

# ***Nucleic Acid Structure & Function***

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# THE CHEMICAL NATURE OF RNA DIFFERS FROM THAT OF DNA

**Ribonucleic acid (RNA) is a polymer of purine and pyrimidine ribonucleotides linked together by 3', 5'-phosphodiester bridges analogous to those in DNA. Although sharing many features with DNA, RNA possesses several specific differences:**

- (1) In RNA, the sugar moiety to which the phosphates and purine and pyrimidine bases are attached is ribose rather than the 2'-deoxyribose of DNA.**
- (2) The pyrimidine components of RNA differ from those of DNA. Although RNA contains the ribonucleotides of adenine, guanine, and cytosine, it does not possess thymine except in the rare case mentioned below. Instead of thymine, RNA contains the ribonucleotide of uracil.**
- (3) RNA exists as a single strand, whereas DNA exists as a double-stranded helical molecule. However, given the proper complementary base sequence with opposite polarity, the single strand of RNA is capable of folding back on itself like a hairpin and thus acquiring double stranded characteristics.**
- (4) Since the RNA molecule is a single strand complementary to only one of the two strands of a gene, its guanine content does not necessarily equal its cytosine content, nor does its adenine content necessarily equal its uracil content.**
- (5) RNA can be hydrolyzed by alkali to 2',3' cyclic diesters of the mononucleotides, compounds that cannot be formed from alkali-treated DNA because of the absence of a 2'-hydroxyl group. The alkali lability of RNA is useful both diagnostically and analytically.**

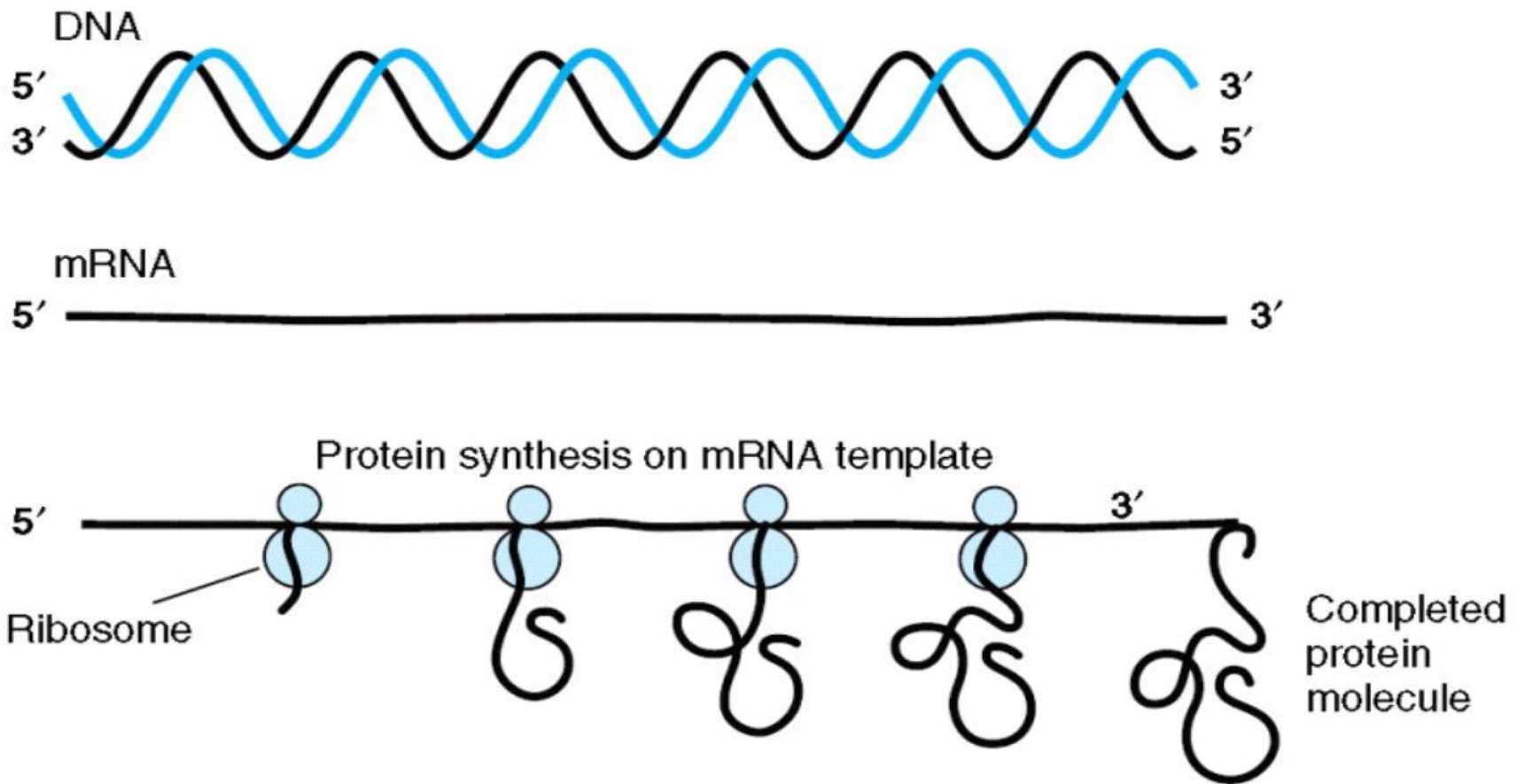
**Those cytoplasmic RNA molecules that serve as templates for protein synthesis (ie, that transfer genetic information from DNA to the protein-synthesizing machinery) are designated messenger RNAs, or mRNAs.**

**Many other cytoplasmic RNA molecules (ribosomal RNAs; rRNAs) have structural roles wherein they contribute to the formation and function of ribosomes (the organellar machinery for protein synthesis) or serve as adapter molecules (transfer RNAs; tRNAs) for the translation of RNA information into specific sequences of polymerized amino acids.**

**Some RNA molecules have intrinsic catalytic activity. The activity of these ribozymes often involves the cleavage of a nucleic acid. An example is the role of RNA in catalyzing the processing of the primary transcript of a gene into mature messenger RNA.**

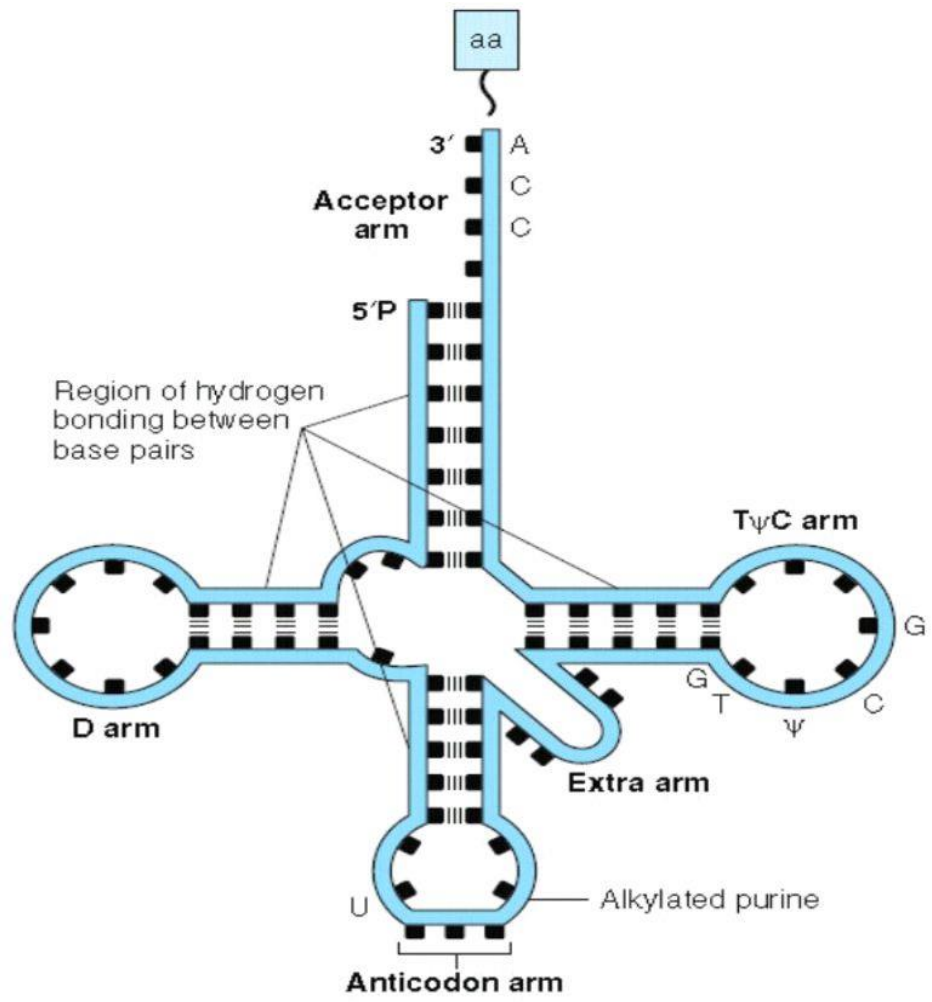
## **A. MESSENGER RNA (mRNA)**

**This class is the most heterogeneous in size and stability. All members of the class function as messengers conveying the information in a gene to the protein synthesizing machinery, where each serves as a template on which a specific sequence of amino acids is polymerized to form a specific protein molecule, the ultimate gene product.**

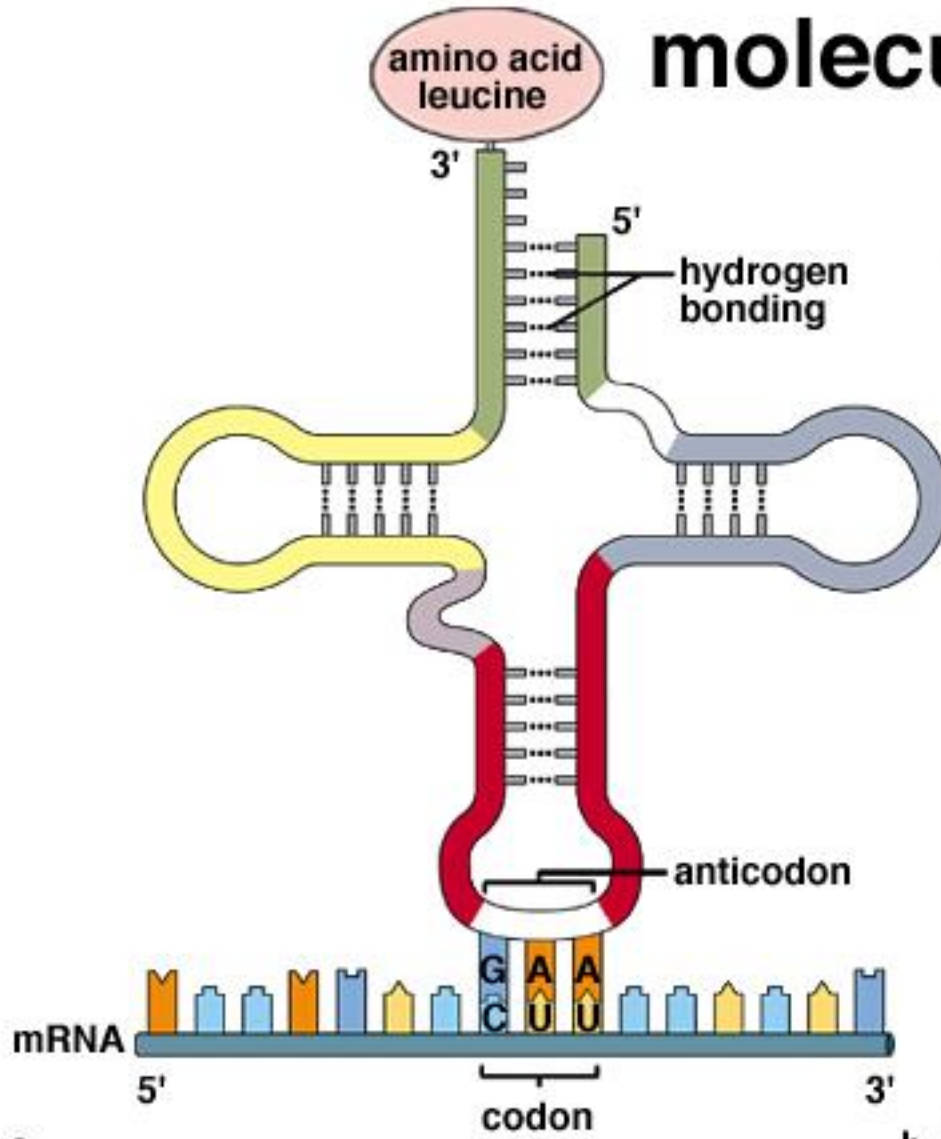


## **B. TRANSFER RNA (tRNA)**

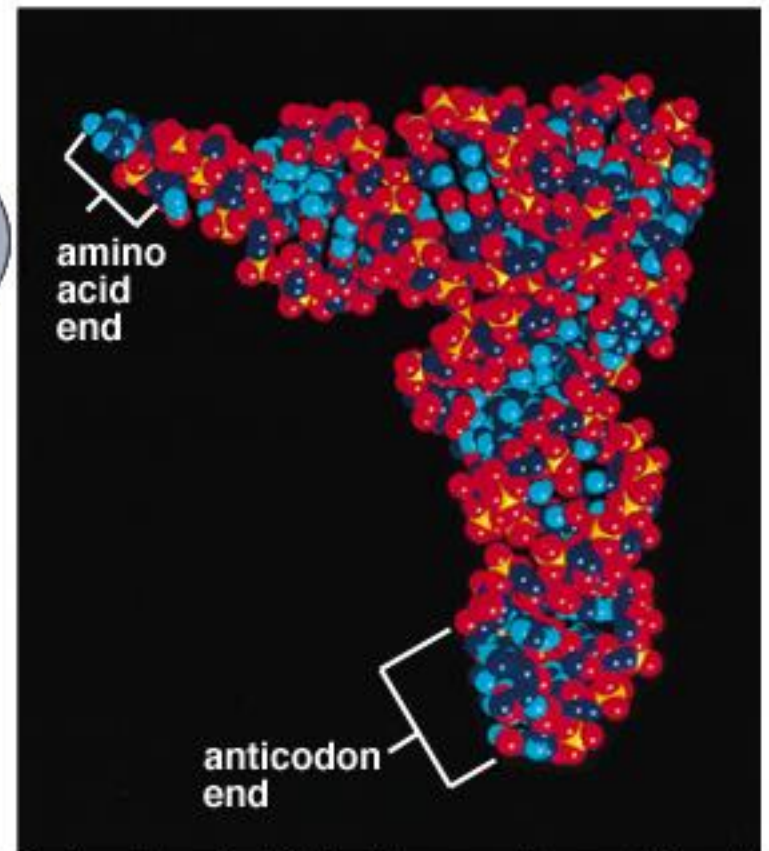
**tRNA molecules vary in length from 74 to 95 nucleotides. They also are generated by nuclear processing of a precursor molecule. The tRNA molecules serve as adapters for the translation of the information in the sequence of nucleotides of the mRNA into specific amino acids. There are at least 20 species of tRNA molecules in every cell, at least one (and often several) corresponding to each of the 20 amino acids required for protein synthesis. Although each specific tRNA differs from the others in its sequence of nucleotides, the tRNA molecules as a class have many features in common. The primary structure—ie, the nucleotide sequence—of all tRNA molecules allows extensive folding and intrastrand complementarity to generate a secondary structure that appears like a cloverleaf.**



# Structure of a transfer RNA (tRNA) molecule



a.



b. Courtesy University of California Lawrence Livermore National Library and the U.S. Department of Energy



### **C. RIBOSOMAL RNA (RRNA)**

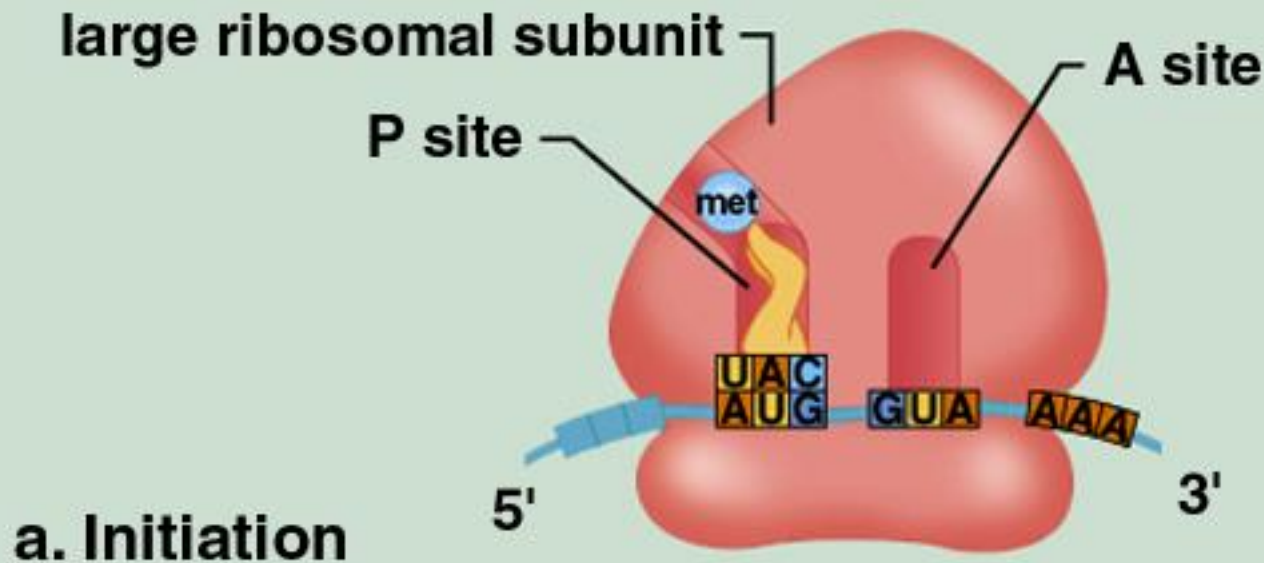
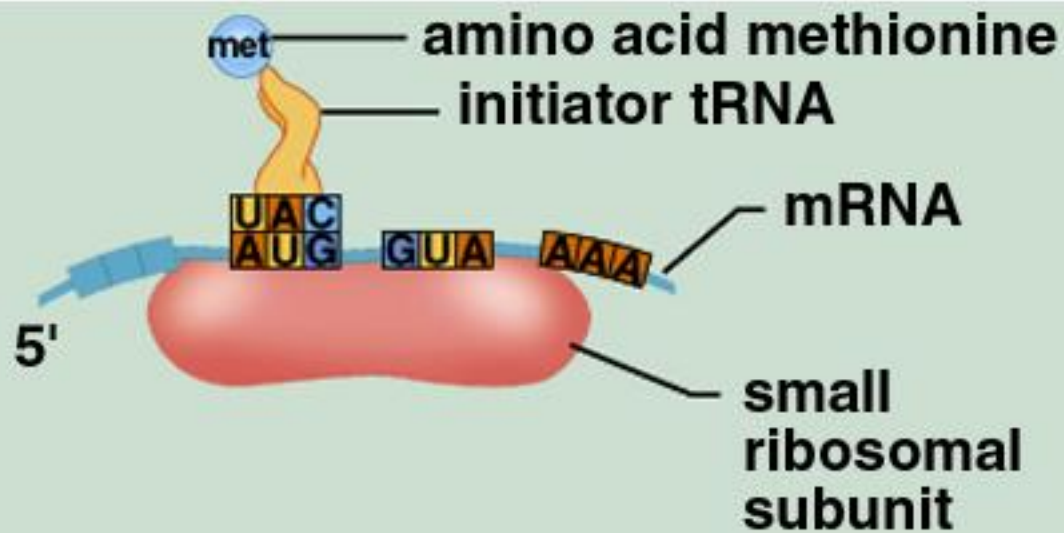
**A ribosome is a cytoplasmic nucleoprotein structure that acts as the machinery for the synthesis of proteins from the mRNA templates. On the ribosomes, the mRNA and tRNA molecules interact to translate into specific protein molecule information transcribed from the gene. In active protein synthesis, many ribosomes are associated with an mRNA molecule in an assembly called the polysome.**

**The components of the mammalian ribosome, which has a molecular weight of about  $4.2 \times 10^6$  and a sedimentation velocity of 80S (Svedberg units). The mammalian ribosome contains two major nucleoprotein subunits—a larger one with a molecular weight of  $2.8 \times 10^6$  (60S) and a smaller subunit with a molecular weight of  $1.4 \times 10^6$  (40S). The 60S subunit contains a 5S ribosomal RNA (rRNA), a 5.8S rRNA, and a 28S rRNA; there are also probably more than 50 specific polypeptides. The 40S subunit is smaller and contains a single 18S rRNA and approximately 30 distinct polypeptide chains.**

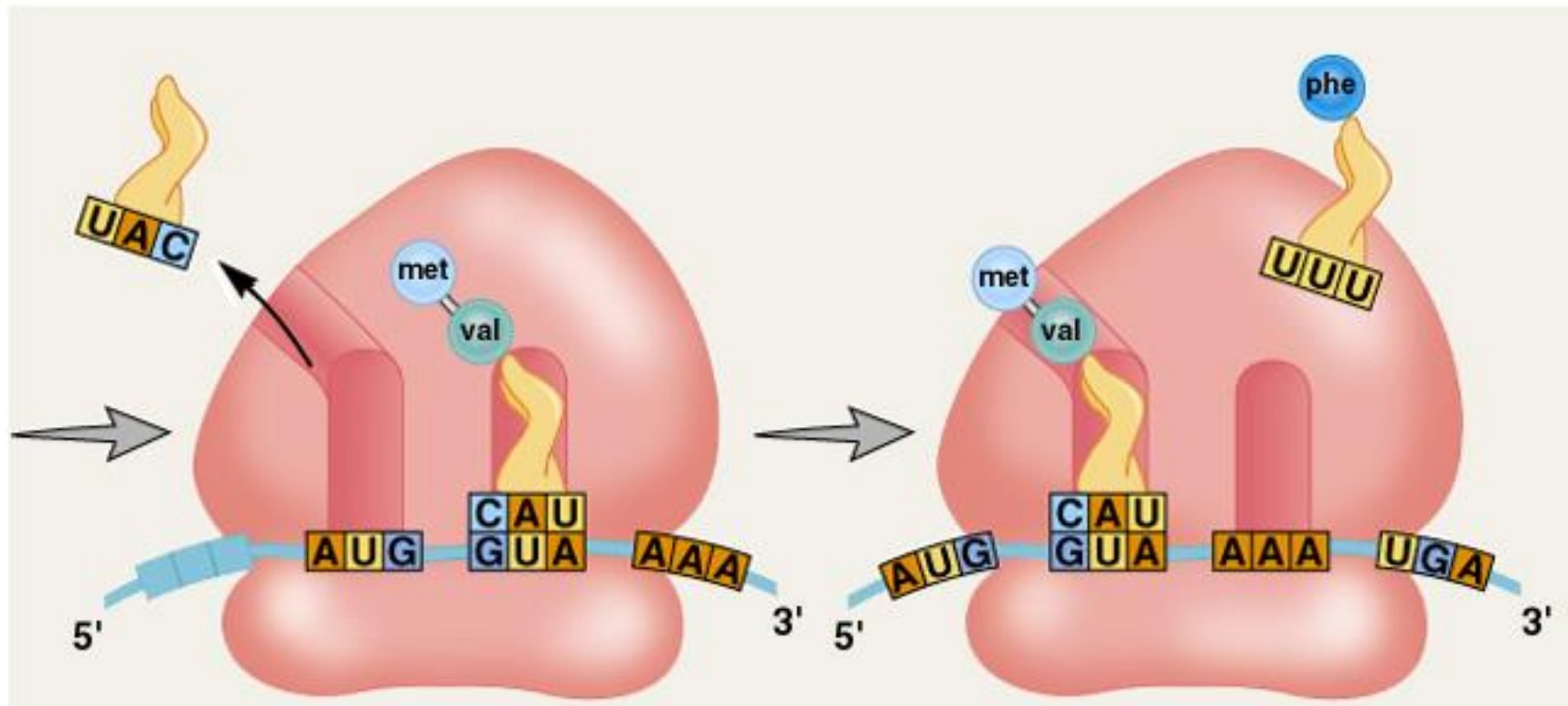
## **D. SMALL STABLE RNA**

**A large number of discrete highly conserved, and small stable RNA species are found in eukaryotic cells. The majority of these molecules are complexed with proteins to form ribonucleoproteins and are distributed in the nucleus, in the cytoplasm, or in both. They range in size from 90 to 300 nucleotides and are present in 100,000–1,000,000 copies per cell. Small nuclear RNAs (snRNAs), a subset of these RNAs, are significantly involved in mRNA processing and gene regulation. Of the several snRNAs, U1, U2, U4, U5, and U6 are involved in intron removal and the processing of hnRNA into mRNA.**

# Protein synthesis — chain initiation (1)



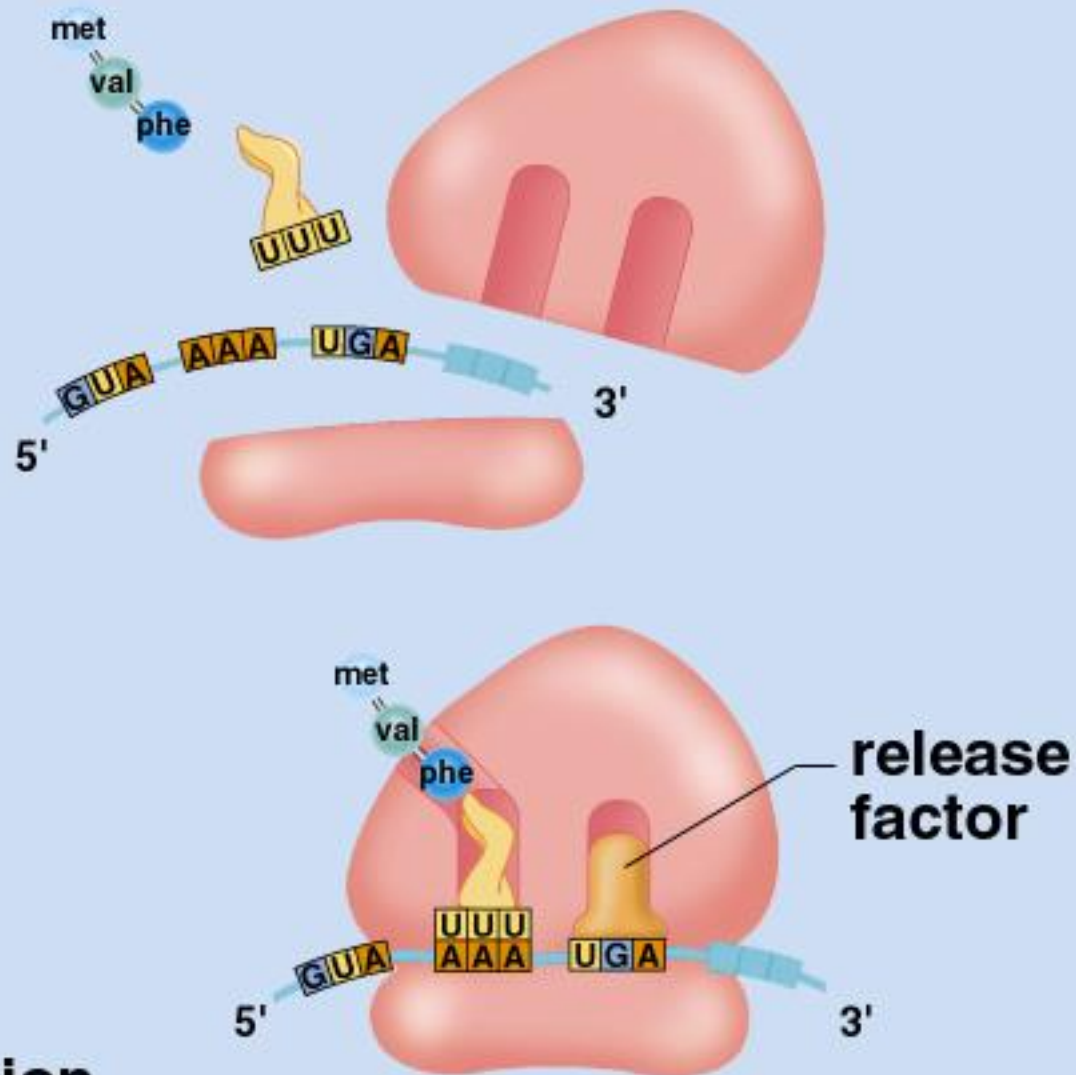
# Protein synthesis — chain elongation (3)



5. As tRNA leaves the P site, its amino acid is passed to tRNA-amino acid at the A site.

6. The ribosome has moved forward, making room for the next tRNA-amino acid at the A site.

# Protein synthesis — chain termination (4)



c. Termination

Any Questions