Message to Molecule

Trace how a cell makes a protein and where the process can fail.

BIO.3C.2 "Evaluate the mechanisms of transcription and translation in protein synthesis."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline steps that make or process mRNA, circle steps that build an amino acid chain, and number two places where a change could affect the final protein.

Making Hemoglobin

1. A red blood cell precursor makes hemoglobin before the cell matures. A mature human red blood cell has no nucleus and cannot make new hemoglobin. In the precursor's nucleus, RNA polymerase attaches near the hemoglobin gene and separates a short stretch of DNA. It reads one DNA strand as a template and builds a complementary RNA strand, using U instead of T. This first product, called pre-mRNA, carries the gene's information while the DNA stays in the nucleus. If polymerase cannot begin or stops early, the cell lacks a complete message for that protein.

2. Before the message leaves the nucleus, the cell removes introns and joins the remaining exons. This processing produces mature mRNA. Outside the nucleus, a ribosome binds the mRNA and reads its bases three at a time, in units called codons. A start codon sets the reading frame, so each later codon is read in the intended group of three. Transfer RNA molecules, or tRNAs, pair with codons and carry particular amino acids. The ribosome links the amino acids in order until it reaches a stop codon. This stage is translation, not another copy of DNA.

3. These stages can fail in different ways. A change in DNA may be copied into mRNA, but it does not always alter the protein because more than one codon can specify the same amino acid. Removing one base from a coding region can shift how the ribosome groups later codons, potentially changing many amino acids. Even with an accurate mRNA, a ribosome that cannot move along it will not finish a protein. Hemoglobin works because its amino acid chains fold and join in a specific way. Producing an RNA message, therefore, does not guarantee a working hemoglobin molecule.

2 ANSWER WITH EVIDENCE

Use the passage

1. A chemical prevents RNA polymerase from attaching near the hemoglobin gene. How would this affect both transcription and translation of that gene?

2. An mRNA is processed correctly, but tRNAs cannot pair with its codons. Which stage is directly disrupted, and what happens to the amino acid chain?

3. A ribosome loses its place and reads the next codon starting one base late. Why could many amino acids change even though the mRNA has not changed?

4. A DNA base changes, but the hemoglobin chain has the same amino acid sequence. How is this possible, and during which stage is the changed message read?

3 YOUR TURN

Your own words

Invent a cell that makes a protein for a job you choose. In four or five sentences, describe a transcription error and a different translation error not used in Part 2, predict each error's effect on the protein, and explain how checking mature mRNA could tell the errors apart.

ANSWER KEY

Message to Molecule

HIGH SCHOOL · BIO.3C.2

PART 1 · READ AND MARK

Underline steps that make or process mRNA, circle steps that build an amino acid chain, and number two places where a change could affect the final protein. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	A chemical prevents RNA polymerase from attaching near the hemoglobin gene. How would this affect both transcription and translation of that gene?	**Transcription could not begin, so the cell would not make that gene's mRNA. Without the mRNA, ribosomes could not translate it into a new hemoglobin chain.**
2	An mRNA is processed correctly, but tRNAs cannot pair with its codons. Which stage is directly disrupted, and what happens to the amino acid chain?	**Translation is directly disrupted. The ribosome cannot add the amino acids specified by the codons, so it cannot complete the chain.**
3	A ribosome loses its place and reads the next codon starting one base late. Why could many amino acids change even though the mRNA has not changed?	**Codons are read in groups of three. Starting one base late changes the grouping of later bases, so many later codons may specify different amino acids.**
4	A DNA base changes, but the hemoglobin chain has the same amino acid sequence. How is this possible, and during which stage is the changed message read?	**The changed codon may specify the same amino acid as the original codon. A ribosome reads the changed mRNA during translation.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

A skin cell makes a protein that helps cells stick together. During transcription, RNA polymerase inserts an incorrect RNA base, changing a codon in the mature mRNA, so the protein may contain a different amino acid. In another cell, the mRNA is normal, but a ribosome cannot recognize its start codon, so the protein chain cannot begin. Comparing the cells' mature mRNA would reveal a changed sequence only in the first cell.

Accept other plausible errors if the response distinguishes a change to the RNA message from a failure to translate an intact message. A changed codon may still specify the same amino acid, so students may describe a possible rather than certain protein change.