Protein Synthesis

As you know, DNA carries the code for the synthesis of proteins. The code resides in the order of nitrogenous bases found in each gene on a given chromosome. When the cell needs to synthesize a protein, how does the code get from the DNA (inside the nucleus) to the ribosomes (in the cytoplasm?

Quick Review

RNA (ribonucleic Acid)

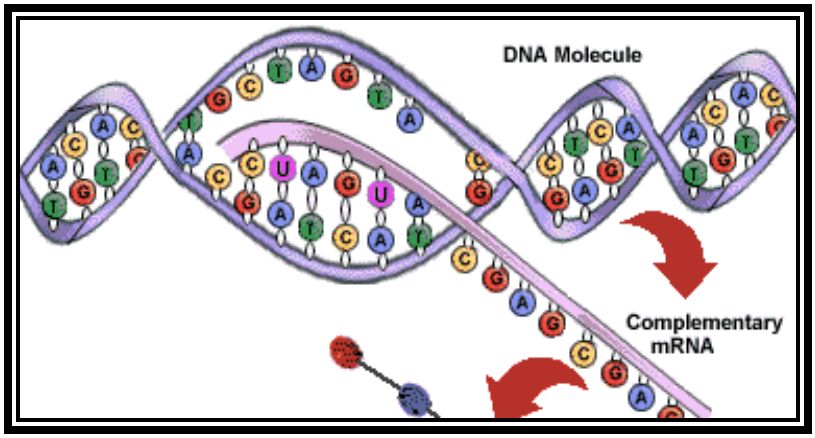
- Single stranded
- Contains ribose sugar
- Contains Uracil (U) instead of Thymine (T) as the nitrogenous base that matches up to Adenine (A).
- **There are three types of RNA.** They include:
  --messenger RNA (mRNA)
  --ribosomal RNA (rRNA)
  --transfer RNA (tRNA)

The Process of 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. This first step in this process is called **TRANSCRIPTION.**

Step 1: Transcription

a. RNA polymerase then separates the two strands of DNA of the gene that is to be copied.
b. RNA polymerase uses only 1 DNA strand as a **TEMPLATE** to synthesize mRNA.
c. Free-floating mRNA nucleotides in the nucleus join up with the DNA template bases in a complimentary fashion. (remember that **Uracil binds with the DNA adenine base**).



In this diagram, RNA polymerase (not pictured) separates the two strands of DNA at the gene. One side of the DNA acts as template. mRNA nucleotides bind to the DNA strand to create a mRNA strand complimentary to the DNA template.

f. The mRNA molecule leaves the nucleus via a nuclear pore and attaches to a ribosome.
g. **A ribosome is made up of protein and rRNA.**

Questions:

1. Discuss the process of transcription and explain why it is necessary for protein synthesis to occur.
2. Describe the function of RNA polymerase in the process of translation.
3. Why is mRNA a compliment of the DNA template strand?

4. Imagine a gene has the following nitrogenous base sequence: GTAACCTAGGGCATT.
    a. Write the sequence of the complimentary DNA strand.
    b. Write the transcribed sequence of bases on the mRNA strand.
    c. Discuss the similarities and differences between the two strands (DNA compliment strand and mRNA strand).
5. When the mRNA molecule leaves the nucleus, where does it go?
6. Describe the composition of a ribosome.

Now that the mRNA strand is attached to the ribosome, the code it contains must be translated so that the proper amino acids can be joined in the right sequenced in the correct order.

Codons

a. The genetic code on the mRNA is "read" in 3 base sequences known as CODONS. Each codon names a particular amino acid. For example:

UCACACGGU is read as 3 separate codons…
UCG ~ CAC ~ GGU that represent the amino acids
Serine-Histidine-Glycine

b. There are 64 possible three base codons. Some amino acids may be specified by more than one codon.
c. Codons also may code for the start of stop of protein synthesis at the ribosome.

Questions:

7. Below is the sequence of bases found in an mRNA molecule. Rewrite this sequence putting a dash between each codon.

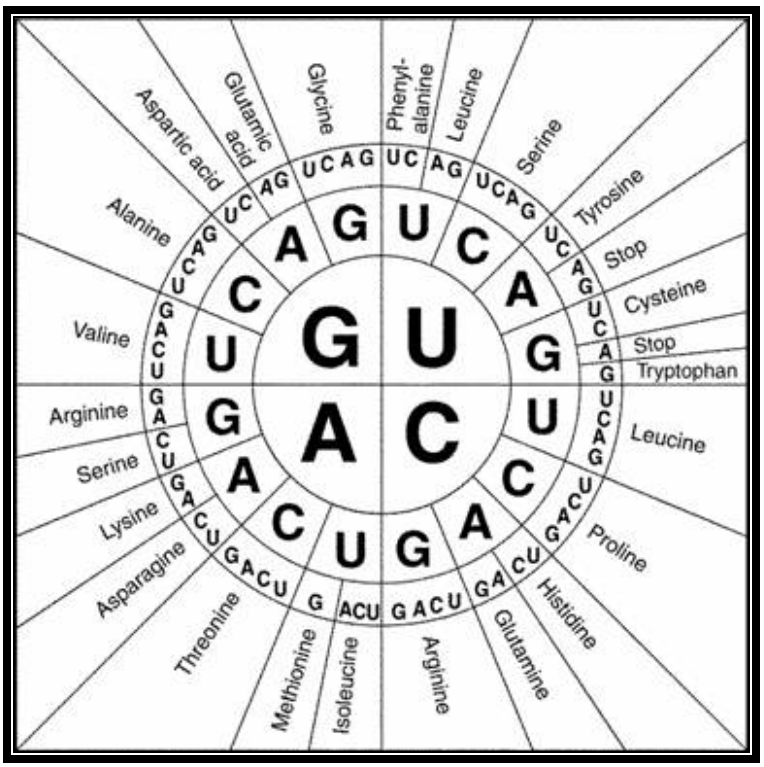
mRNA: AUAGUAUGGCGCGACCUUGAGUGA

8. How many amino acids are named in this mRNA molecule? Explain your answer.
9. The codon chart found below can be used to determine which amino acids are needed to assemble the polypeptide chain coded in the mRNA molecule above. Let's say we have the codon **GGU**. Find the G on the left side of the chart. Then find the 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**.

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

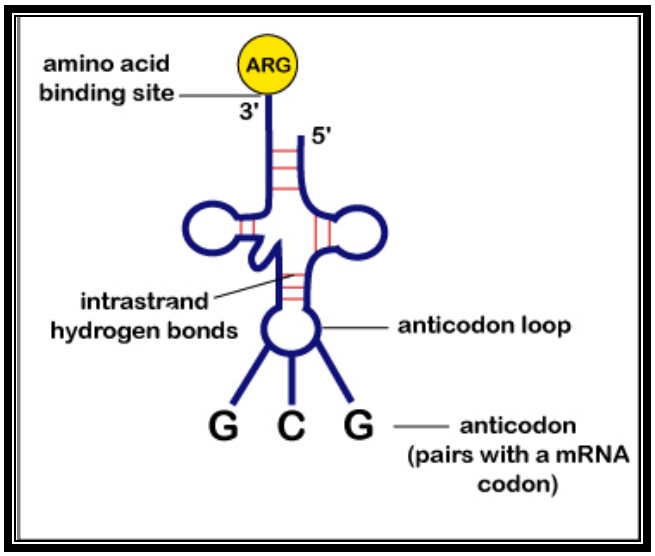
Another type of codon chart is sometimes used to aid in the identification of amino acids. In the circle codon chart below, identify the full name of GLY, the amino acid named by the codon GGU.



10. Using the mRNA strand found in question #8, write each codon and the amino acid it names on your paper.

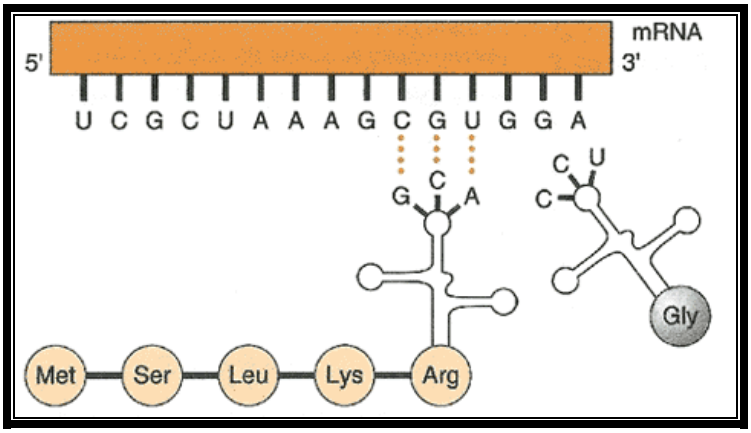
Step 2: Translation

a. mRNA binds to the ribosome.
b. 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!**



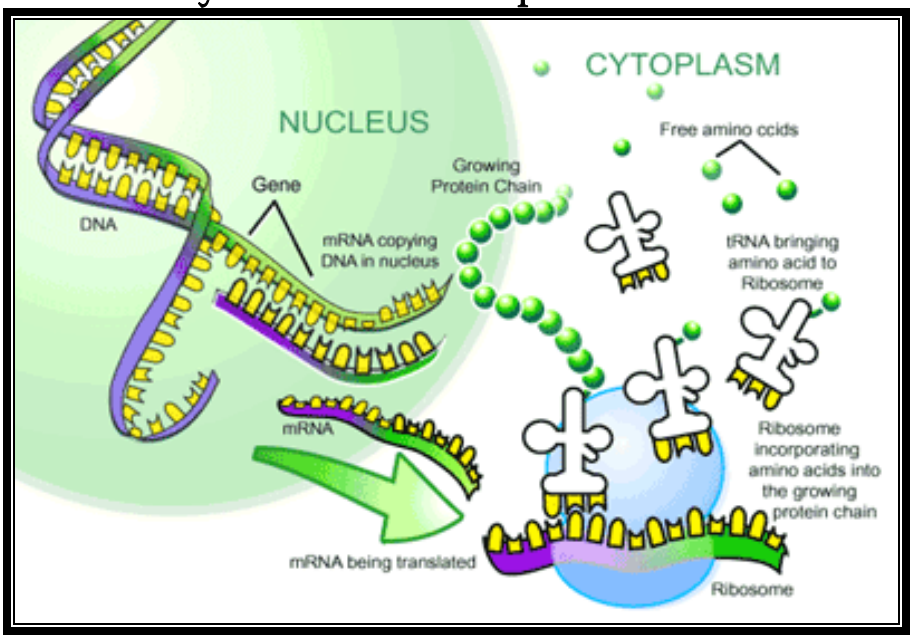
c. As the mRNA molecule moves along the ribosome, each codon is "read" or transcribed.

d. The tRNA is joined to the mRNA – anticodon to codon.
e. The ribosome breaks the bond between the amino acid and the tRNA.
f. The amino acid is joined in sequence to the next amino acid by the ribosome until a stop codon is reached.
g. The polypeptide chain detaches itself from the ribosome.



In this diagram, a section of mRNA is illustrated. Imagine this mRNA is attached to a ribosome. The anticodon on the tRNA (GCA) matches with the codon on the mRNA (CGU). Anticodon and codon join and the amino acid is attached to the growing polypeptide chain.

Protein Synthesis: Transcription and Translation



One Gene-One Polypeptide Hypothesis

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. Therefore, **MORE THAN ONE GENE MAY CONTROL the synthesis of a single protein.**

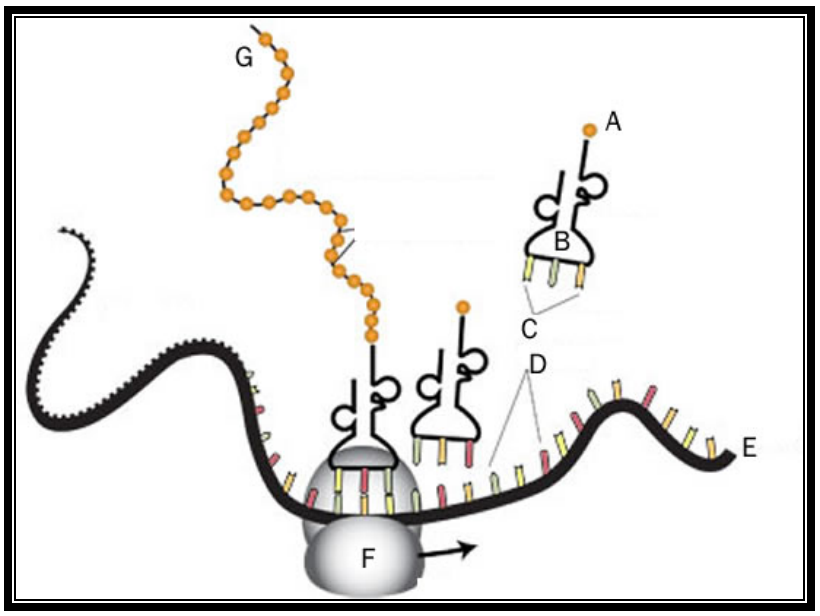
Making the Protein

Parts of the polypeptide chain may be attracted to and bond with other parts of the chain. One or more polypeptide chains may also join and bond together. The connections formed between and among different

parts of the polypeptide chains, causing the resulting molecule to fold and bend in a particular way. **The final folded 3-dimentional shape of the protein molecule determines its function within the cell.**

Questions:

11. Describe the function of each end of a tRNA molecule.
12. How do an anticodon and codon differ?
13. How does the anticodon compare to the original DNA triplet?
14. The diagram below illustrates the process of translation. Write the letter A-G on your paper, identify each labeled structure, and explain the function or purpose of each part.



15. If an mRNA molecule carries the following sequence: GUC-AAG-GCU-UAA, what anticodons would temporarily bind with mRNA codons?
16. List in sequence the amino acids that would be joined as a result of translation of this mRNA.
17. Name and describe the process are amino acids joined to form a polypeptide?
18. Explain the statement – "protein function is determined by its shape".
19. Discuss the one gene-one polypeptide hypothesis.