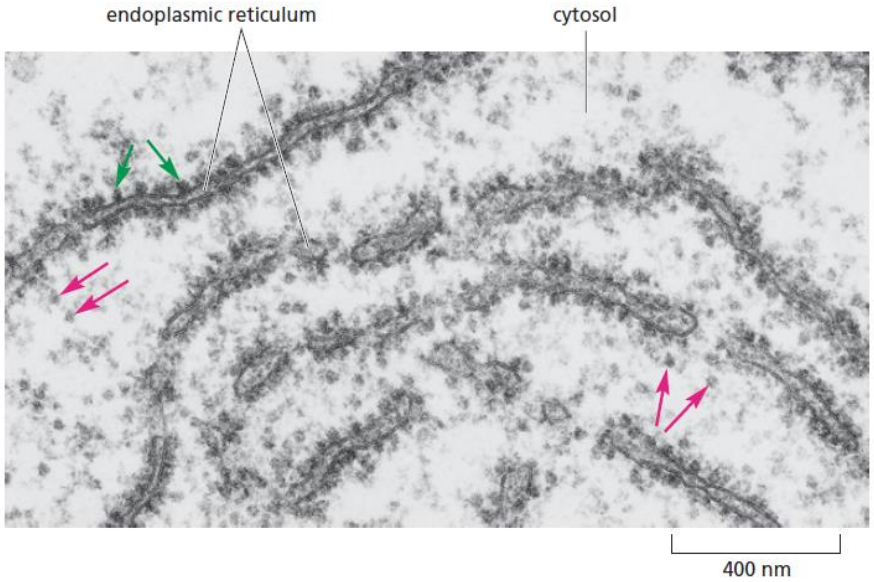
Coupling of tRNAs to the correct amino acid

Recognition and attachment of the correct amino acid to appropriate tRNA depends on enzymes called aminoacyl-tRNA synthetases



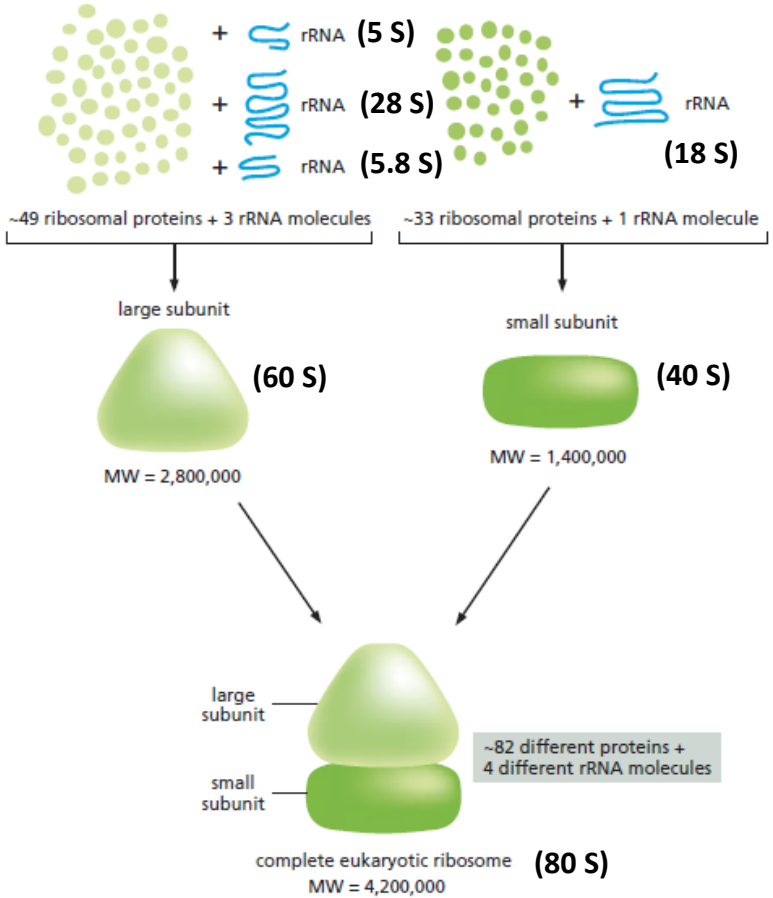
The mRNA message is decoded by Ribosomes

- Accurate and rapid translation of mRNA into protein requires a molecular machine that can move along the mRNA, capture complementary tRNA molecules, hold the tRNAs in position, and then covalently link the amino acids that they carry to form a polypeptide chain.

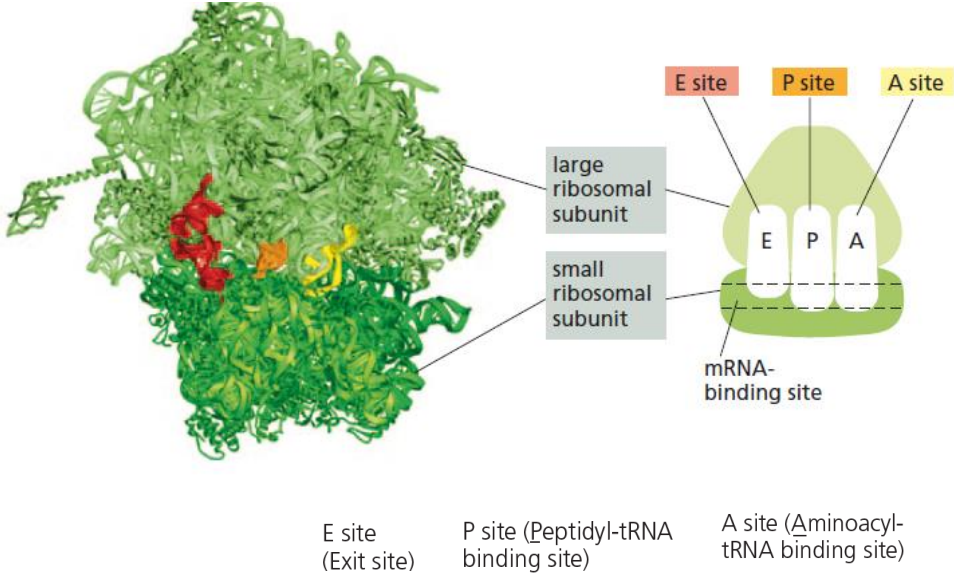


- In both prokaryotes and eukaryotes, the machine that gets the job done is the ribosome - a large complex made from dozens of small proteins (the ribosomal proteins) and several crucial RNA molecules called ribosomal RNAs (rRNAs).

mRNA binding site in ribosome

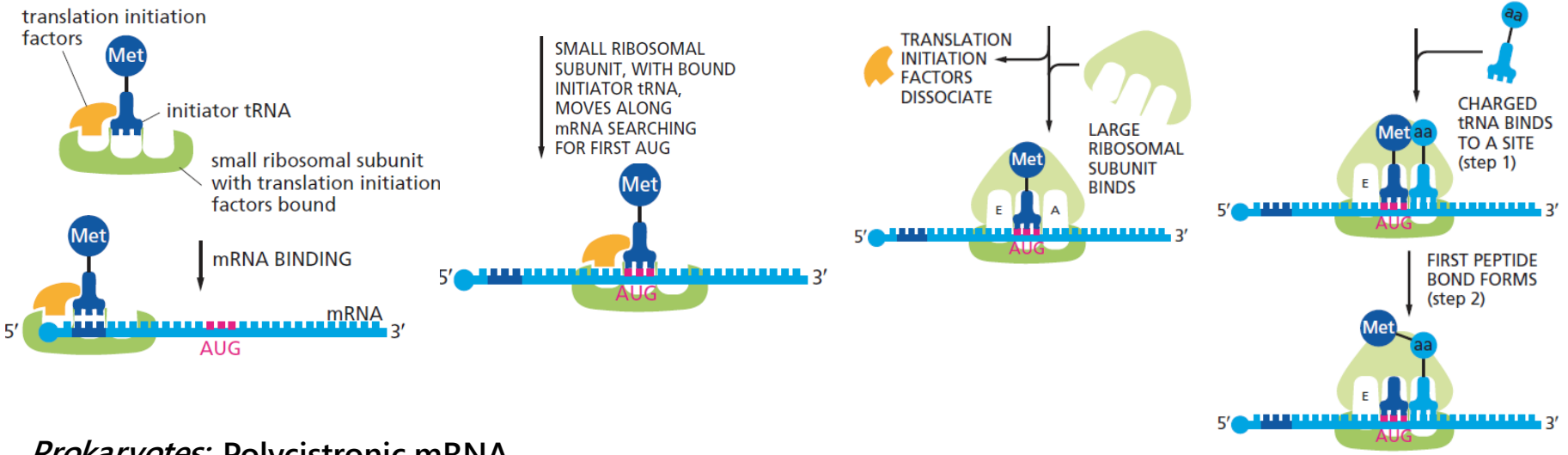


- Ribosomal RNAs give the ribosome its overall shape.
- RNA molecules that possess catalytic activity are called ribozymes

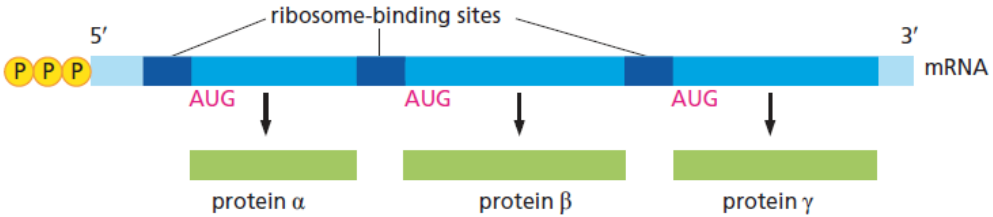


Initiation of protein synthesis

Eukaryotes

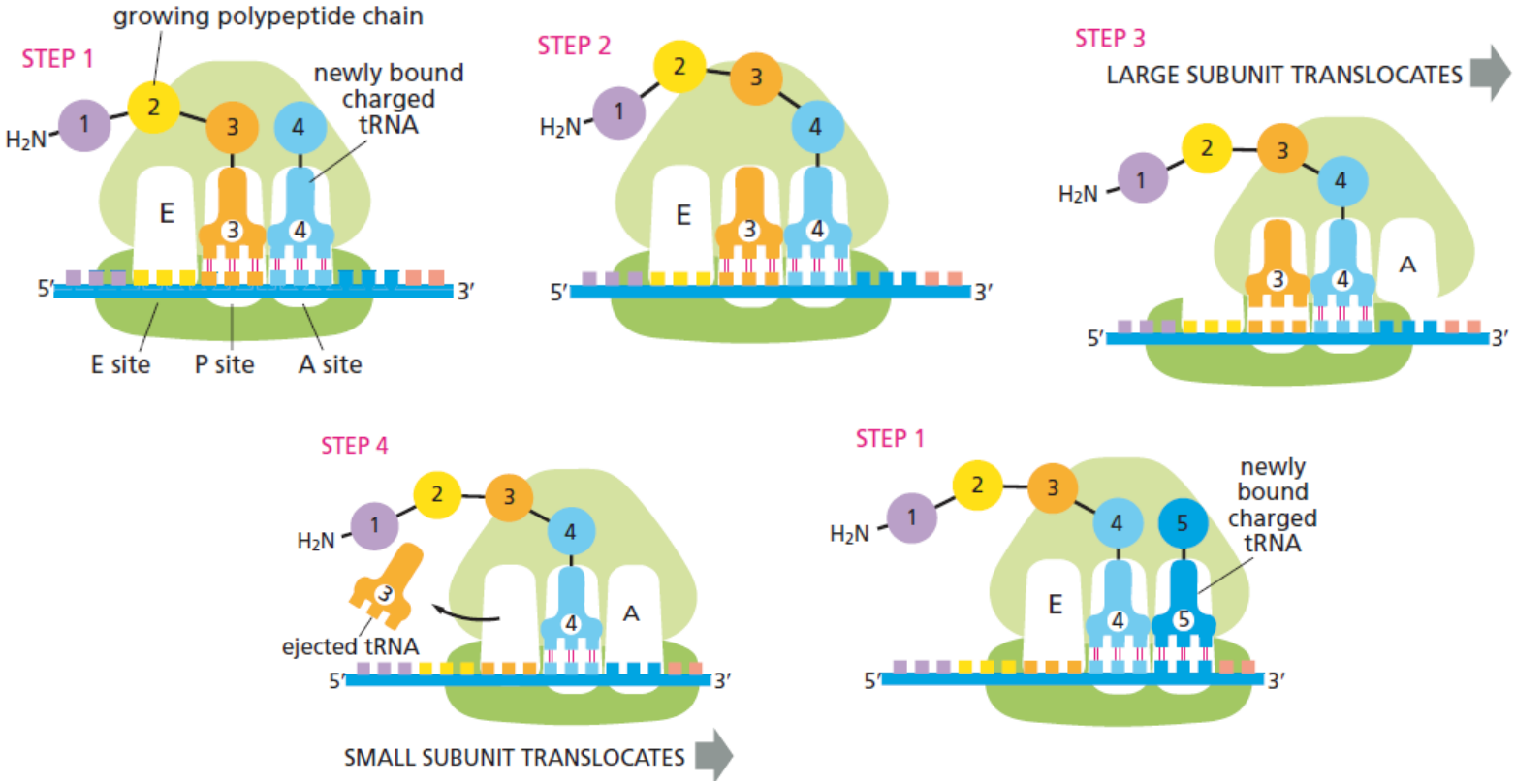


Prokaryotes: Polycistronic mRNA

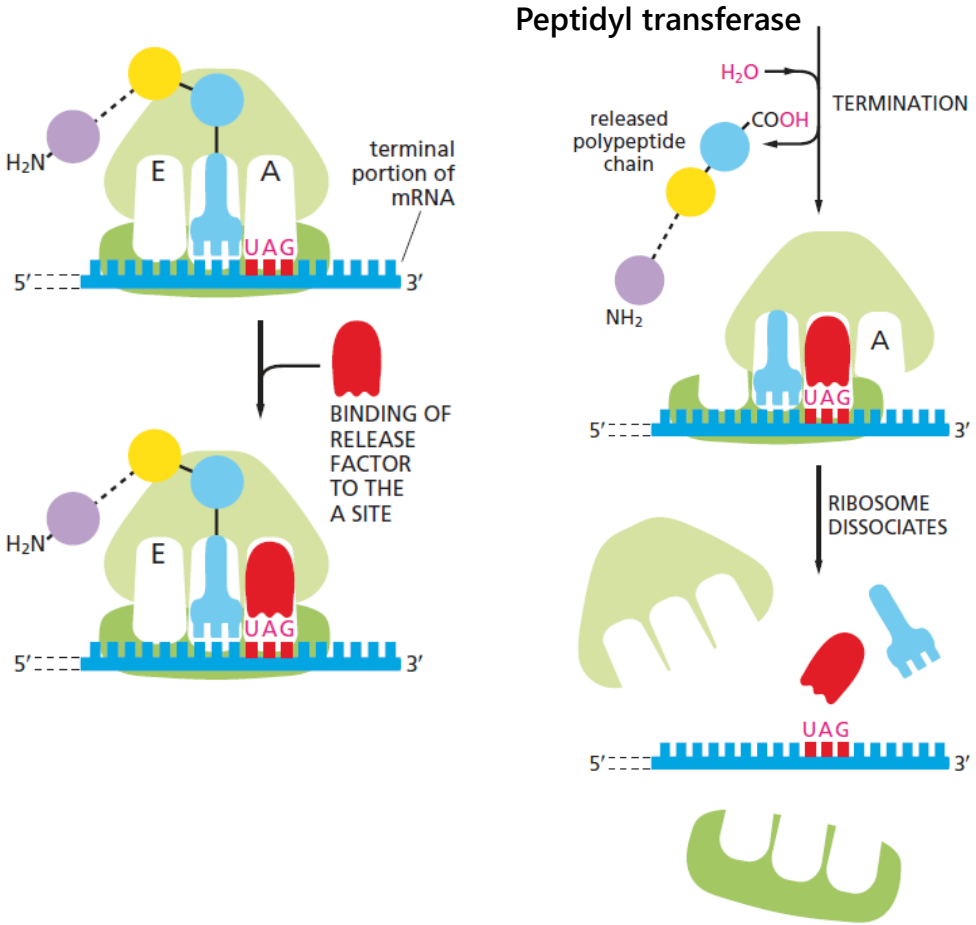


The initiator tRNAs carries a modified form of methionine, formyl-methionine, in bacteria

The process of translation

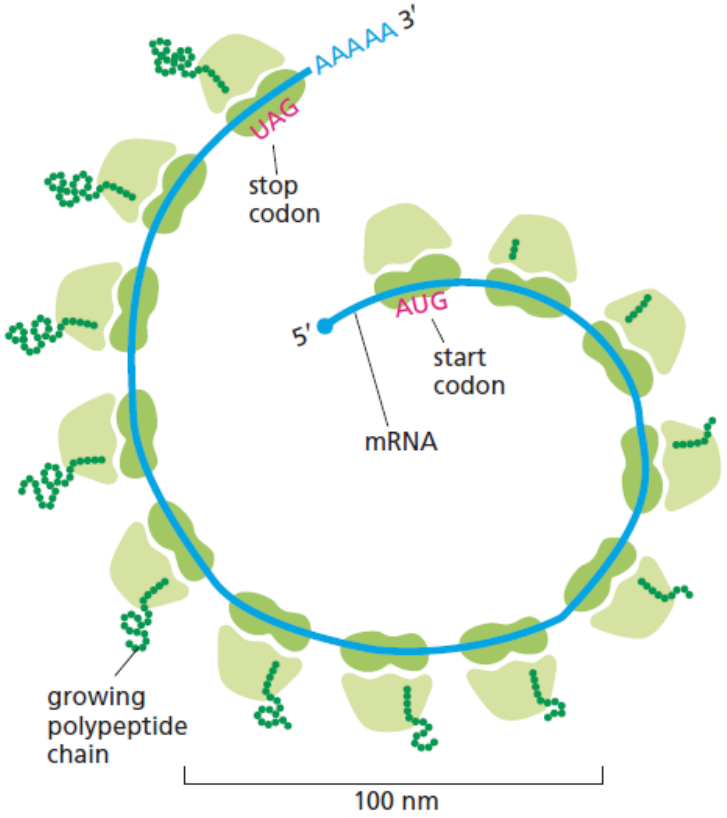


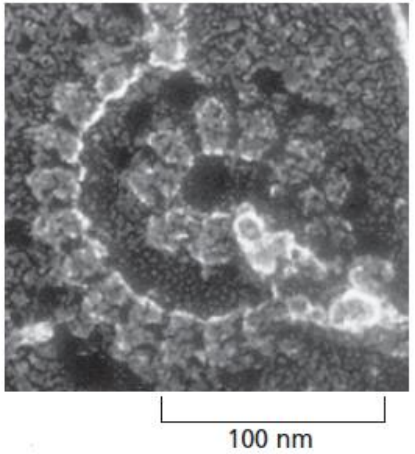
Termination of protein synthesis and Post-translational modification



Polyribosomes/Polysomes

- The synthesis of most protein molecules takes between 20 seconds and several minutes.
- Multiple ribosomes usually bind to each mRNA molecule being translated.
- With multiple ribosomes working simultaneously on a single mRNA, many more protein molecules can be made in a given time than would be possible if each polypeptide had to be completed before the next could be started.

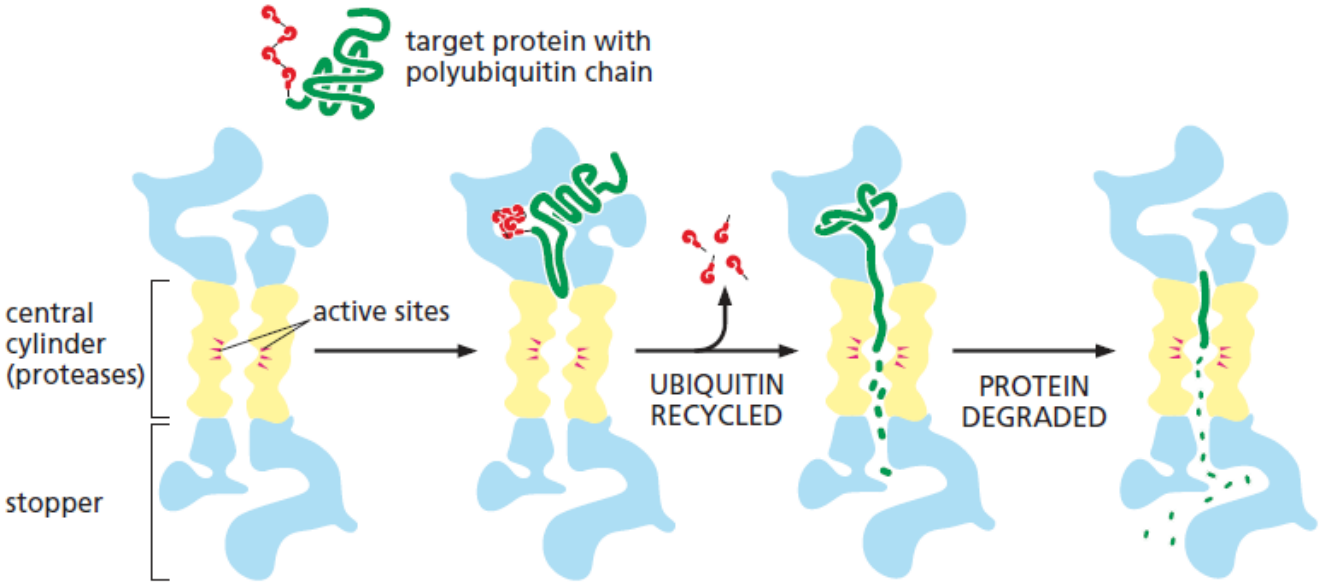




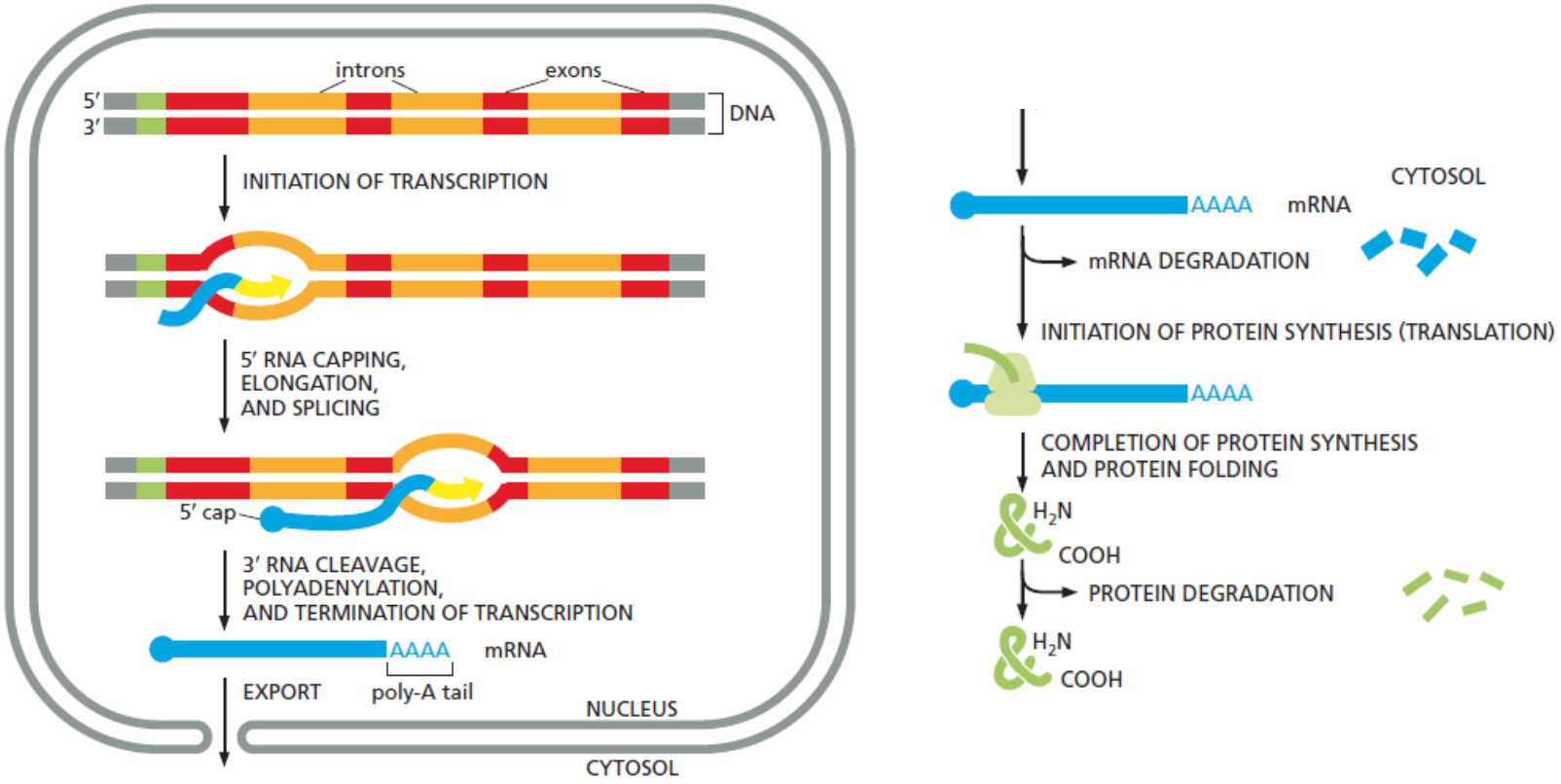
Antibiotics: Inhibitors of Prokaryotic Protein Synthesis

ANTIBIOTICS THAT INHIBIT BACTERIAL PROTEIN OR RNA SYNTHESIS	
Antibiotic	**Specific Effect**
Tetracycline	blocks binding of aminoacyl-tRNA to A site of ribosome
Streptomycin	prevents the transition from initiation complex to chain elongation also causes miscoding
Chloramphenicol	blocks the peptidyl transferase reaction on ribosomes
Cycloheximide	blocks the translocation reaction on ribosomes
Rifamycin	blocks initiation of transcription by binding to RNA polymerase

Protein degradation by Proteosomes



Translational summary



Post translational modifications

Many proteins require various modifications to become fully functional.