



Scope Phenomenon

Name: _____ Date: _____

Changing Instructions

These are the instructions for making a glass of hot chocolate:

- a. Fill a glass with heated milk.
- b. Add 2 Tbsp. of cocoa powder.
- c. Stir it.

1. Rewrite the instructions above, but make a single typo or change. Record your revised instructions below, and comment on how this would affect the product.

2. How is a typo in the instructions to make hot chocolate similar to a change in DNA?

3. How are the instructions for making hot chocolate a model for how DNA codes for life functions?

4. What other models do you think could be used to explain how DNA codes for life functions?



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Components of DNA

DNA contains the instructions for all of life's building blocks. It also contains the instructions for the operations that are needed to carry out the processes of life. Sections of DNA are divided into genes that code for specific proteins. Each gene is, on average, about 230 bases long.

The expression of those proteins creates a phenotype for an organism. One allele of a gene might code for brown hair while another allele for the same gene might code for red hair. These genes dictate the traits that each organism expresses. It is the sequence of the nucleotides in genes that determines the traits of each organism—from bacteria to elephants.

The unique structure and bonding abilities of the DNA molecule lend to its functionality. The true nature of DNA was finally unlocked after years of work by many notable scientists. The current model of DNA was proposed in 1953 by James Watson and Francis Crick. Now, you will discover the model for yourself.

Part I

1. Cut out the puzzle pieces that are provided by your teacher.
2. Fit the individual pieces together lengthwise.
3. Sketch an image of the puzzle in the space below.



4. How would you describe the structure of the puzzle that you put together?
5. What did you notice about the individual puzzle pieces? Could they have fit together in any other way?

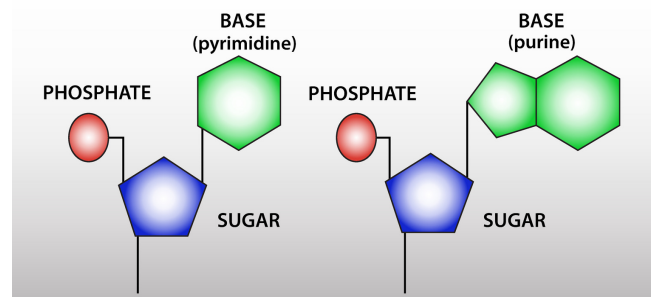
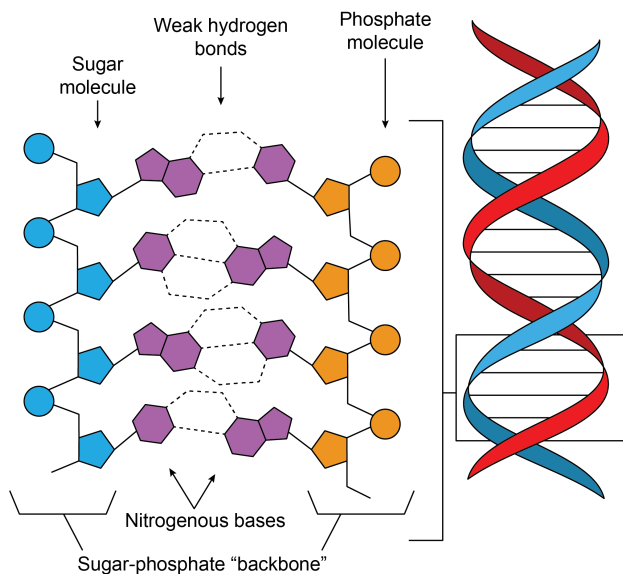
Part II

1. Read the following passage about DNA. While reading it, think about the puzzle that you just put together.

All known forms of life contain ribonucleic acid (RNA) and deoxyribonucleic acid (DNA), which are found in abundance in all living cells from single-celled prokaryotes to complex eukaryotes (such as humans). DNA needs to be coded, transmitted, and expressed. To understand how DNA carries information about the physical traits of an organism, it is necessary to first understand the structure of the DNA molecule.

DNA consists of repeating monomers called nucleotides. Each nucleotide consists of three parts:

- Phosphate group
- Five-carbon (pentose) sugar
- Nitrogenous base





Explore

The phosphate group is attached to one end of the five-carbon sugar. The phosphate of one nucleotide binds to the sugar of the next to form what is called the sugar-phosphate backbone. The sugar deoxyribose gives DNA part of its name.

There are four nitrogenous bases within DNA: adenine (A), thymine (T), cytosine (C), and guanine (G). These four bases can be further divided into two groups based on their atomic structure: A and G are called purines, and T and C are called pyrimidines. Each nitrogenous base has a specific partner with which it shares a hydrogen bond. Adenine always binds to thymine by forming two hydrogen bonds, and cytosine always binds only to guanine by forming three hydrogen bonds.

The structure of DNA is like a ladder that has been twisted into a spiral. This shape is known as a double helix.

2. Return to the puzzle that you constructed, and label and color it according to the following key.
 - Deoxyribose (sugar molecule): purple
 - Phosphate: orange
 - Nitrogenous bases
 - Adenine: blue
 - Thymine: red
 - Guanine: green
 - Cytosine: yellow
 - Hydrogen bond: label the bond
3. After labeling and coloring your DNA puzzle, pair with another student, and use your puzzle pieces to create a DNA model with this DNA sequence: ACTGCATG.
4. In the space below, draw a simplified model of your new DNA puzzle. Use the appropriate letters to represent the nitrogenous bases, and be sure to follow the base-pairing rules. Include the hydrogen bond.
5. What are the three parts of a nucleotide in a DNA molecule?
6. DNA looks like a twisted ladder. What makes up each rung of the ladder? What holds the rungs together?



Explore

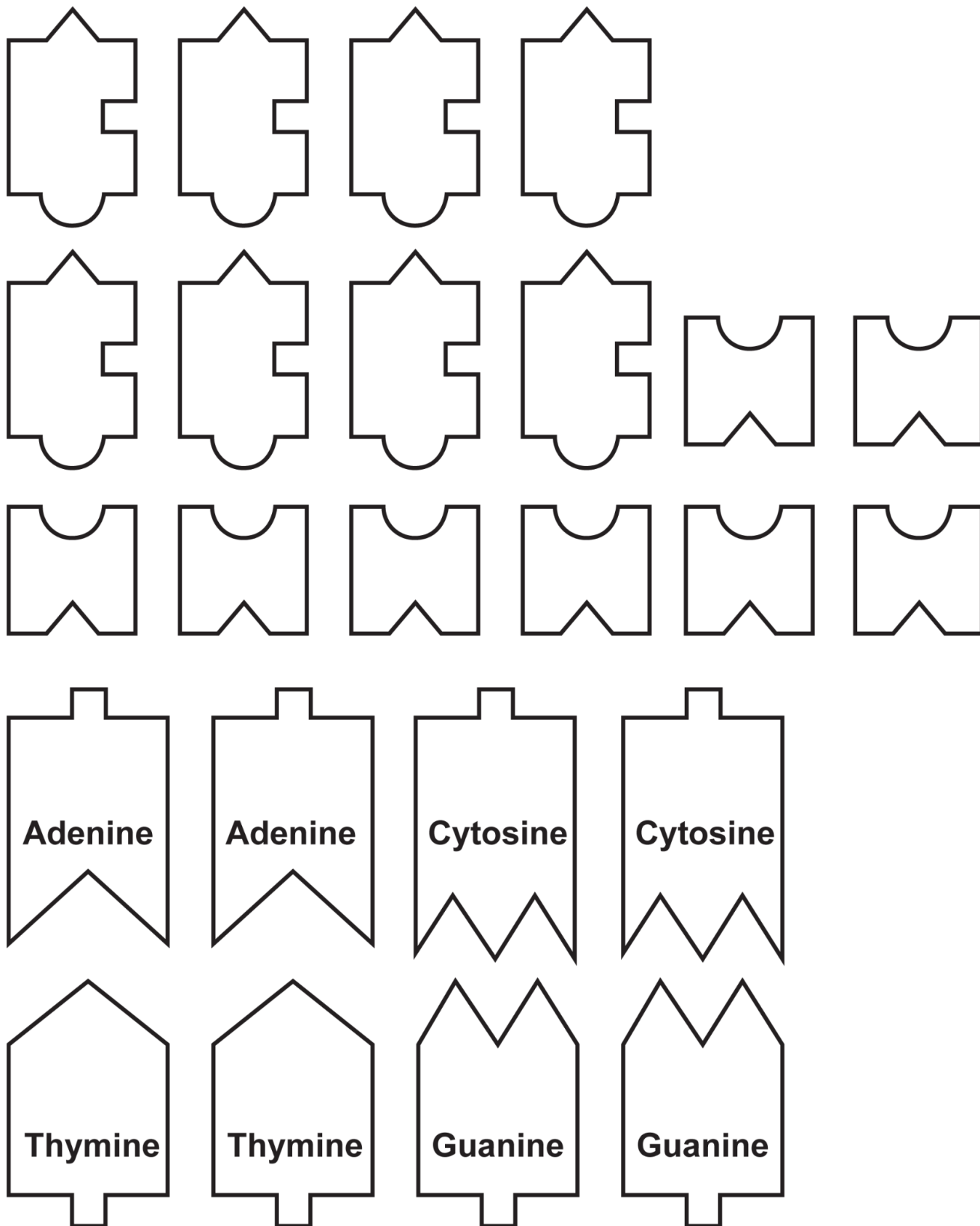
7. Describe what “base pairing” means. What did you have to pay attention to when you were building your DNA molecule model?
8. If one side of the DNA strand has the base sequence ATGGCAATGTTACTAG, what is the base sequence of the complementary strand?
9. How does DNA code for traits?

Reflections and Conclusions

1. What makes your DNA different from someone else's?
2. A segment of DNA contains 24% thymine. How much of the segment is guanine? Explain how you got your answer.
3. What is an advantage of building a model of DNA? What are two limitations of the DNA model that you created? What properties of DNA cannot be demonstrated using this model?



DNA Puzzle





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Make a Sandwich

The central dogma of biology describes the flow of genetic information in a living organism. DNA contains the instructions for life. It is copied to RNA, which is then read to create the proteins that make our cells, tissues, organs, and organ systems. Proteins are complex biomolecules that are made of one or more amino acid polymers that are joined together by peptide bonds and then folded into a complex structure that performs a specific function. In this activity, you will make a sandwich to model the process of protein formation and complete transcription and translation for a DNA sequence.

Procedure

Part I

1. Complete the scenario that is provided by your teacher to model how proteins are made using the analogy of making a sandwich.
2. Once you have completed the activity, answer questions 1–5 below.

Part II

1. Get a set of DNA sequences from your teacher.
2. Have each person in your group choose one of the four DNA sequences.
3. Transcription is the process in which a strand of DNA is copied into a messenger RNA (mRNA) strand for the purpose of protein synthesis. You and your teacher will go through the process of transcription and translation, step by step, with the following sample DNA strand and sequence:
 - a. DNA: 3' TACGTTAGGAACCCCACGCTGGATCATATT 5'
 - b. mRNA:
 - c. mRNA codons (with the start codon in bold): **AUG** CAA UCC UUG GGG UGC GAC CUA GUA UAA
 - d. AA:
4. After your teacher has modeled the process, transcribe your chosen DNA strand into mRNA.
 - a. Start at the 3' end of the DNA strand.
 - b. Match each base on the DNA strand with the corresponding base for RNA. (Remember that DNA pairs adenine with thymine, but RNA pairs adenine with a different nitrogenous base called uracil.)
 - c. Record the new mRNA strand sequence on your copy of DNA Sequences under the DNA sequence that you chose.



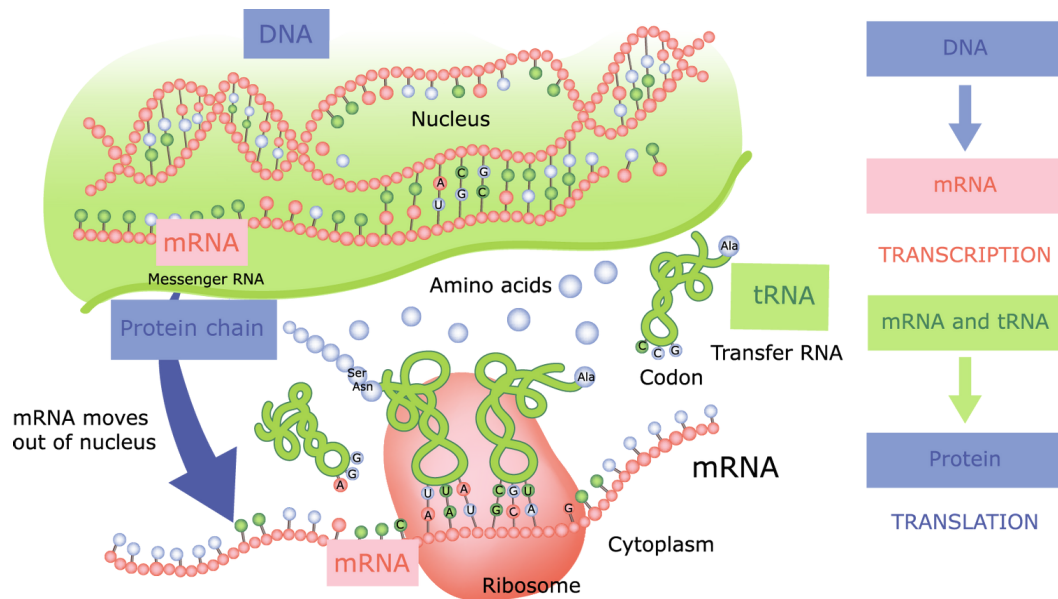
5. Have a group member check that you have correctly transcribed your DNA sequence to an mRNA sequence.
6. Next, translate the mRNA strand. Translating mRNA means reading the mRNA in three-base sections called codons to assemble amino acids (AA) in a specific sequence to form a protein.
 - a. Find the start codon, AUG.
 - b. Divide all of the bases after the first codon into three-base sections, and record these on your copy of DNA Sequences under the DNA sequence that you chose.
 - c. On your Codon Chart, find the start codon's first letter, A. Then, find its second letter, U. Find the third letter, G, on the far side of the chart.
 - d. Note that where these letters meet on the chart is the abbreviation Met, indicating the amino acid methionine.
 - e. Record "Met" in the AA portion of your copy of DNA Sequences below the DNA sequence that you chose.
 - f. Follow the same procedure to translate each of the remaining three-base codons into amino acids.
 - g. Record each AA on your copy of DNA Sequences.
7. Answer the remaining questions below.

Questions

1. Does the sandwich have all of the needed ingredients?
2. Does the sandwich have the correct order of ingredients?
3. Would a change in the order of the ingredients change the taste of the sandwich?



4. This process simulated protein synthesis. After reviewing the image that explains protein synthesis, in the chart below, identify the cell structure and function that each part of the scenario represented.



Part in Scenario	Cell Structure	Function
House		
Student stuck in house		
Sibling retrieving sandwich		
Sandwich builder		
Ingredient carriers		
Ingredients		
Sandwich		



Explore

5. What cell structure do you think the sandwich-shop owner represents? What is their role in the protein-making process?
6. The function of a protein is determined by the shape of the molecule. The shape is determined by the order of amino acids. How does DNA determine the order of amino acids?
7. What nitrogenous base is found in your DNA sequence but not in your mRNA sequence? Why?
8. Does the order of amino acids in a protein matter? Explain your answer.
9. Given the DNA sequence 3' TACTAAACCACGACAATC 5', what is the amino acid sequence? Go through the steps from DNA to mRNA to protein.
10. How is the process of making a sandwich like that of making a protein? How is it different? (Read the introduction again if needed.)



Reflections and Conclusions

1. How did this activity demonstrate the central dogma of biology?
2. What is the difference between transcription and translation?



Name: _____ Date: _____

DNA Sequences

Sequence 1

DNA: 3' TACAAAAACAAGCTAGTACACTTGATC 5'

mRNA:

mRNA codons:

AA:

Sequence 2

DNA: 3' TACTAATTGAGGGAATAGTATTCAATT 5'

mRNA:

mRNA codons:

AA:

Sequence 3

DNA: 3' TACGTTCAACACTTCCAGCCACGTACT 5'

mRNA:

mRNA codons:

AA:

Sequence 4

DNA: 3' TACTGGGTATGTCTGGCGTATGGGTCATC 5'

mRNA:

mRNA codons:

AA:



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Sandwich Menu

Choose from these ingredients to make your sandwich. You must pick at least one ingredient from each category to have between 10 and 20 sandwich components. You may have duplicates of the same ingredient if you like, but each duplicate counts as one of your 20-count maximum. Your ingredients can be assembled in any order you choose, but you must start and end your ingredient list with a choice of bread.

Breads

- Whole wheat
- Italian
- Honey wheat

Cheeses

- Cheddar
- American
- Swiss

Meats

- Ham
- Turkey
- Bacon

Veggies

- Lettuce
- Tomato
- Pickle

Condiments

- Salt
- Pepper
- Mustard



Ingredient Cards

Whole wheat	Whole wheat
Italian	Italian
Honey wheat	Honey wheat
Cheddar	Cheddar
American	American



Swiss	Swiss
Ham	Ham
Turkey	Turkey
Bacon	Bacon
Lettuce	Lettuce
Tomato	Tomato
Pickle	Pickle



Salt	Salt
Pepper	Pepper
Mustard	Mustard



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Codon Chart

First Letter	Second Letter				Third Letter
	U	C	A	G	
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



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Enzyme Simulation

Introduction

Enzymes are special types of proteins that catalyze biochemical reactions. Enzymes work to speed up biological reactions but are not used up in the process. The substance on which an enzyme acts is called a substrate. In this investigation, you will simulate the reaction of an enzyme with its substrate. You will pretend that toothpicks are the substrate to be broken down and your hand is the enzyme. However, not all enzymes have the same shape. Each group member's hand will be modified slightly to represent different shaped enzymes.

Question

How does changing the shape of enzymes impact their function?

Hypothesis

Materials

Flat toothpicks
Bowl
Tape

What, if any, safety steps need to be taken?

Procedure

Part I: Design of Enzymes

1. You will be divided into groups of four.
2. Each student in your group will be assigned a letter, *A* through *D*. Using tape, modify the hand you will be using to break the toothpicks according to your assigned letter:
 - A. Tape together the thumb and pointer finger.
 - B. Tape together the ring and pinky finger.
 - C. No modification.
 - D. Tape together all fingers except for the thumb.



Part II: Enzyme Activity

The Rules

- You must break each toothpick one at a time.
- You must break each toothpick with one hand ONLY.
- You must break each toothpick completely in half.
- You cannot rebreak a broken toothpick.
- All broken toothpicks must remain in the bowl along with the unbroken toothpicks.
- You cannot begin before the teacher says, “GO!”
- You must stop precisely when the teacher says, “STOP!”
- Keep your eyes closed during this portion of the investigation.

Play the Game

1. Count out 50 unbroken toothpicks into a bowl on your desk.
2. When the teacher says, “GO!” begin breaking toothpicks.
3. At the end of 1 minute, the teacher will say, “STOP!”
4. Count and record the total number of toothpicks broken.
5. Report your group’s data.
6. Record class data.

Data

Enzyme Modification	Number of Toothpicks Broken	Class Total Number of Toothpicks Broken
A		
B		
C		
D		



Part III: What's the Connection?

Almost all the chemical reactions that take place within cells are catalyzed by enzymes. Enzymes are biological catalytic proteins that lower the activation energy needed to start a chemical reaction and, as a result, greatly increase the rate of the reaction. The structure of an enzyme is based on the interaction and bonding of amino acids that make up the protein. There are thousands of different enzymes in a cell, and they are structurally diverse. The structure of the enzyme determines the chemical reaction that it will catalyze.

How does DNA impact the function of enzymes?

Claim:

Evidence:

Reasoning:



Rubric for Writing a Scientific Explanation

Points Awarded	2	1	0
Claim	Answers the question, and is accurate based on data.	Answers the question, but is inaccurate based on data.	No claim, or does not answer the question.
Evidence	Cites data and patterns within the data and uses labels accurately.	Cites data from the data source, but not within the context of the prompt.	No evidence, or cites changes, but does not use data from the data source.
Reasoning	Cites the scientifically accurate reason, using correct vocabulary, and connects this to the claim. Shows accurate understanding of the concept.	Cites a reason, but it is inaccurate or does not support the claim. Reasoning does not use scientific terminology or uses it inaccurately.	No reasoning, or restates the claim but offers no reasoning.



Linking Literacy

Name: _____ Date: _____

Vocabulary Table

Before reading, look at the vocabulary terms listed below. Evaluate your own understanding of each term, and write if you “know it,” have “seen it,” or have “no clue” about it. Attempt to define each term, using your collective knowledge, context clues, etc. Then, while reading, make corrections to your definitions, and draw images to further clarify.

Word	Know It Seen It No Clue	Definition	Image
Amino acid			
Catalyst			
Chromosomes			
Codon			
DNA			
Enzymes			
Genes			
Gene expression			
Hydrogen bond			



mRNA			
Nitrogen base			
Nucleotide			
Phosphate			
Protein synthesis			
RNA			
Ribosome			
Trait			
Transcription			
tRNA			
Translation			