

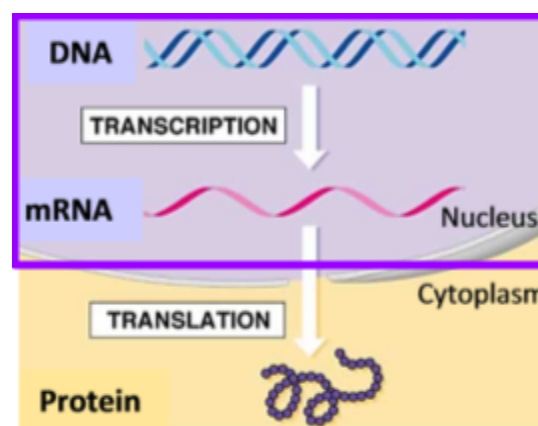
2.7 Protein Synthesis

Essential Question(s): How does the structure of DNA determine its function?

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Background Information:

DNA is used to make proteins in cells using a two step process: **transcription** and **translation**. First, watch this video: [What are proteins?](#)



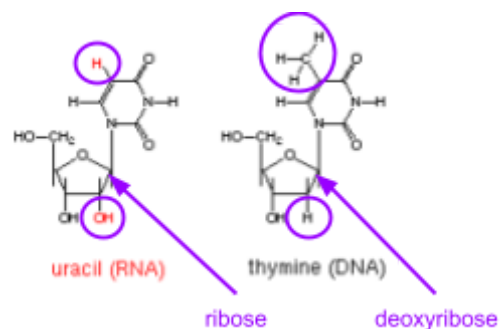
Part 1: Transcription

Transcription is the process in which one small section of DNA (a gene) is copied into a **messenger RNA (mRNA)** molecule. It's taking one string of nucleotides (DNA) and transcribing it into another string of nucleotides (RNA), a little like listening to a sentence and then writing it down. The sequence of nucleotides in the DNA determines the sequence of nucleotides in the mRNA.

DNA is transcribed to mRNA using [base pairing rules](#) much like those used when DNA is copied (replication), but there are some differences. Notably, RNA does not contain thymine, but has a different base, *uracil*, instead. So, when RNA is being made from a DNA template, uracil pairs with adenine (U pairs with A). Use [this video](#) to help you in transcribing DNA to mRNA.

1. Check your skills. Use base pairing rules to transcribe the DNA strand into mRNA.

DNA	TAC	GCG	CCA	CAA	CGC	TAT	ACC	GAC	TCT	GGG	TGA	ATT
mRNA	AUG	CGC										



Watch [transcription happening in real time](#) as it occurs in living cells.

- Summarize the process of transcription: explain how a gene in DNA directs the synthesis of an mRNA molecule. Use the word bank and sentence frames below, or write your own sentences.

Word Bank:

base-pairing rule	cytoplasm	gene	nucleotide	RNA polymerase
complementary	DNA	messenger RNA	nucleus	unzip

First, _____, then _____, last _____.

Prior to, _____, followed by _____, eventually _____.

Part 2: Translation

Translation is the process in which an **mRNA** molecule is used to produce a protein molecule. A string of mRNA nucleotides is “read” and translated into a string of amino acids, a little like reading a sentence in Spanish and translating it to English. The sequence of nucleotides in the mRNA determines the sequence of amino acids in the protein.

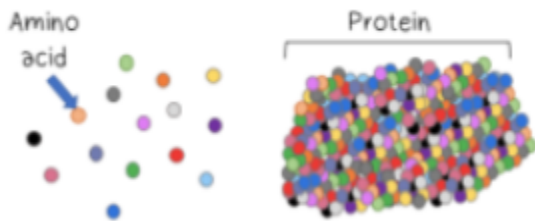
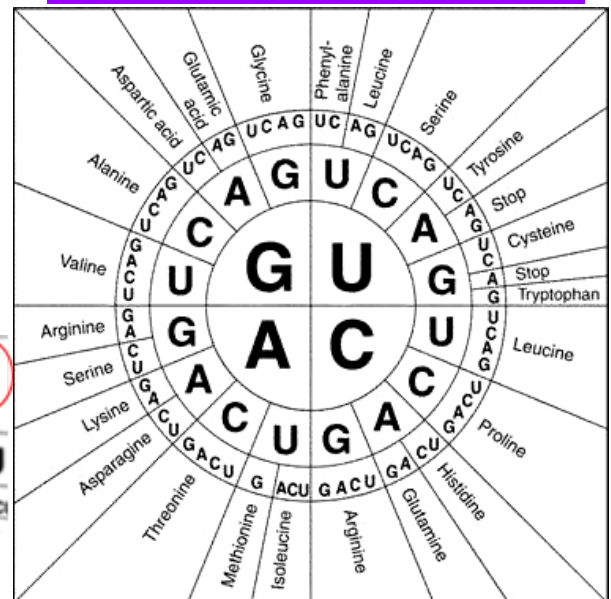
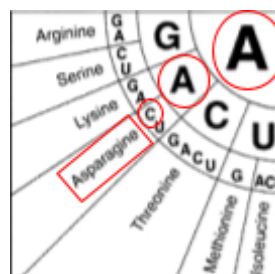
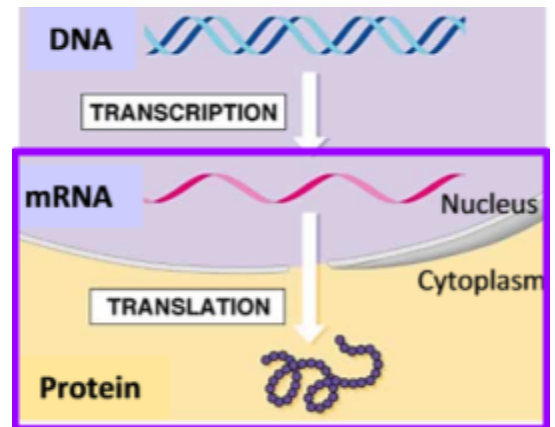


Image Source: Rachel Taylor, Millenium HS, New York NY

Translation is like a secret code. The charts below provide a key used to translate from the mRNA “nucleotide language” to the amino acid “protein language”. Read the codon chart by taking a 3-letter mRNA codon, starting with the first letter in the center circle, and moving outwards with each successive letter. For example, the codon A A C codes for asparagine. Use [this video](#) to help you in reading the two different types of codon chart.



		Second base					
		U	C	A	G		
First base	U	UUU] Phenyl-alanine F UUC] F UUA] Leucine L UUG] L	UCU] Serine S UCC] S UCA] S UCG] S	UAU] Tyrosine Y UAC] Y UAA] Stop codon UAG] Stop codon	UGU] Cysteine C UGC] C UGA] Stop codon UGG] Tryptophan W	Third base	U C A G
	C	CUU] Leucine L CUC] L CUA] L CUG] L	CCU] Proline P CCC] P CCA] P CCG] P	CAU] Histidine H CAC] H CAA] Glutamine Q CAG] Q	CGU] Arginine R CGC] R CGA] R CGG] R		U C A G
	A	AUU] Isoleucine I AUC] I AUA] I AUG] Methionine start codon M	ACU] Threonine T ACC] T ACA] T ACG] T	AAU] Asparagine N AAC] N AAA] Lysine K AAG] K	AGU] Serine S AGC] S AGA] Arginine R AGG] R		U C A G
	G	GUU] Valine V GUC] V GUA] V GUG] V	GCU] Alanine A GCC] A GCA] A GCG] A	GAU] Aspartic acid D GAC] D GAA] Glutamic acid E GAG] E	GGU] Glycine G GGC] G GGA] G GGG] G		U C A G

3. Practice using the codon chart to translate from 3-letter mRNA codons to amino acids. *Note: You only need to include the first 3 letters of each amino acid.*

mRNA	AUG	CGC	GGU	GUU	GCG	AUA	UGG	CUG	AGA	CCC	ACU	UAA
Amino Acid	methionine											

Finally, watch [translation happening in real time](#) as it occurs in living cells.

Review:

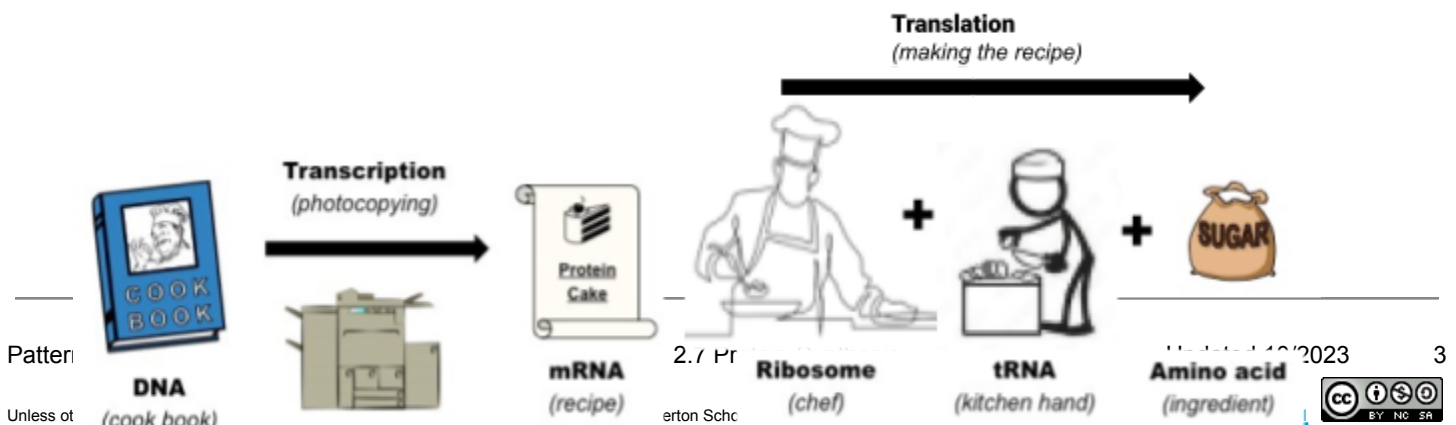
	Original molecule (subunits and polymer)	Molecule that is synthesized (subunits and polymer)	Location in a cell where process takes place
Transcription			
Translation			

Part 3: The Central Dogma: Tying It All Together

The process of transcription and translation is sometimes referred to as the Central Dogma of Molecular Biology. All the functions of a cell are taken care of by proteins, so the manufacturing of those proteins are central to the proper functioning of the cell, and therefore an organism.

Think about it this way: (analogy from [Bioninja](#))

- A cell is like a restaurant – differentiated cell types are like restaurants specializing in different cuisines
- The DNA is the set of instructions for the cell – like a cookbook is the set of instructions for a restaurant
- A single DNA instruction is a gene – like a single recipe in a cookbook
- Transcription is the process of making an RNA copy of a gene – RNA polymerase is like a photocopier
- The mRNA transcript (i.e. photocopied recipe) is transported to the ribosome – which functions as the cook
- The ribosome reads the mRNA one codon at a time – as a chef would read the recipe one step at a time
- Each codon corresponds to an amino acid – just like each step in a recipe refers to a specific ingredient
- The amino acids are brought to the ribosome by tRNA – these tRNA molecules are like kitchen hands
- The ribosome joins the amino acids together to make a polypeptide – just like a cook mixes ingredients to make food.



Summary: Write a paragraph describing the steps necessary to turn a gene into a protein using the word bank shown below. In your paragraph, **bold** the word bank words and make sure you use each of these words at least once. Use the picture of the restaurant analogy and sentence frames to help you write your paragraph.

Word Bank:

transcription	nucleus	amino acid	nucleotide	tRNA
mRNA	translation	ribosome	genes	protein

Sequencing Sentence Frames:

First, ____, then ____, last ____.
Initially, ____, meanwhile ____, finally ____.
Prior to, ____, followed by ____, eventually ____.

Summary Paragraph: