

Name: \_\_\_\_\_

Date: \_\_\_\_\_

## Student Exploration: RNA and Protein Synthesis

**Vocabulary:** amino acid, anticodon, codon, messenger RNA, nucleotide, ribosome, RNA, RNA polymerase, transcription, transfer RNA, translation

**Prior Knowledge Questions** (Do these BEFORE using the Gizmo.)

1. Suppose you want to design and build a house. How would you communicate your design plans with the construction crew that would work on the house?

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2. Cells build large, complicated molecules, such as proteins. What do you think cells use as their “design plans” for proteins?

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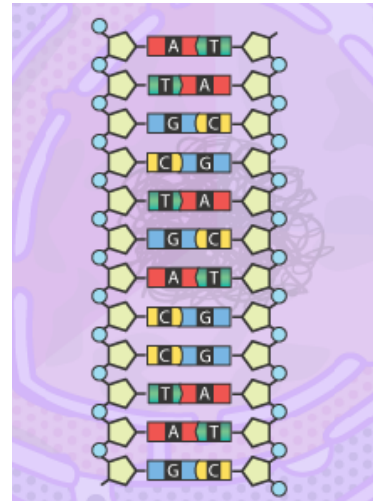
### Gizmo Warm-up

Just as a construction crew uses blueprints to build a house, a cell uses DNA as plans for building proteins. In addition to DNA, another nucleic acid, called **RNA**, is involved in making proteins. In the *RNA and Protein Synthesis* Gizmo™, you will use both DNA and RNA to construct a protein out of **amino acids**.

1. DNA is composed of the bases adenine (A), cytosine (C), guanine (G), and thymine (T). RNA is composed of adenine, cytosine, guanine, and uracil (U).


Look at the SIMULATION pane. Is the shown molecule DNA or RNA? How do you know?

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2. **RNA polymerase** is a type of enzyme. Enzymes help chemical reactions occur quickly. Click the **Release enzyme** button, and describe what happens.

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<b>Activity A:</b> <b>Transcription</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>If necessary, click <b>Release enzyme</b>.</li> </ul>	
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**Introduction:** The first stage of building a protein involves a process known as **transcription**. In transcription, a segment of DNA serves as a template to produce a complementary strand of RNA. This complementary strand is called **messenger RNA**, or mRNA.

**Question: What occurs during transcription?**

1. Experiment: Like DNA, RNA follows base-pairing rules. Experiment to find which RNA **nucleotide** on the right side of the Gizmo will successfully pair with the thymine at the top of the template strand of DNA. (NOTE: The DNA on the right side is the template strand.)

Which RNA base bonded with the thymine? \_\_\_\_\_

2. Experiment: The next three bases on the DNA template strand are adenine, cytosine, and guanine. Use the Gizmo to answer the following questions:

A. Which RNA base bonds with adenine? \_\_\_\_\_

B. Which RNA base bonds with cytosine? \_\_\_\_\_

C. Which RNA base bonds with guanine? \_\_\_\_\_

3. Analyze: In molecules of RNA, uracil takes the place of the DNA base \_\_\_\_\_.

4. Build: Continue building the molecule of mRNA until you have used all of the RNA nucleotides. What is the nucleotide sequence of the mRNA strand you built?

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5. Apply: Suppose a template strand of DNA had the following sequence:


T A C   G G A   T A A   C T A   C C G   G G T   A T T   C A A

What would be the complementary strand of mRNA?

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6. Predict: How would a change in the sequence of nucleotides in a DNA molecule affect the mRNA transcribed from the DNA molecule? \_\_\_\_\_

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<b>Activity B:</b>  <b>Translation</b>	<u>Get the Gizmo ready:</u> <ul style="list-style-type: none"> <li>Once the mRNA strand has been built, click <b>Continue</b>.</li> </ul>	
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**Introduction:** After a strand of mRNA has been built, the strand exits the cell's nucleus. The second stage of protein synthesis, called **translation**, occurs next. During translation, the strand of mRNA is used to build a chain of amino acids.

**Question: What occurs during translation?**

1. Observe: Examine the strand of mRNA on the SIMULATION pane. Every group of three bases of mRNA is called a **codon**.

In the table at right, list the nitrogen bases in each codon. (Hint: Start from the top of the strand and read down.) The first mRNA codon is called the *universal start codon*.

Codon	mRNA bases
1	
2	
3	
4	

2. Predict: Translation starts when a **ribosome** (the purple structure on the SIMULATION pane) binds to a strand of mRNA. **Transfer RNA**, or tRNA, begins bringing amino acids into the ribosome. Each tRNA molecule carries only one kind of amino acid. This amino acid is determined by the tRNA's **anticodon**, a set of three unpaired bases.

Which anticodon do you think would attach to the mRNA's start codon? \_\_\_\_\_

Use the Gizmo to check your answer.

3. Observe: Place the next two anticodons on the mRNA strand. What happens?

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As each tRNA molecule binds to the mRNA, the ribosome joins the amino acid carried by the tRNA to the growing amino acid chain.

4. Describe: UAG (as well as UAA and UGA) is an example of a *stop codon*. Molecules called *release factors* bind to stop codons. Place the release factor on the mRNA molecule.

What happens? \_\_\_\_\_

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Click **Continue**. Your protein is now complete. Most actual proteins consist of sequences of hundreds of amino acids.

**(Activity B continued on next page)**

## Activity B (continued from previous page)

5. Infer: Why do you think stop and start codon signals are necessary for protein synthesis?

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6. Translate: Codons code for different amino acids. Examine the codon chart below. The amino acid coded for by a specific mRNA codon can be determined by finding the first base of the codon along the left side of the table, the second base along the top of the table, and the third base along the right side of the table.

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

What amino acids do the following codons code for?

AUG: \_\_\_\_\_ CUG: \_\_\_\_\_ ACC: \_\_\_\_\_ UAG: \_\_\_\_\_

7. Apply: Suppose you wanted a protein that consists of the amino acid sequence methionine, asparagine, valine, and histidine. Give an mRNA sequence that would code for this protein.

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8. Extend your thinking: Sometimes errors occur during transcription or translation. Examine the codon chart above. Each amino acid is coded for by several different codons.

How might this offset transcription or translation errors? \_\_\_\_\_

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