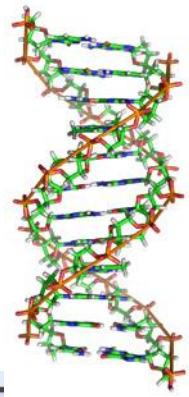
Name: _____ Date: _____

Student Exploration: Building DNA

Vocabulary: double helix, DNA, enzyme, lagging strand, leading strand, mutation, nitrogenous base, nucleoside, nucleotide, replication

Prior Knowledge Questions (Do these BEFORE using the Gizmo.) **DNA** is an incredible molecule that forms the basis of life on Earth. DNA molecules contain instructions for building every living organism on Earth, from the tiniest bacterium to a massive blue whale. DNA also has the ability to **replicate**, or make copies of itself. This allows living things to grow and reproduce.

1. Look at the DNA molecule shown at right. What does it look like?



_____

This shape is called a **double helix**.

2. Based on this picture, how do you think a DNA molecule makes a copy of itself? (Hint: Look at the bottom two "rungs" of the ladder.)

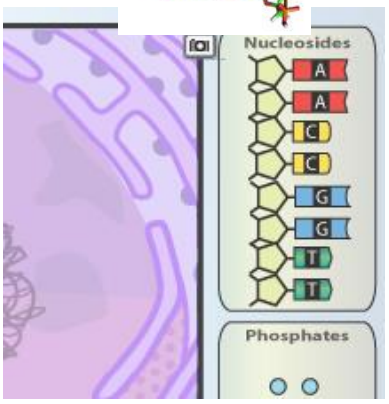
_____

_____

Gizmo Warm-up

The *Building DNA* Gizmo™ allows you to construct a DNA molecule and go through the process of DNA replication. Examine the components that make up a DNA molecule.

1. What are the two DNA components shown in the Gizmo?



_____

2. A **nucleoside** has two parts: a pentagonal sugar (deoxyribose) and a **nitrogenous base** (in color). When a nucleoside is joined to a phosphate, it is called a **nucleotide**.

How many different nitrogenous bases do you see? _____

Note: The names of these nitrogenous bases are adenine (red), cytosine (yellow), guanine (blue), and thymine (green).

Activity A: **Build a DNA molecule**	Get the Gizmo ready: • If necessary, click **Reset** to start the building process.	

Question: What is the structure of DNA?

1. Build: Follow the steps given in the Gizmo to construct a molecule of DNA. (Note: For simplicity, this DNA molecule is shown in two dimensions, without the twist.)

Stop when the hint reads: "The DNA molecule is complete." In the spaces at right, list the sequence of nitrogenous bases on the left-hand strand, called the **leading strand**, and the right-hand strand, called the **lagging strand**

2. Explain: Describe the structure of the DNA molecule

A. What makes up the sides of the DNA molecule?

_____

B. What makes up the "rungs" of the DNA molecule?

_____

3. Fill in: Write the name of the nitrogenous base that joins to each of the bases below:

Adenine (A) joins to _____

Thymine (T) joins to _____

Cytosine (C) joins to _____

Guanine (G) joins to _____

Leading strand	Lagging strand
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____
_____	_____

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.)

3. 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?

   _____

   _____

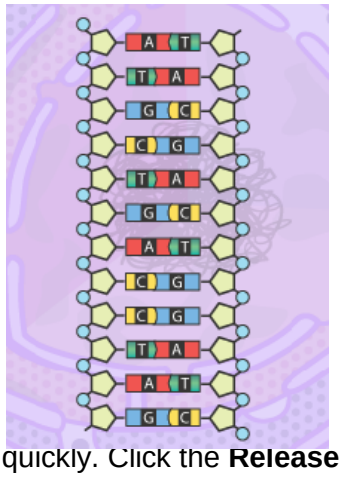
4. Cells build large, complicated molecules, such as proteins. What do you think cells use as their "design plans" for proteins?

   _____

   _____

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**.



3. 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?

   _____

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

   _____

Activity A: **Transcription**	Get the Gizmo ready: • If necessary, click **Release enzyme**.	

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?

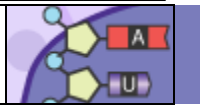
_____

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?

   ___

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

_____

Activity B: **Translation**	Get the Gizmo ready: • Once the mRNA strand has been built, click **Continue**.	

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?

   _____

   _____
   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? _____

_____

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

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

_____

_____

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

First base	U		C		A		G		Third base
U	UUU	Phenylalanine	UCU	Serine	UAU	Tyrosine	UGU	Cysteine	U
	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.

___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___ ___

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? _____

_____

_____

DNA Coloring - Transcription & Translation

Transcription → RNA, Ribonucleic Acid is very similar to DNA. RNA normally exists as a single strand (and not the double stranded double helix of DNA). It contains the same bases, adenine, guanine and cytosine. However, there is no thymine found in RNA, instead there is a similar compound called uracil.

Transcription is the process by which RNA is made from DNA. It occurs in the nucleus. Label the box with the x in it near the nucleus with the word TRANSCRIPTION and proceed to color the bases according to the key below

Thymine = orange 
Adenine = dark green 
Guanine = purple 
Cytosine = yellow 
Uracil = brown 

Color the strand of DNA dark blue (D) and the strand of RNA light blue (R). Color the nuclear membrane (E) gray. Draw nuclear pores in the nuclear envelope.

Translation →Translation occurs in the cytoplasm, specifically on the ribosomes. The mRNA made in the nucleus travels out to the ribosome to carry the "message" of the DNA. Here at the ribosome, that massage will be translated into an amino acid sequence. Color the ribosome light green (Y) and note how the RNA strand threads through the ribsosome like a tape measure and the amino acids are assembled. The RNA strand in the translation area should also be colored light blue, as it was colored in the nucleus.

Label the box with the X in the translation area with the word TRANSLATION.

Important to the process of translation is another type of RNA called Transfer RNA (F) which function to carry the amino acids to the site of protein synthesis on the ribosome. Color the tRNA red.

A tRNA has two important areas. The anticodon, which matches the codon on the RNA strand. Remember that codons are sets of three bases that code for a single amino acid. Make sure you color the bases of the anticodon the same color as the bases on your DNA and RNA strand - they are the same molecules!

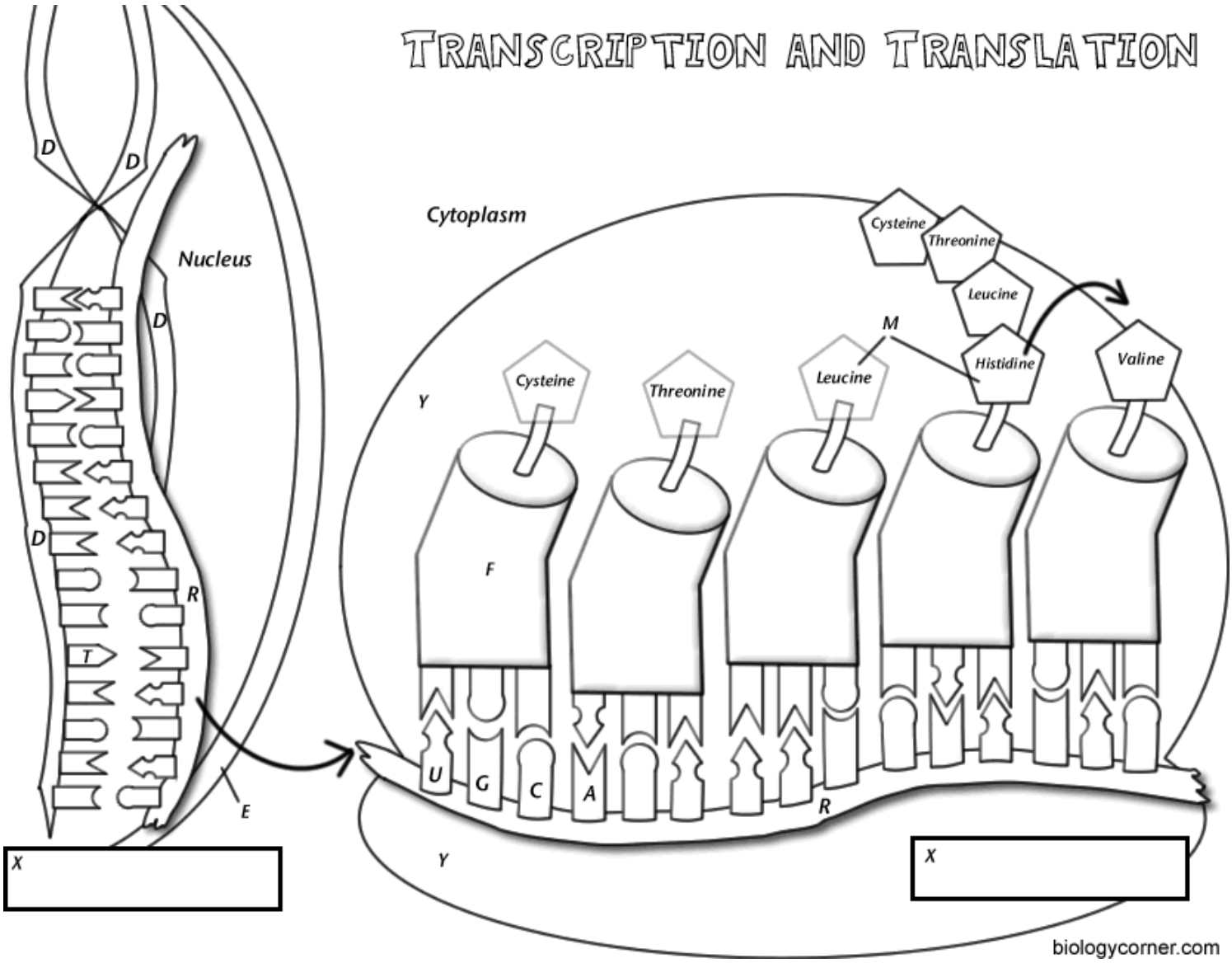
At the top of the tRNA is the amino acids. There are twenty amino acids that can combine together to form proteins of all kinds, these are the proteins that are used in life processes. When you digest your food for instance, you are using enzymes that were originally proteins that were assembled from amino acids. Each tRNA has a different amino acid which link together like box cars on a train. Color all the amino acids (M) pink.

Questions:

1. How many different kinds of bases can be found on DNA _____
2. What base is found on RNA but not on DNA? _____
3. How many bases are in a codon? _____ In an anticodon? _____
4. How many amino acids are attached to a single transfer RNA? _____
5. Transcription occurs in the _____; translation occurs in the _____.
6. The process of making RNA from DNA is called _____ and it occurs in the _____

7. The process of assembling a protein from RNA is called

_____ and it occurs in the _____



Draw and Label 3 places where you might see deoxyribose with a purple

Draw and Label 3 places where you might see ribose with a pink

Draw and Label 3 places where you might see phosphate group with a gold