Transcription and Translation

TEKS

(6) Science concepts. The student knows the mechanisms of genetics, including the role of nucleic acids and the principles of Mendelian Genetics. The student is expected to:

(C) Explain the purpose and process of transcription and translation using models of DNA and RNA.

(D) Recognize that gene expression is a regulated process.

Vocabulary

- Ribonucleic acid (RNA)
- Transcription
- RNA Polymerase
- Complementary
- Uracil
- mRNA
- Codon
- Codon chart
- Translation
- rRNA
- tRNA
- Anticodon
- Amino Acid
- Polypeptide/Protein
- Protein Synthesis

Prerequisite Questions

1. How does DNA store our genetic information?

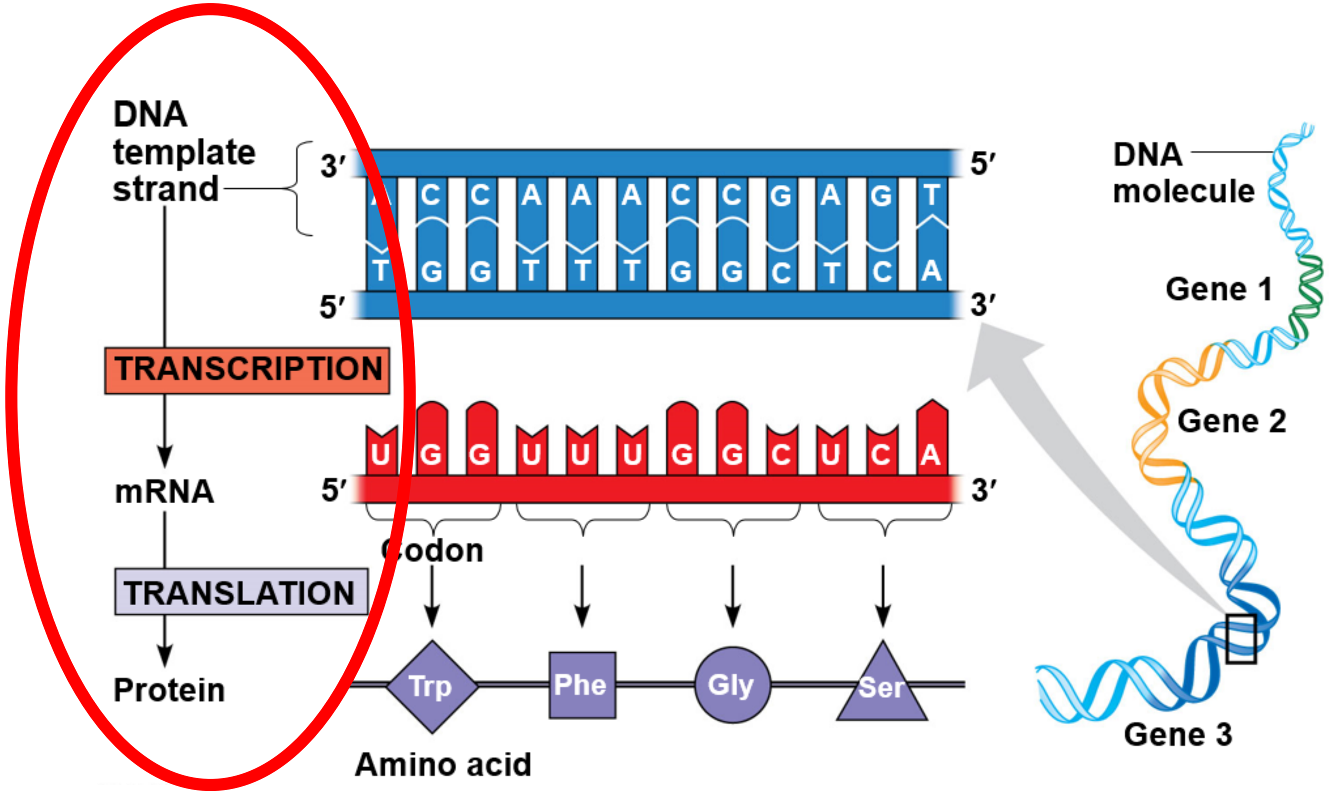
Essential Question

- How is RNA important in protein synthesis?

Central Dogma of Biology (Protein Synthesis)

- DNA is the genetic code for the making of proteins that are used for structure and enzymatic functions.

- DNA → RNA → Proteins



Kinds of Nucleic Acids

There are 2 kinds of nucleic acid

1. Deoxyribonucleic Acid (DNA)

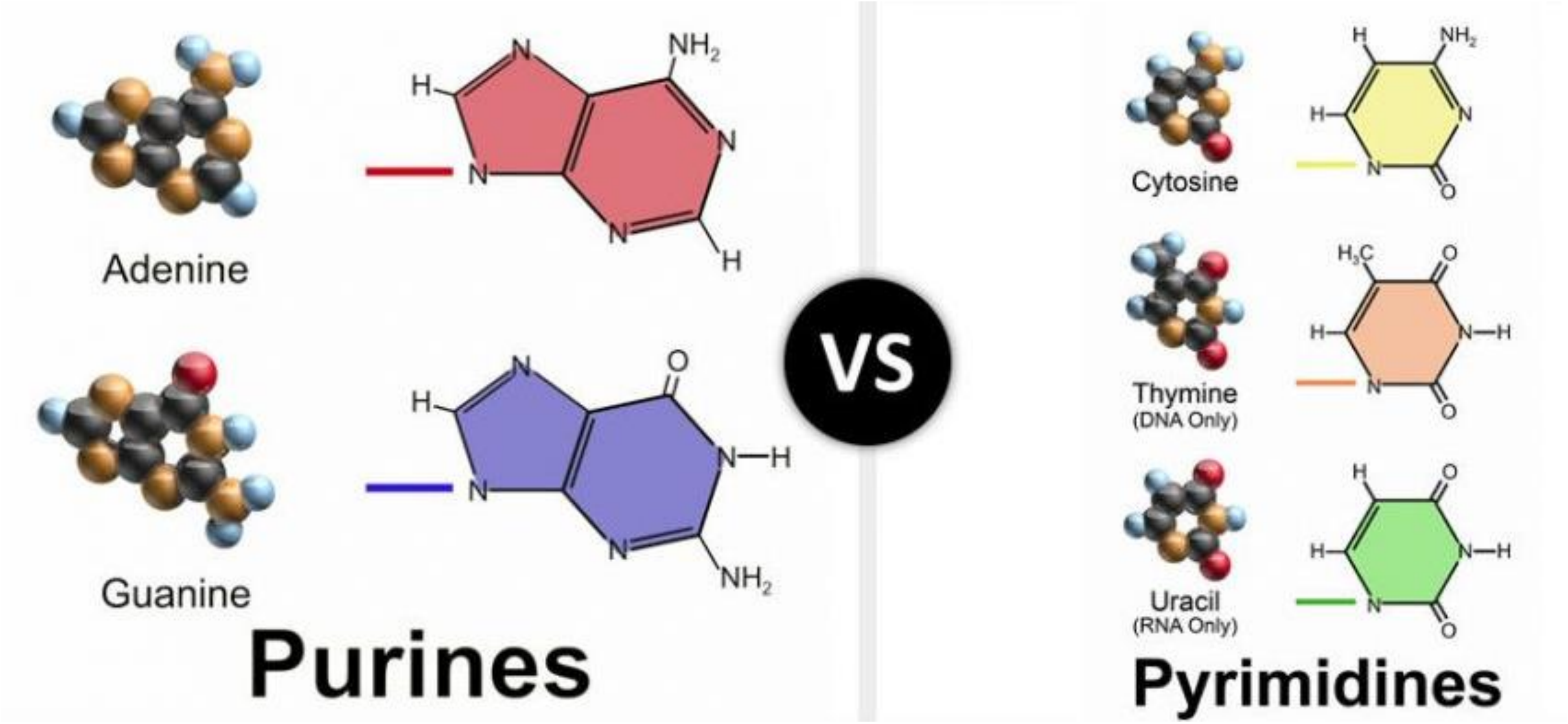
2. Ribonucleic Acid (RNA)
   a) mRNA
   b) rRNA
   c) tRNA

DNA vs RNA comparison

Characteristic	DNA	RNA
Monomer Name	Nucleotide	Nucleotide
Sugar	Deoxyribose	Ribose
Nitrogenous Bases	A, T, G, C	A, **U**, G, C
Location found in cell	Nucleus (Chromatin)	Nucleus (where its created) and cytosol/cytoplasm (Must leave the nucleus)
Function	Stores genetic information	1) Carries/transfers genetic info to ribosome 2) Used to build polypeptides in protein synthesis
Structure	Double stranded	Single stranded

5 different Nitrogenous Bases of Nucleotides

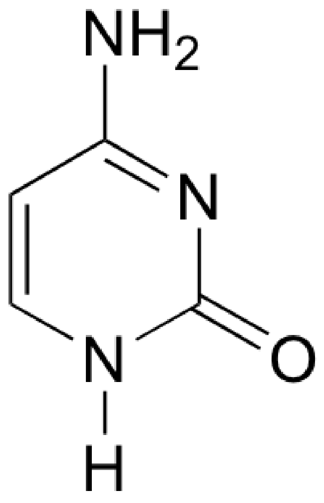
- The large bases are called Purines (Adenine & Guanine).
- The small bases are called Pyrimidines (Thymine, Cytosine and Uracil).



Uracil vs Thymine

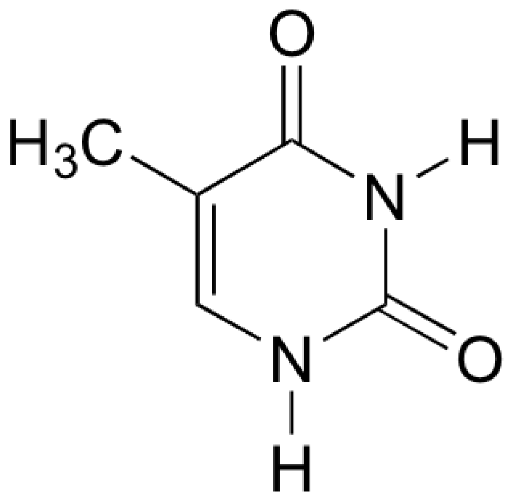
- RNA contains the nitrogenous base Uracil.

DNA and RNA



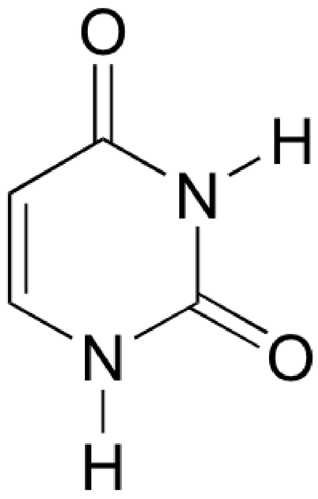
cytosine

DNA only



thymine

RNA only



uracil

Transcription

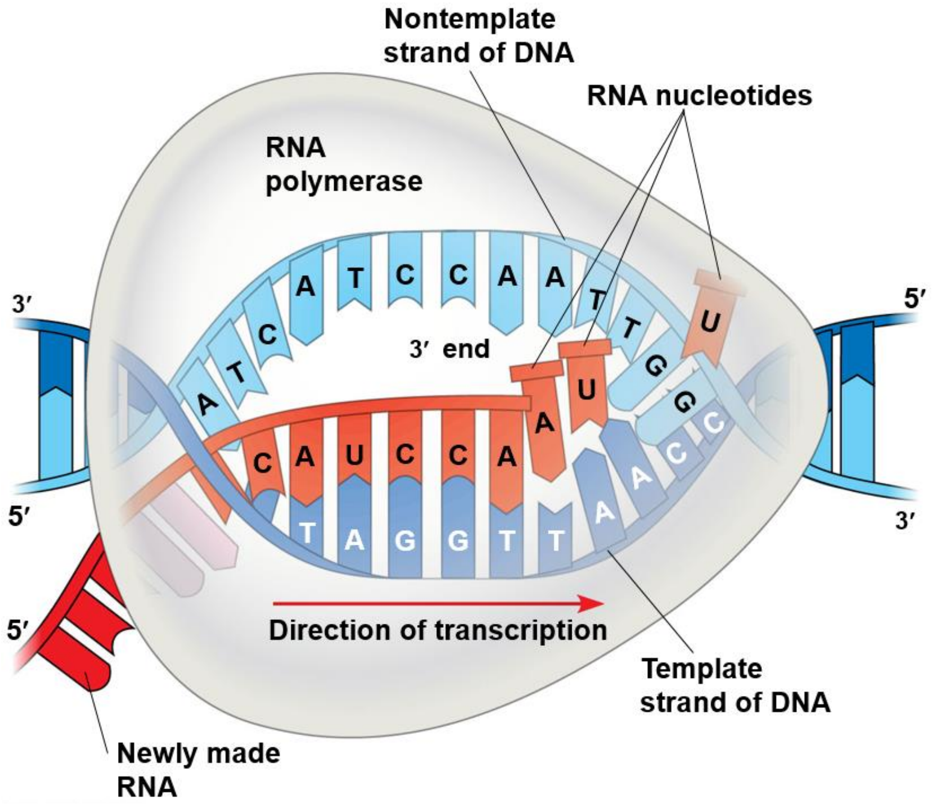
- The genetic code in the sequence of DNA's nitrogenous bases are copied over to RNA.

- **RNA Polymerase** uses the nucleotides Adenine, **Uracil**, Guanine and Cytosine (Notice: there is <u>NO</u> thymine in RNA)

A U

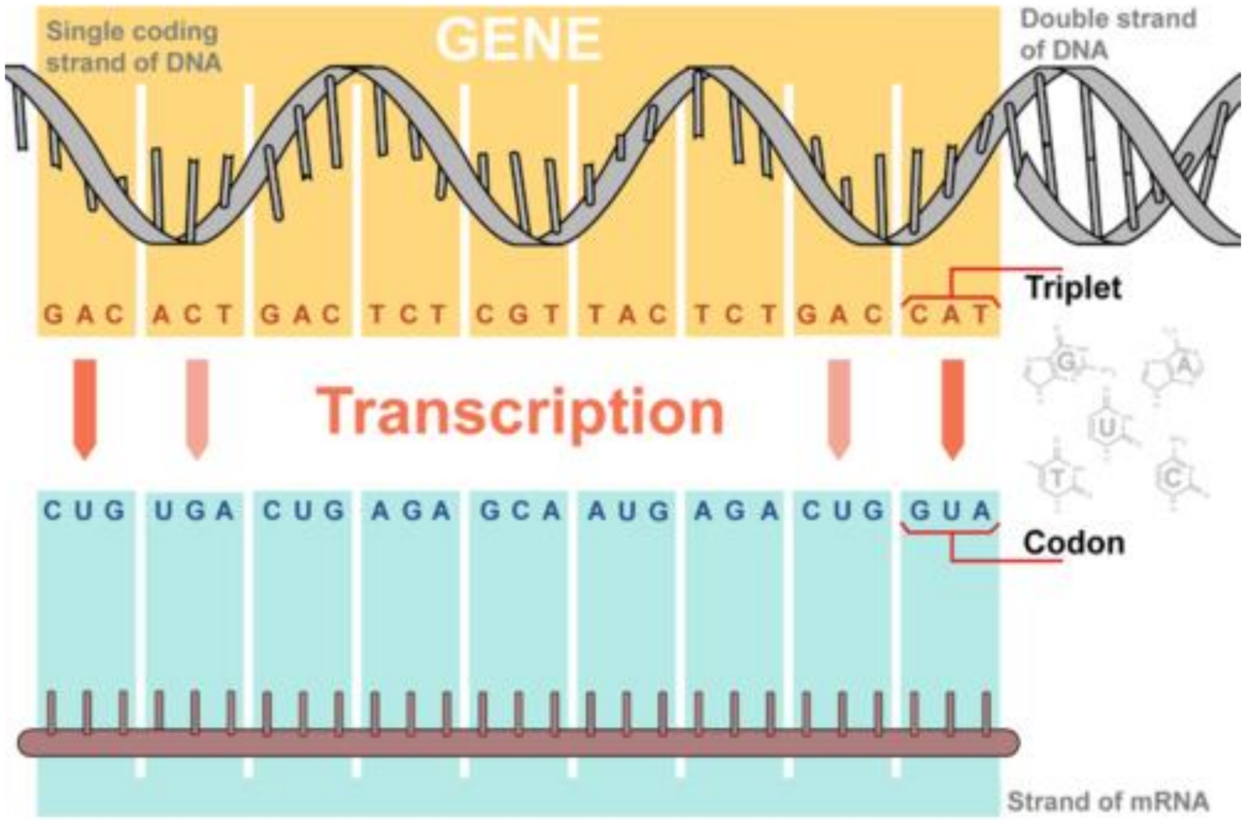
G C

- The RNA molecule(s) leave the nucleus.



mRNA made of many CODON groups

- mRNA nucleotides are grouped in 3 base sets called **Codons**.



Draw boxes around the codons:

U A C G C U A U C C G C A U U U G C

Transcription to Translation

- **All 3 kinds of RNA are made by Transcription**: mRNA, rRNA and tRNA

- **mRNA** – carries the code from DNA to Ribosome
- **rRNA** – makes up the Ribosomes (site of protein production)
- **tRNA** – carries the amino acids to the ribosomes to be made into proteins

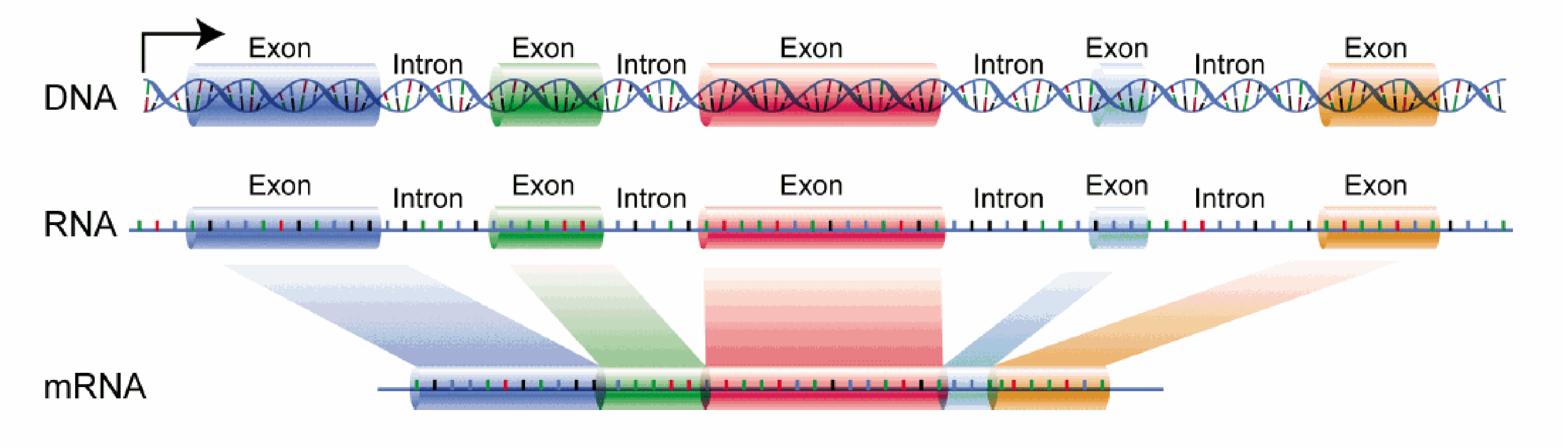
- Most biology classes focus on the production of mRNA in the nucleus for transcription.

Why make RNA, why not use DNA?

- DNA is the master copy of the genetic code in your cells' nuclei.
- If something happens to the DNA then **EVERY** protein made will be mutated. DNA is kept safer in eukaryotes by protecting it with a nuclear envelope.
- If something happens (mutations) to RNA, then the mutated RNA can be recycle and a new RNA can be made again from the DNA master copy

Eukaryotic mRNA is modified before leaving

- In eukaryotes, mRNA initially contains segments call exons and introns.
- The introns are removed before the mRNA goes to the ribosomes. The exons are left and get used to make the proteins (they are **EX**pressed).
- This is called **Alternative RNA Splicing**.



Transcription Big Picture

- RNA is copied from DNA using RNA polymerase.
- mRNA leaves the nucleus and moves to the ribosomes.

  - Trans – to move
  - script – a copy
  - tion – make a noun out of a verb

- Transcription – the act of moving a copy

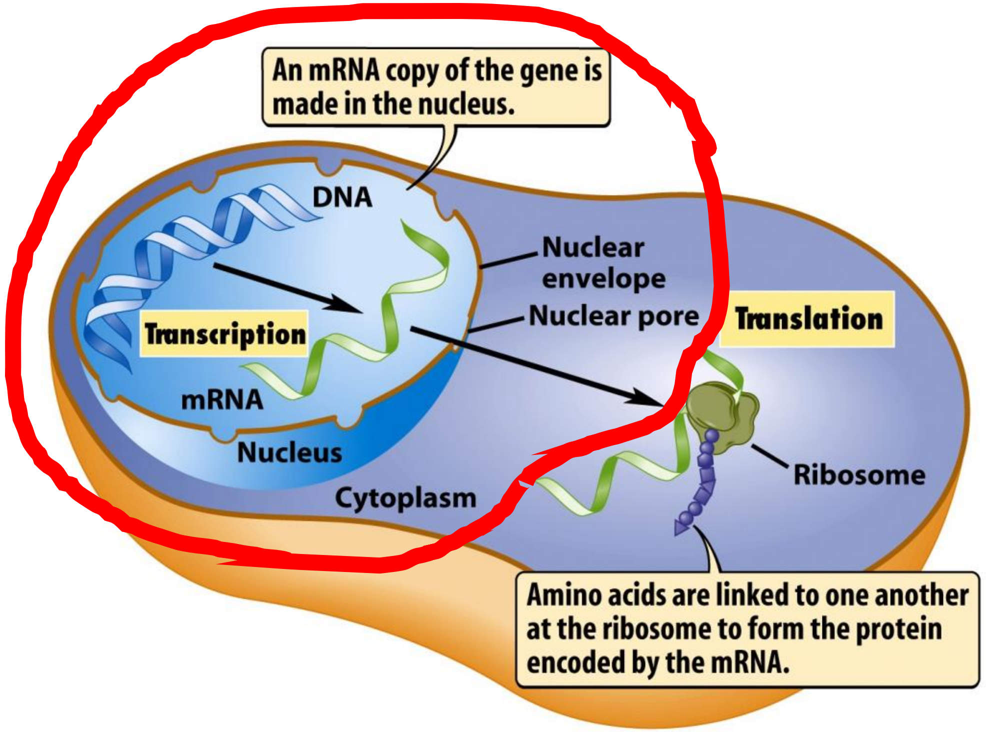


Figure 13-2 Discover Biology 3/e

Translation

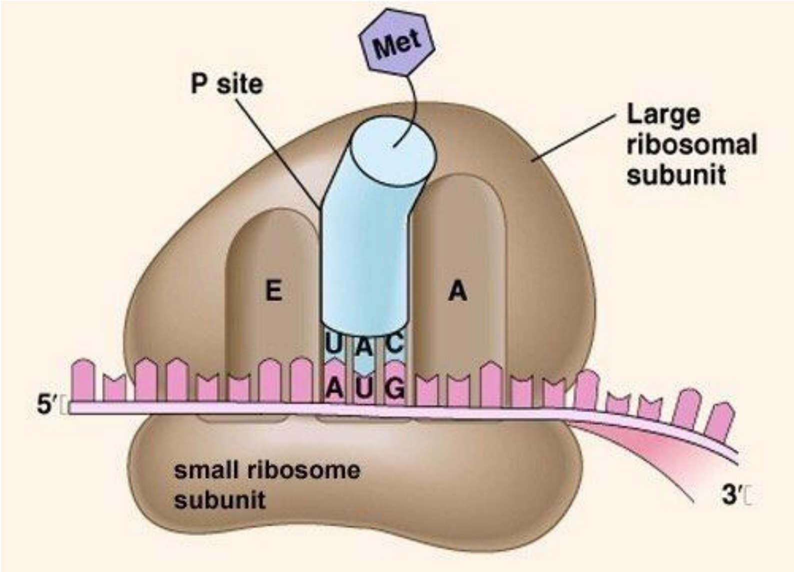
Proteins needs to be made from the genetic instructions coded in DNA. How are proteins made?

- mRNA is sent to the Ribosomes (made of rRNA) in the cytosol/cytoplasm.
- The ribosome reads the mRNA 3 bases at a time, **Codons**.
- tRNA brings the amino acids to the ribosome (rRNA), which builds the polypeptide chain using dehydration synthesis.

Ribosome (rRNA)

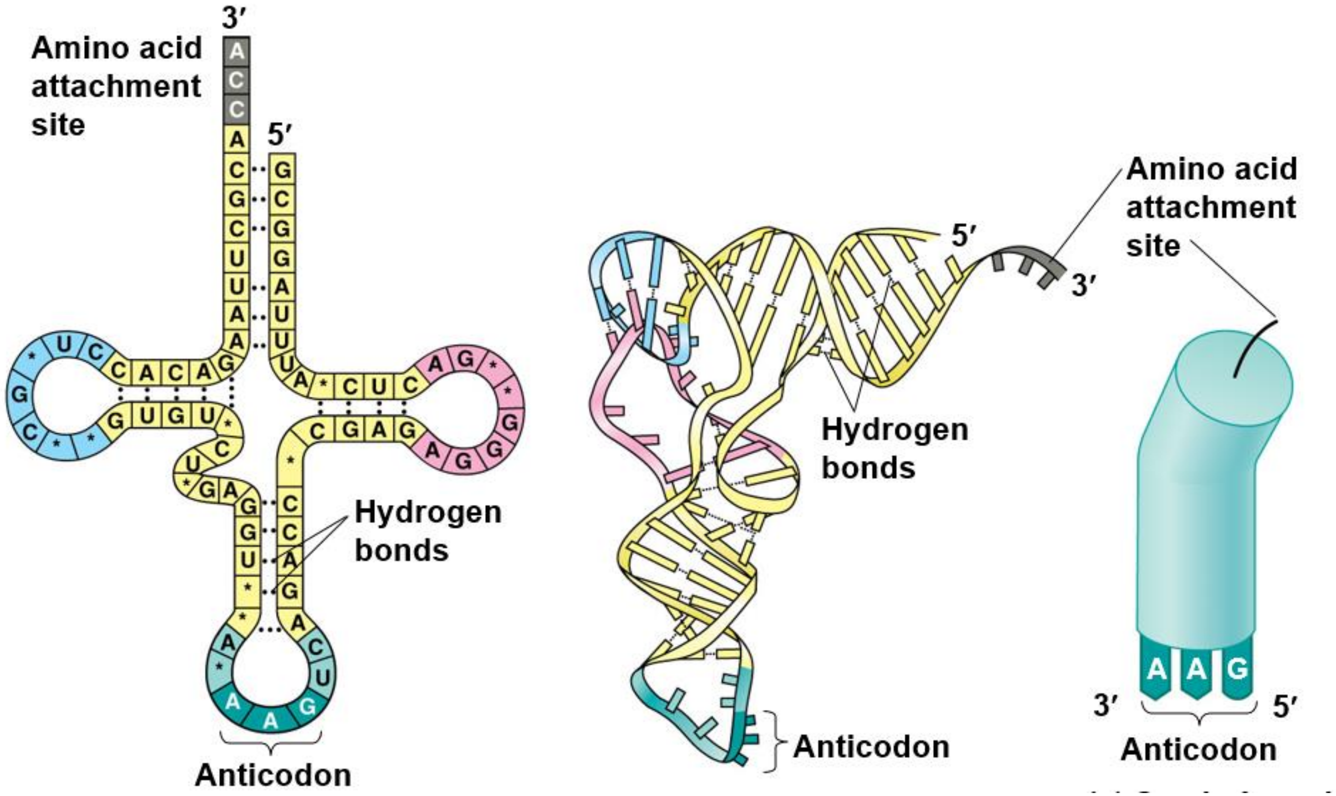
- A **ribosome** is made of two pieces of **rRNA**, the large subunit on top and the small subunit on the bottom.

- The ribosome acts like an enzyme and creates the peptide bonds between amino acids making a protein.



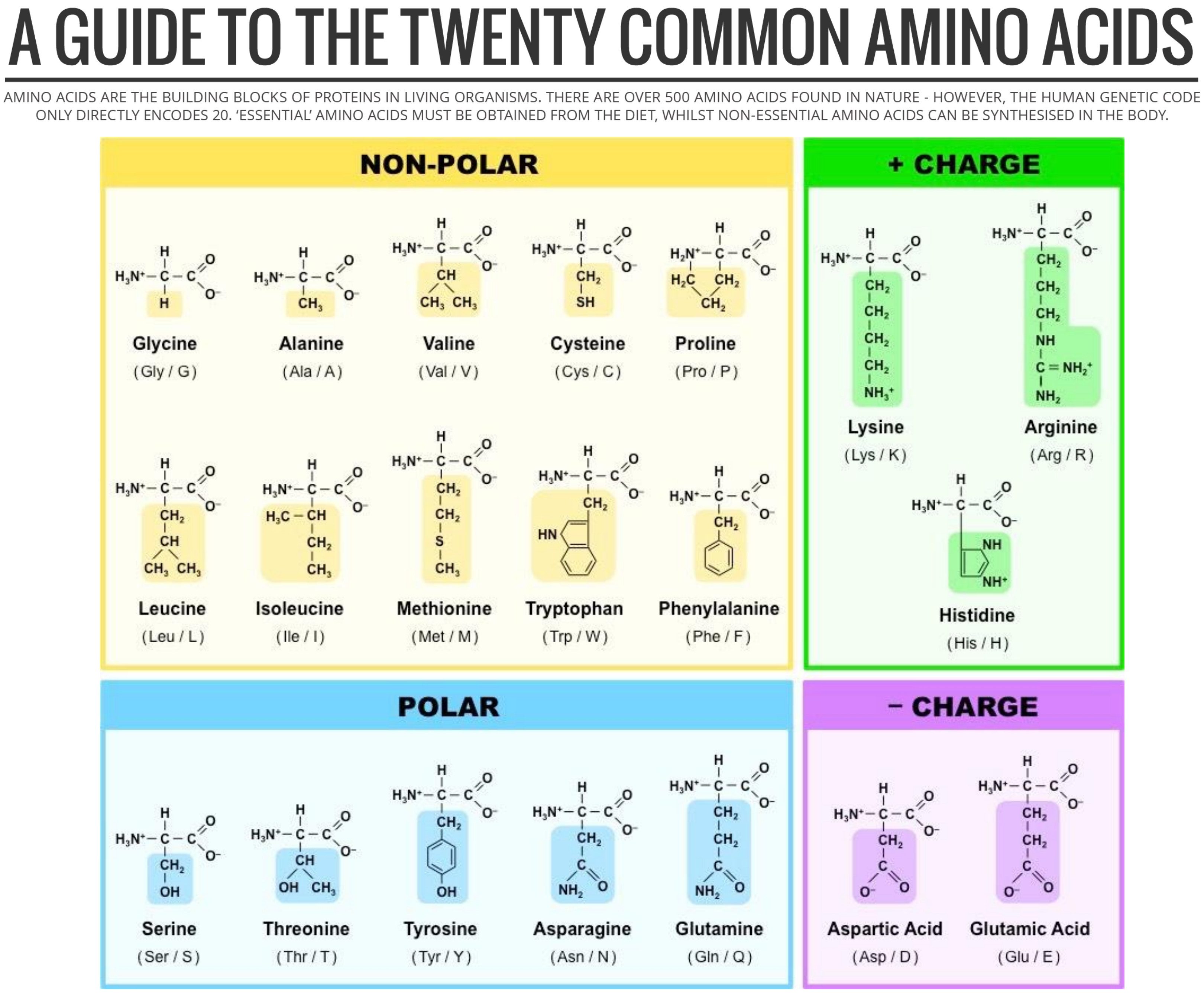
Transfer RNA (tRNA)

- Made of a single strand of RNA folded back on itself.
- tRNA attaches to a specific amino acid at the 3’ end.
- tRNA contains an **anticodon** which is complementary to the codon in mRNA



Amino Acids

- There are 20 unique Amino Acids.
- Amino acids are brought to the ribosome by tRNA



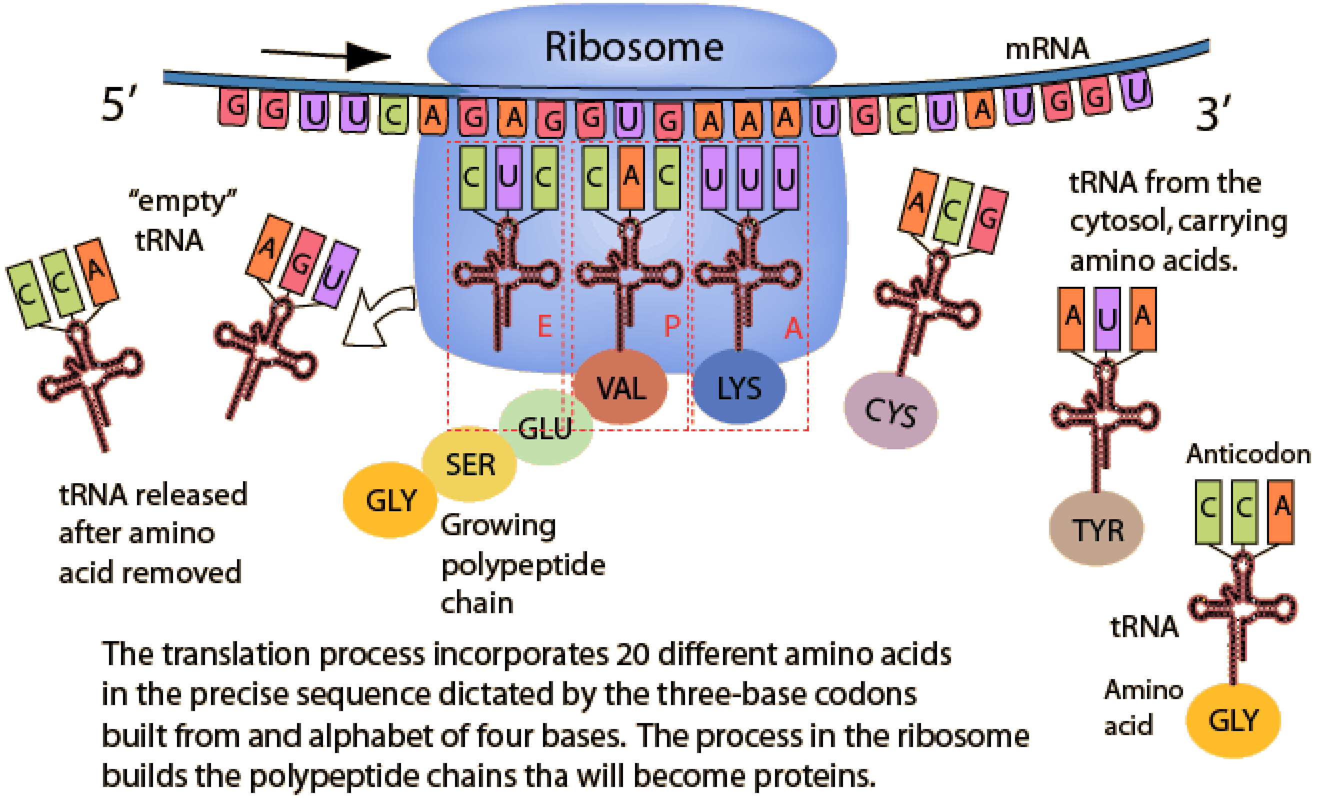
Translation

1. mRNA codon is read at the Ribosome (rRNA)

2. Ribosome matches the mRNA codon to the tRNA anticodon

3. Ribosome breaks the amino acid bond to the tRNA

4. New amino acid is attached to the previous amino acid



Using a Codon Chart to sequence Proteins

- To use a codon chart, you **MUST use mRNA**. You CANNOT use DNA bases!

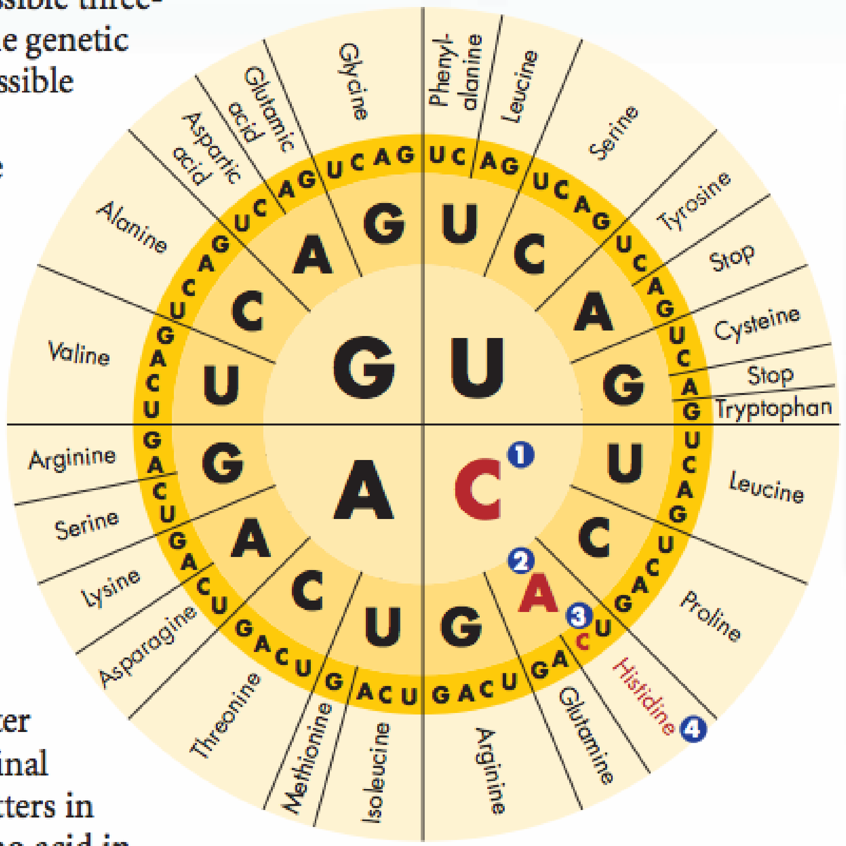
mRNA Codon/Amino Acid Chart

First Base	Second Base U	Second Base C	Second Base A	Second Base G	Third Base
U	UUU, UUC – Phenylalanine (Phe) UUA, UUG – Leucine (Leu)	UCU, UCC, UCA, UCG – Serine (Ser)	UAU, UAC – Tyrosine (Tyr) UAA, UAG – Stop	UGU, UGC – Cysteine (Cys) UGA – Stop UGG – Tryptophan (Trp)	U C A G
C	CUU, CUC, CUA, CUG – Leucine (Leu)	CCU, CCC, CCA, CCG – Proline (Pro)	CAU, CAC – Histidine (His) CAA, CAG – Glutamine (Glu)	CGU, CGC, CGA, CGG – Arginine (Arg)	U C A G
A	AUU, AUC, AUA – Isoleucine (Ile) AUG – Start Methionine (Met)	ACU, ACC, ACA, ACG – Threonine (Thr)	AAU, AAC – Asparagine (Asn) AAA, AAG – Lysine (Lys)	AGU, AGC – Serine (Ser) AGA, AGG – Arginine (Arg)	U C A G
G	GUU, GUC, GUA, GUG – Valine (Val)	GCU, GCC, GCA, GCG – Alanine (Ala)	GAU, GAC – Aspartic Acid (Asp) GAA, GAG – Glutamic Acid (Glu)	GGU, GGC, GGA, GGG – Glycine (Gly)	U C A G

Using a Codon Chart to sequence Proteins

How to Read Codons Because there are four different bases in RNA, there are 64 possible three-base codons (4 × 4 × 4 = 64) in the genetic code. **Figure 13–6** shows these possible combinations. Most amino acids can be specified by more than one codon. For example, six different codons—UUA, UUG, CUU, CUC, CUA, and CUG—specify leucine. But only one codon—UGG—specifies the amino acid tryptophan.

Decoding codons is a task made simple by use of a genetic code table. Just start at the middle of the circle with the first letter of the codon, and move outward. Next, move out to the second ring to find the second letter of the codon. Find the third and final letter among the smallest set of letters in the third ring. Then read the amino acid in that sector.



1. To decode the codon CAC, find the first letter in the set of bases at the center of the circle.
2. Find the second letter of the codon A, in the “C” quarter of the next ring.
3. Find the third letter, C, in the next ring, in the “C-A” grouping.
4. Read the name of the amino acid in that sector—in this case histidine.

Starting and Stopping

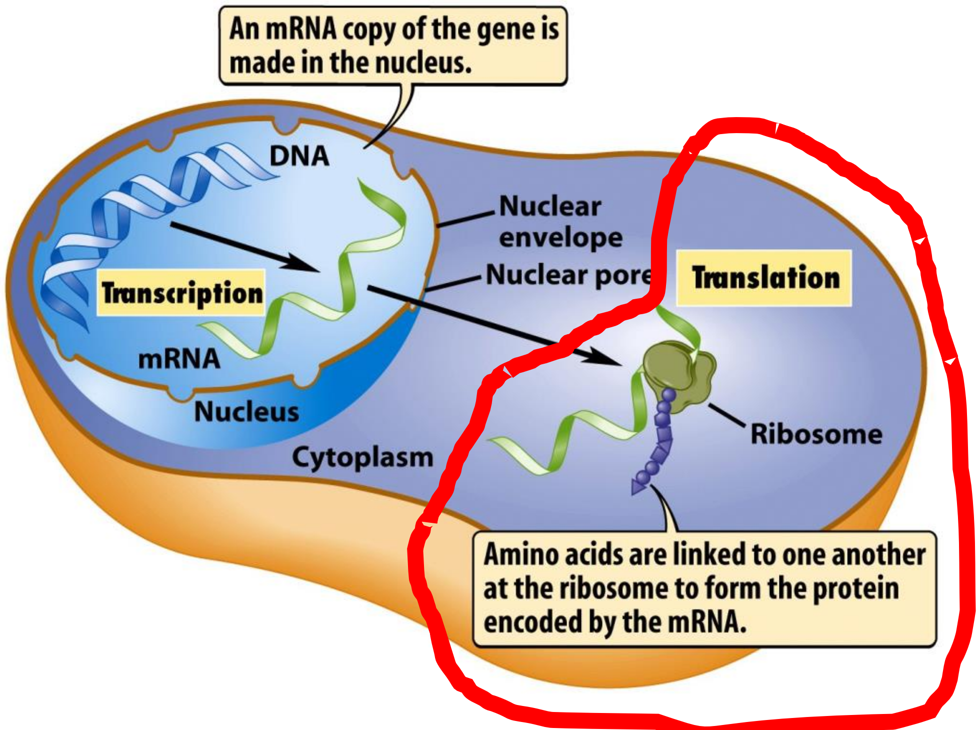
- Ribsomes will begin protein synthesis at **AUG**, which codes for the START CODON, methionine.

- Ribosomes will end protein synthesis it reaches **UAG**, **UAA**, or **UGA** which are the STOP CODONs.

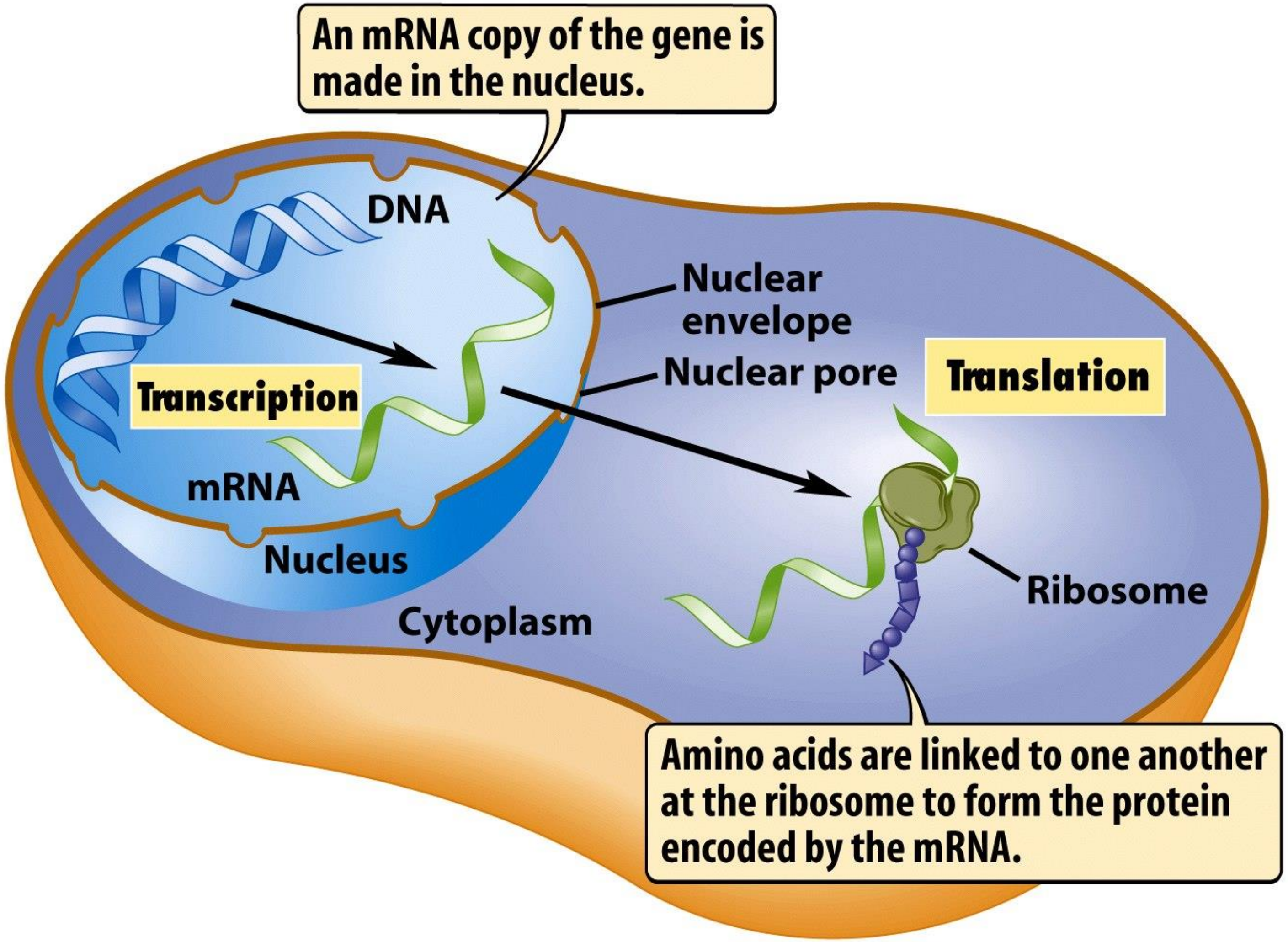
- Stop codons DO NOT code for any amino acids, they make the ribosome cut the protein free to be used.

Translation Big Picture

- mRNA enters the ribosome.
- tRNA brings amino acid to ribosome and its anticodon pairs up with mRNA codon.
- Ribosome (rRNA) connects the amino acids together to make a protein.
    - Translate – to move between languages
    - tion – make a noun out of a verb
- Translation – to change from Nucleic Acid language to Amino Acid language



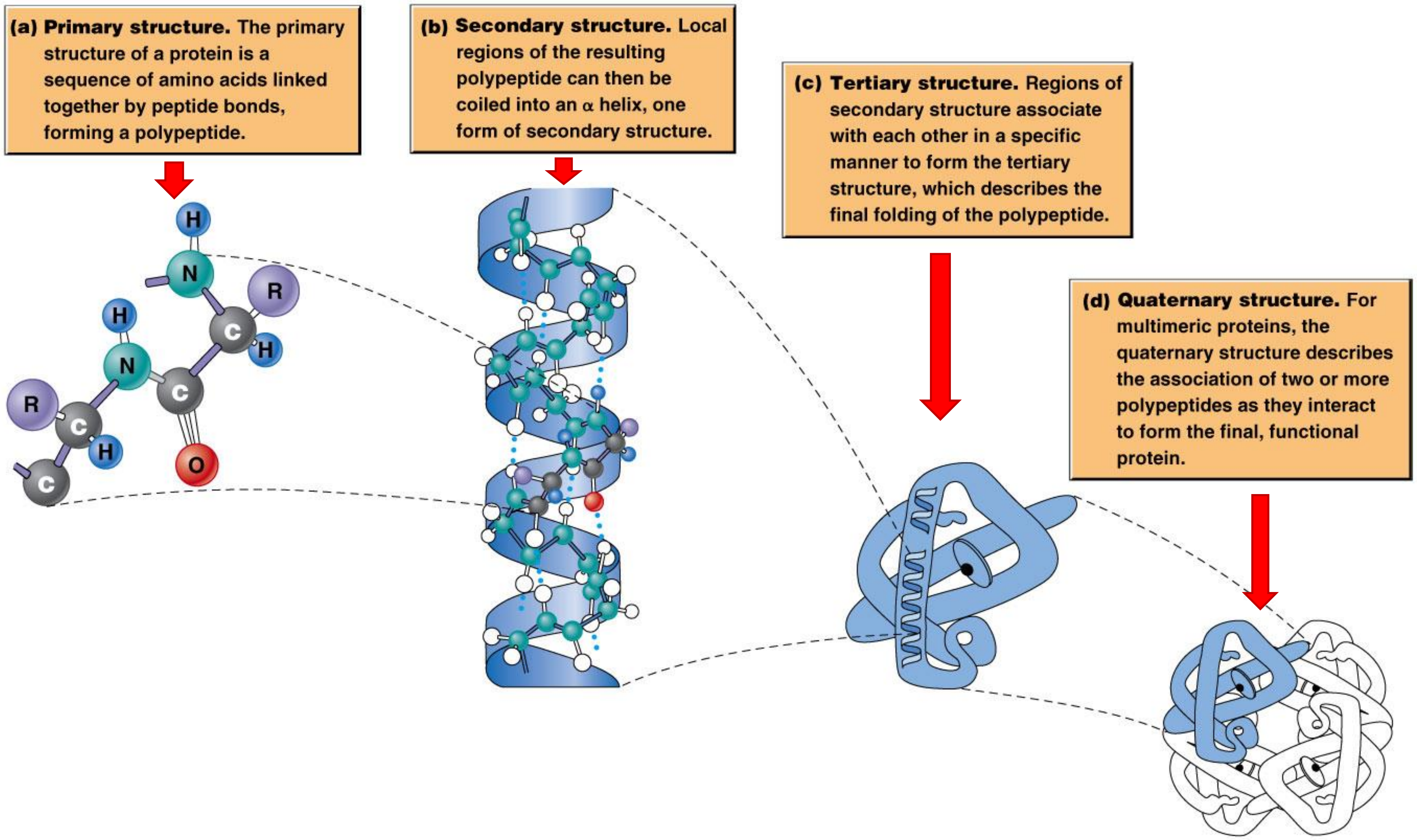
Transcription and Translation Big Picture



Protein Structure

Functional Proteins have 4 levels of structure:

- Primary
- Secondary
- Tertiary
- Quaternary



Primary Structure - 1°

The primary structure is the sequence/order of the amino acids in the polypeptide chain.

Secondary Structure - 2°

Creates either α helix or β pleated sheets due to the hydrogen bonds between the –OH groups of one amino acid, and a –H group of another.

Tertiary Structure - 3°

Creates the 3D shape of the polypeptide chain, when the R-groups of different amino acids interact.

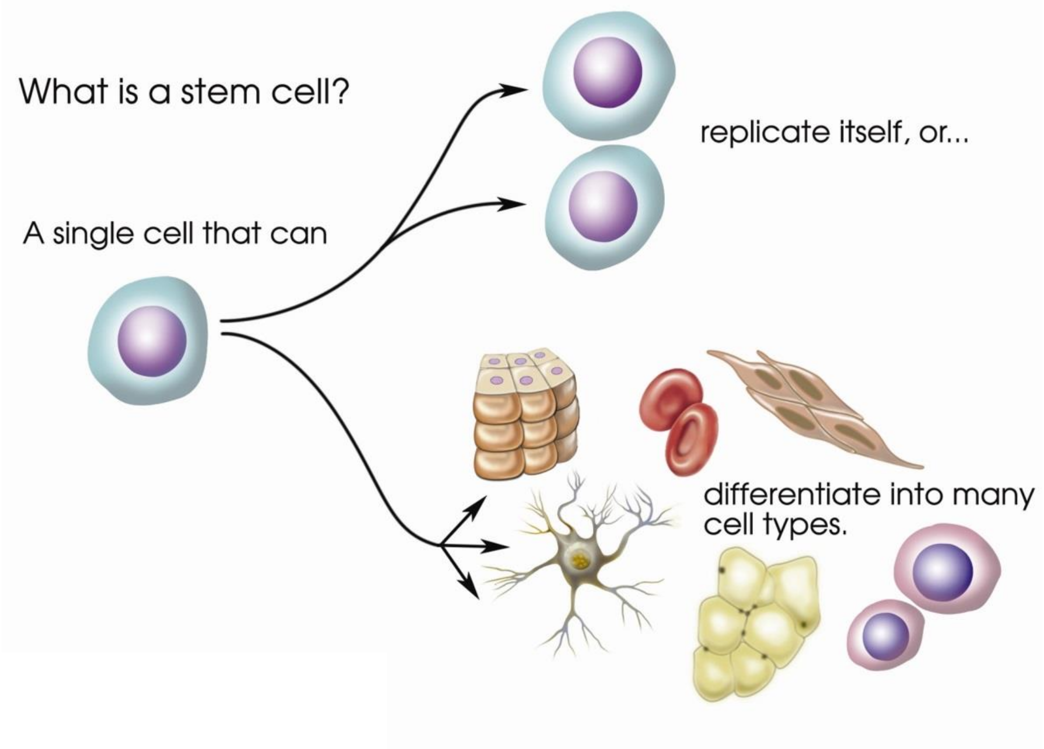
Quaternary Structure - 4°

Multiple polypeptide chains (at 3° structure) work together to create a functional protein.

Cell Differentiation

- Multicellular organisms are made of many different types of cells.

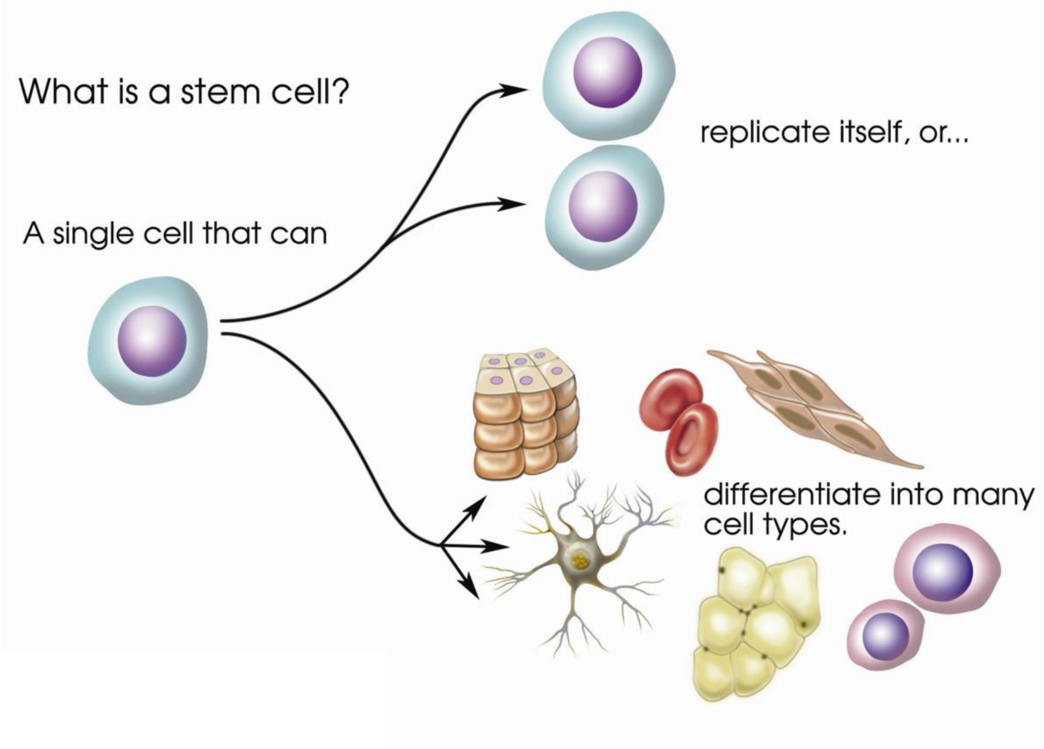
- Different cells will make different proteins from the master DNA sequence, common to all cells within an organism. (due to DNA Replication)



DNA is the **genetic code** for the making of **proteins** used for **structure** and **enzymatic function**

Cell Specialization

- To perform a specific function for the organism, cells must be specialized.
- For example, heart cells are specialized muscle cells, which require more muscle proteins to constantly beat and circulate blood.
- A brain cell will not transcribe the genes to make the muscle proteins for movement, even though its nucleus has the genetic instructions to do so.



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