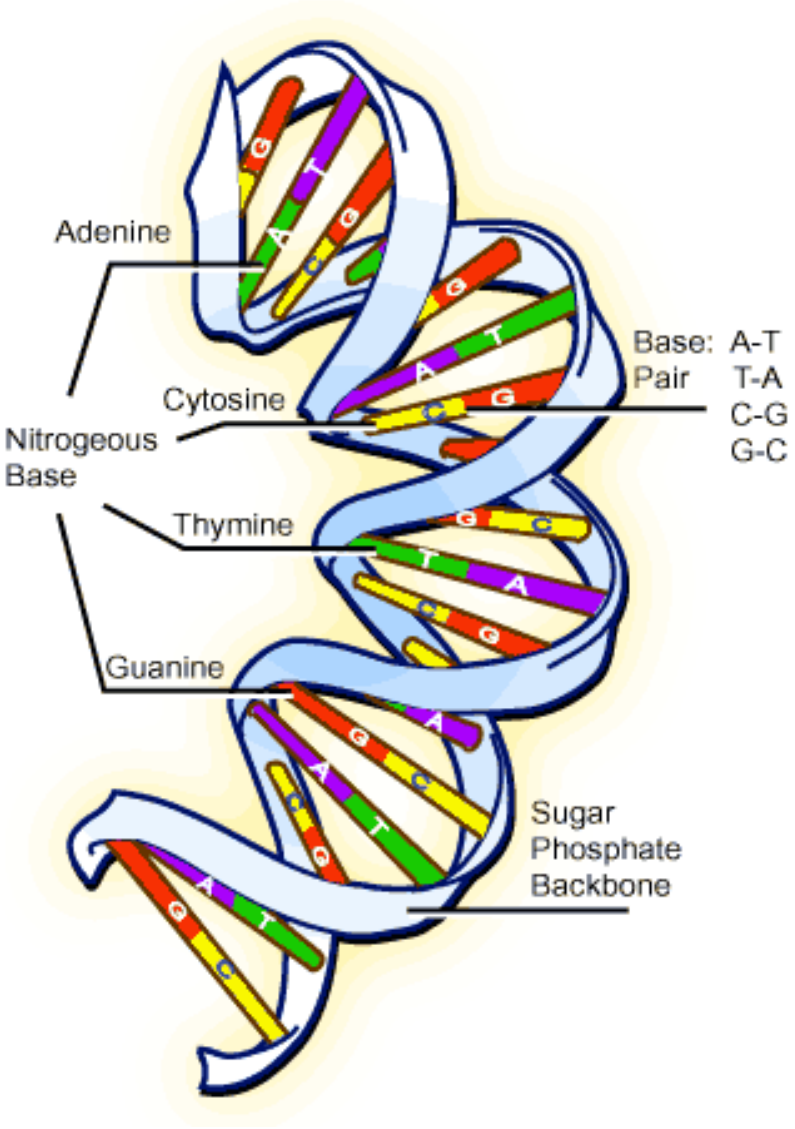
Protein Synthesis

DNA

- Sides: alternating deoxyribose and phosphates
- Nitrogenous base pairs: A-T and G-C
- The order of nitrogenous bases codes for specific proteins
- These codes are found within the genes on the DNA



RNA

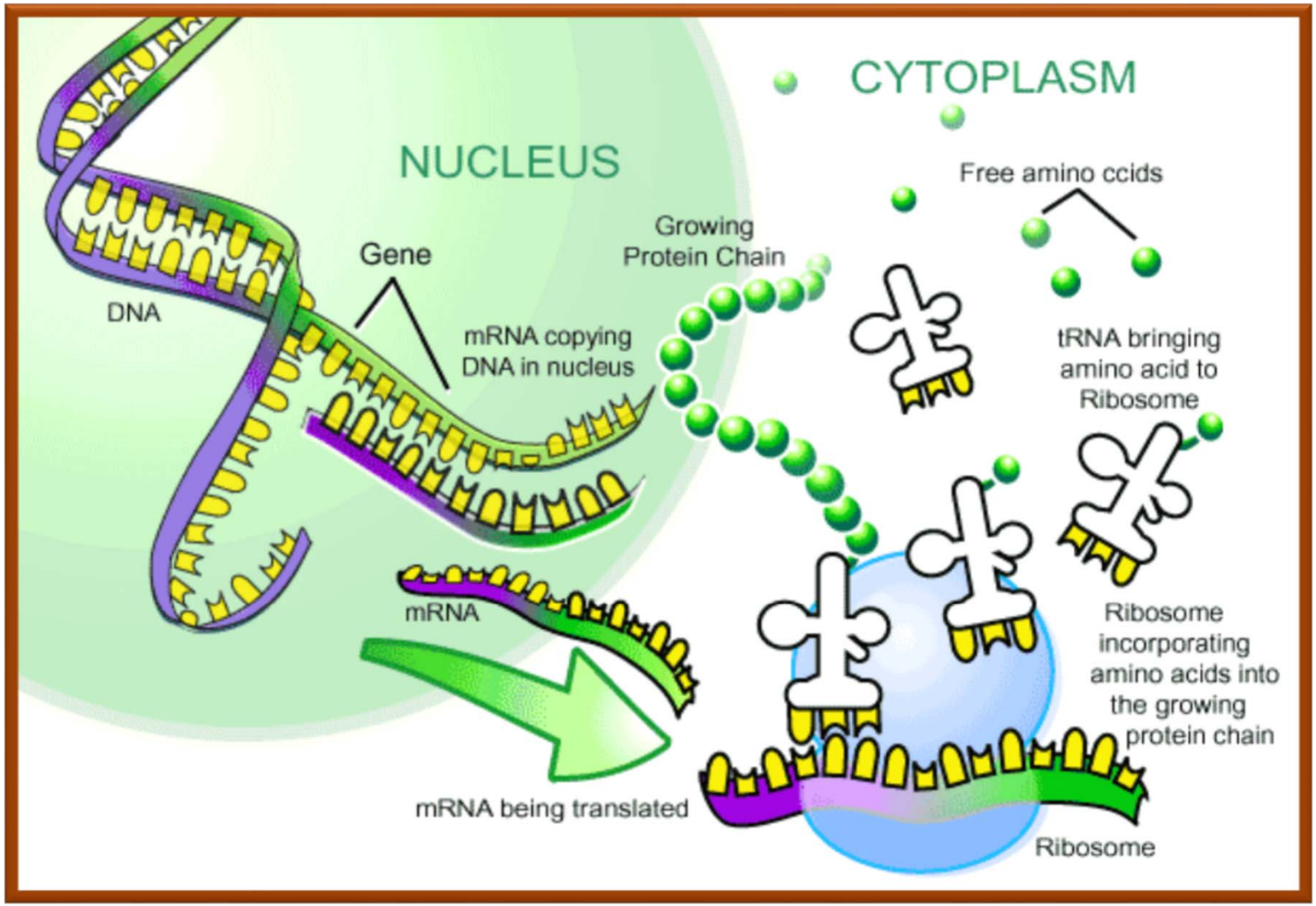
Types of RNA	Characteristics and key functions
messenger RNA (mRNA)	• varies in length, depending on the gene that has been copied • acts as the intermediary between DNA and the ribosomes • translated into protein by ribosomes • RNA version of the gene encoded by DNA
transfer RNA (tRNA)	• functions as the delivery system of amino acids to ribosomes as they synthesize proteins • very short, only 70–90 base pairs long
ribosomal RNA (rRNA)	• binds with proteins to form the ribosomes • varies in length

RNA is single stranded, has a ribose sugar instead of the deoxyribose found in DNA, and when nitrogenous bases join: guanine joins with cytosine but adenine joins with a different base called URACIL. (G-C and A-U)

Protein Synthesis

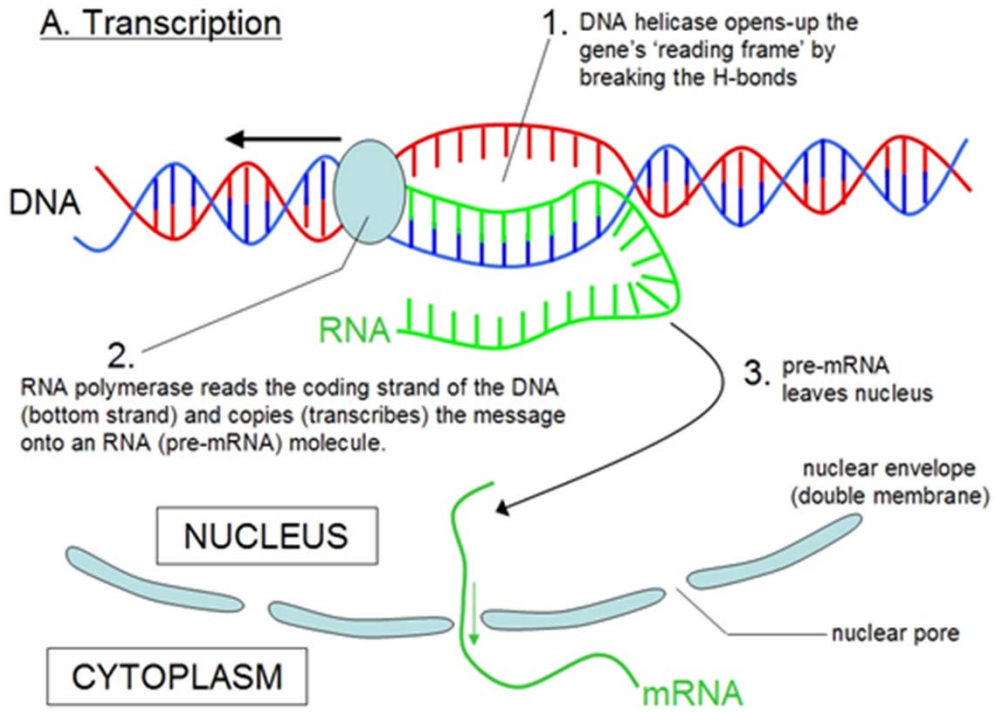
- **In order to assemble a polypeptide chain in order to make a specific protein, the gene's DNA code (sequence of nitrogenous bases) must be copied and carried to the ribosomes in the cytoplasm.**
- **The first step in this process: Transcription**
  - ✓ Transcription is the process by which the information in a strand of DNA is copied into a new molecule of messenger RNA (mRNA).
  - ✓ DNA safely and stably stores genetic material in the nuclei of cells as a reference, or ***template.***
  - ✓ **mRNA** is comparable to a copy from a reference book because it carries the same information as DNA but is not used for long-term storage and **can freely exit the nucleus**.
  - ✓ mRNA contains the same information as the DNA code, but it is not an identical copy of the DNA segment, because **the mRNA sequence is complementary to the DNA template.**

Overview: Protein Synthesis



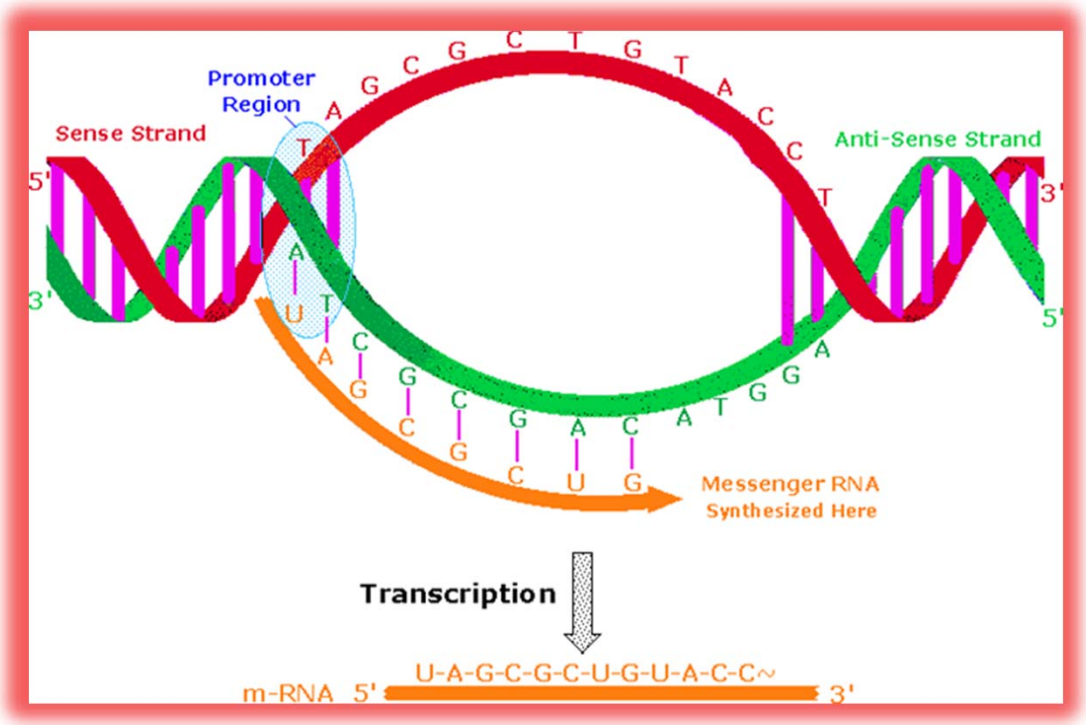
TRANSCRIPTION OF DNA

- Takes place in the nucleus of the cell.
- DNA Helicase opens up the DNA reading frame at the gene to be transcribed by breaking the H bonds between nitrogenous bases.
- RNA polymerase (enzyme) binds to a region of DNA called a PROMOTER. Promoters have specific base sequences signal the RNA polymerase where to start transcription.



TRANSCRIPTION (CONT'D)

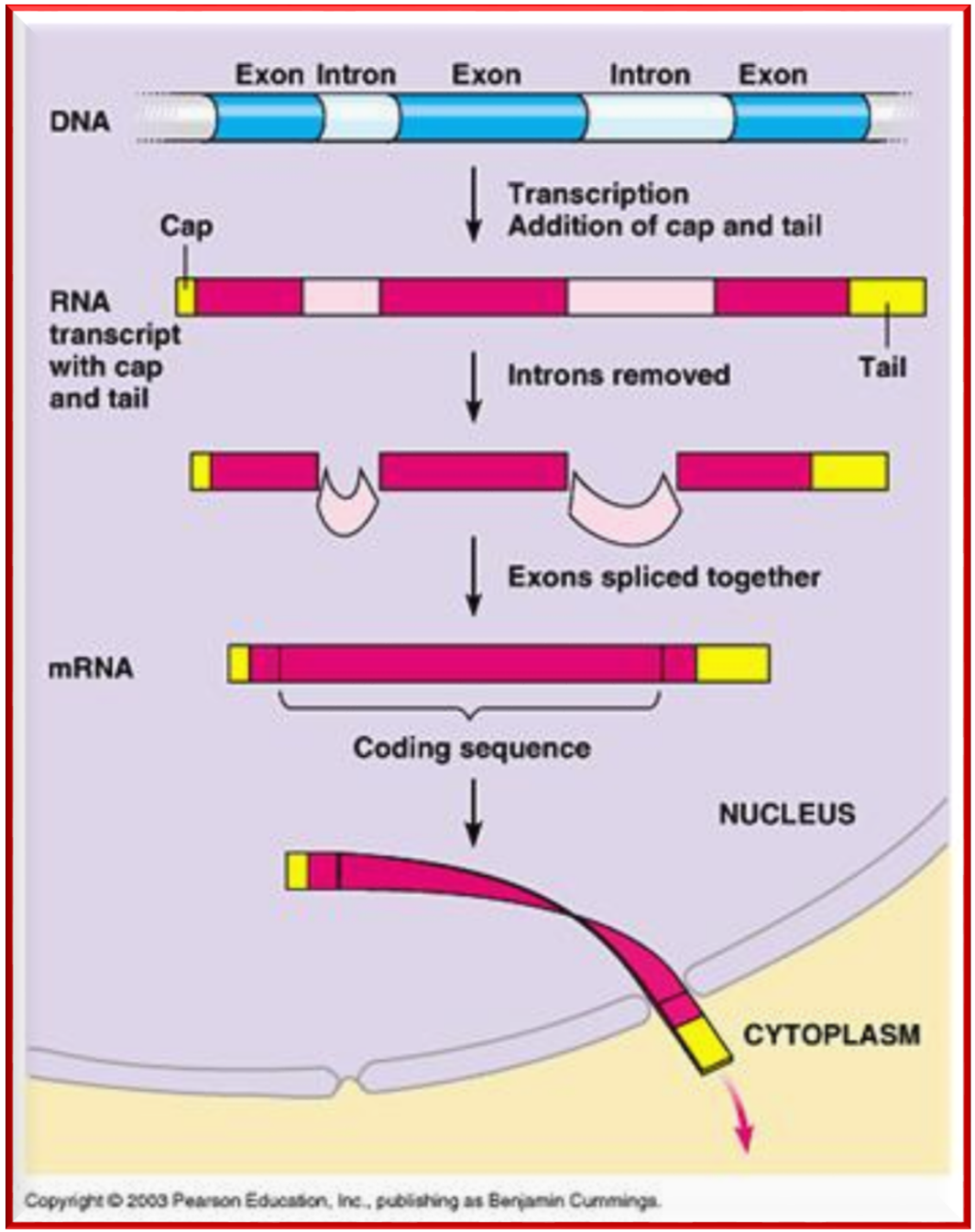
- ***RNA polymerase uses only 1 DNA strand as a TEMPLATE to synthesize mRNA.***
- **Free-floating mRNA nucleotides in the nucleus join up with the DNA template bases in a complimentary fashion.**



mRNA Editing

- mRNA may require some editing before it can leave the nucleus and travel to a ribosome.
- **Introns** (intervening RNA nucleotide noncoding sequences) that are ***NOT*** needed to make the polypeptide are cut out of the mRNA molecule before it leaves the nucleus.
- **Exons** (the remaining sections of mRA) are spliced together. A cap and a tail are added to the ends to form the final mRNA molecule.
- The mRNA molecule leaves the nucleus via a nuclear pore and attaches to a ribosome.
- **A ribosome is made up of protein and rRNA.**

Introns and Exons



- After transcription occurs and the mRNA molecule is made, a **cap and tail** are added to the molecule and the **introns are removed.**
- **The exons are spliced together.**
- The mature mRNA molecule can now leave the nucleus via a nuclear pore and travel to a ribosome so that the polypeptide can be assembled.

CODONS

- The genetic code on the mRNA is "read" in 3 base sequences (triplets) known as **CODONS.**
- **Each codon names a particular amino acid.**
- For example:
  - ✓ **UCACACGGU is read as 3 separate codons…**

UCG - CAC - GGU

Serine-Histidine-Glycine

- There are **64** possible three base codons. Some amino acids may be specified by more than one codon.
- Codons also may code for the **START or STOP** of protein synthesis at the ribosome.

Deciphering mRNA Codons

How many amino acids are named in the mRNA molecule?

mRNA: AUAGUAUGGCGCGACCUUGAGUGA

1. Divide mRNA into codons

AUA/GUA/UGG/CGC/GAC/CUU/GAG/UGA

How do we find out what amino acids are needed to synthesize the polypeptide coded in the above mRNA molecule?

2. First let's learn how to use the mRNA Codon Chart

- ✓ Using codon **GGU** as an example:
  - -- Find the **G on the left side of the chart.**
  - -- Then find the **second G on the top of the chart.**
  - -- Finally find the **third base, U on the right side of the chart.**
  - --The point where they intersect names the amino acid, in this case, **Gly**.

3. Now find the amino acids named in the mRNA molecule above.

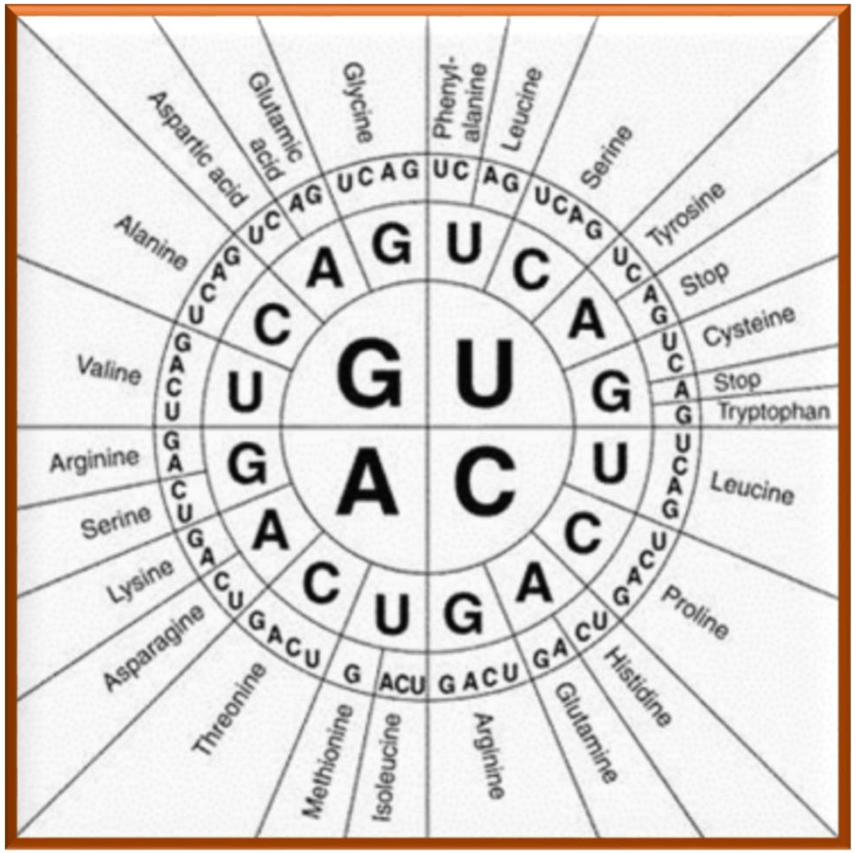
Codons Found in Messenger RNA

First Base	Second Base: U	Second Base: C	Second Base: A	Second Base: G	Third Base
U	Phe	Ser	Tyr	Cys	U
	Phe	Ser	Tyr	Cys	C
	Leu	Ser	Stop	Stop	A
	Leu	Ser	Stop	Trp	G
C	Leu	Pro	His	Arg	U
	Leu	Pro	His	Arg	C
	Leu	Pro	Gln	Arg	A
	Leu	Pro	Gln	Arg	G
A	Ile	Thr	Asn	Ser	U
	Ile	Thr	Asn	Ser	C
	Ile	Thr	Lys	Arg	A
	Met	Thr	Lys	Arg	G
G	Val	Ala	Asp	Gly	U
	Val	Ala	Asp	Gly	C
	Val	Ala	Glu	Gly	A
	Val	Ala	Glu	Gly	G

Ile-Val-Trp-Arg-Asp-Leu- Glu-STOP

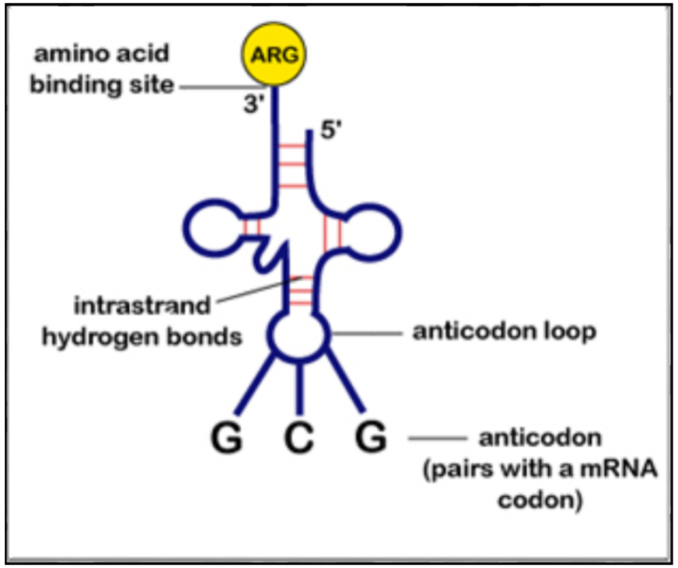
MRNA CODON CHARTS

- There are other charts that are used to identify amino acids named in mRNA codon molecules.
- Using the chart below, identify the amino acid named by the mRNA codon **UUG.**



tRNA (transfer RNA)

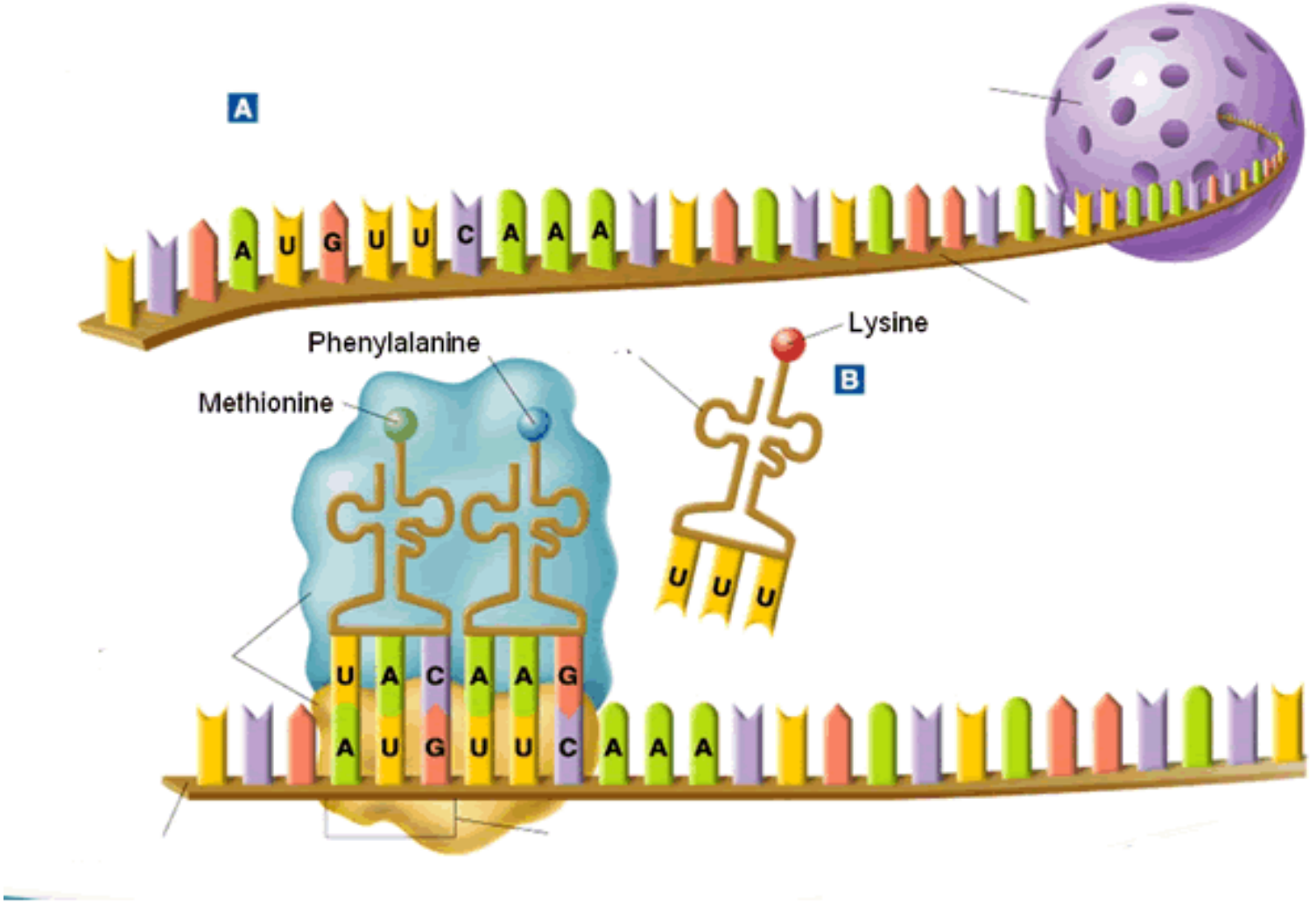
- There are tRNA molecules present in the cytoplasm.
- Each tRNA molecule has an **ANTICODON** (***a triplet of three nitrogenous bases that are complimentary to one of the codons)*** at one end and the amino acid it names at the other end.
- **The anticodon is the same base sequence that is found in the DNA!**



Steps of Translation

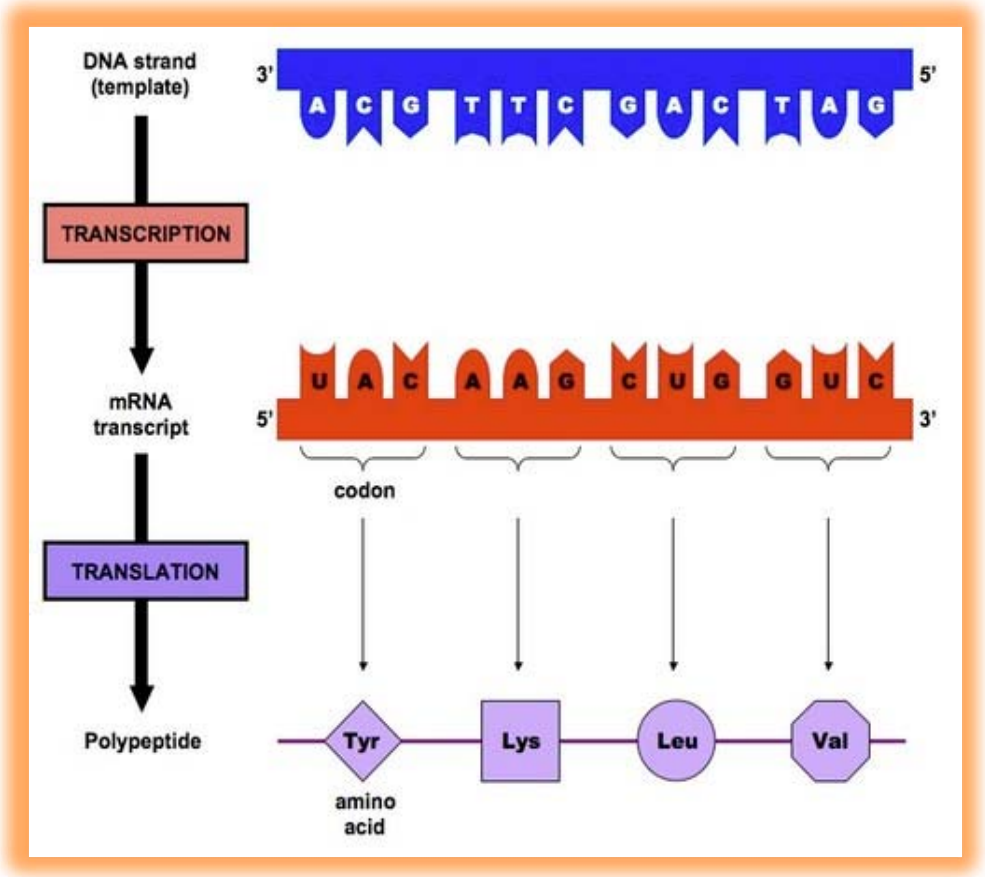
- mRNA leaves the nucleus via a nuclear pore and attaches to a ribosome in the cytoplasm.
- As the mRNA molecule moves along the ribosome, each codon is "read" or transcribed.
- The tRNA is joined to the mRNA – anticodon to codon.
- The ribosome breaks the bond between the amino acid and the tRNA.
- The amino acid is joined in sequence to the next amino acid by the ribosome until a stop codon is reached.
- The polypeptide chain detaches itself from the ribosome.

Translation of mRNA

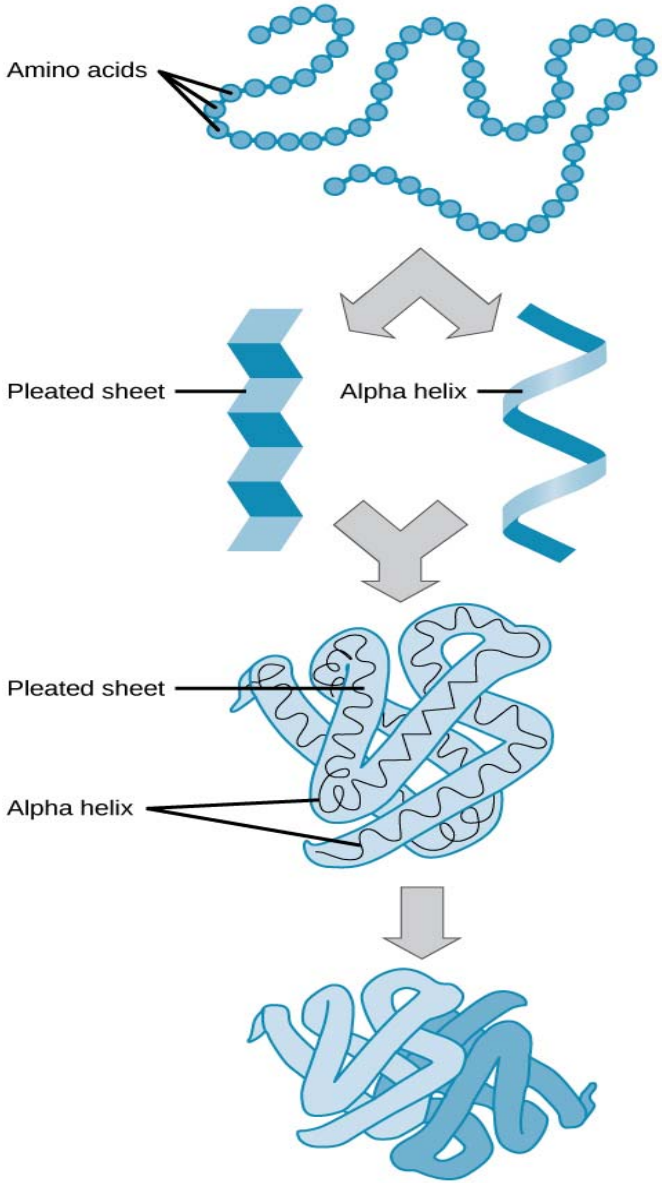


One Gene One Polypeptide

- Each gene controls the synthesis of a single polypeptide.
- Some proteins are made up of a single polypeptide chain, while others consist of two or more polypeptides.
- **MORE THAN ONE GENE MAY CONTROL the synthesis of a single protein.**



Making of a Protein



Primary Protein structure
sequence of a chain of animo acids

Secondary Protein structure
hydrogen bonding of the peptide backbone causes the amino acids to fold into a repeating pattern

Tertiary protein structure
three-dimensional folding pattern of a protein due to side chain interactions

Quaternary protein structure
protein consisting of more than one amino acid chain