A Change That Travels

Trace a DNA change from protein structure to organ function.

HS-LS1-1 "Construct an evidence-based explanation for how the structure of DNA determines the structure of proteins which carry out the essential functions of life through systems of specialized cells, tissues, and organs. (SEP: 6; DCI: LS1.A..."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline the DNA change, circle the change in the protein, and number three effects that follow at the cell, tissue, and organ levels.

Why One Base Matters

1. During a sprint, muscle cells need oxygen to release energy from food. Red blood cells are specialized to move oxygen through blood, a tissue that travels between organs. Their hemoglobin proteins bind oxygen in the lungs and release it near body cells. A red blood cell begins as a developing cell in bone marrow. That developing cell has DNA, including the HBB gene, which contains instructions for one protein chain in hemoglobin. As it matures, the red blood cell loses its nucleus. Its hemoglobin remains and keeps working even though the mature cell no longer has DNA.

2. The order of bases in HBB determines the order of amino acids in a beta-globin chain. In a developing red blood cell, an RNA copy carries the gene's instructions to ribosomes, where amino acids are joined in order. Beta-globin chains combine with other protein chains to make hemoglobin. In one version of HBB, a single DNA base change causes valine to replace glutamic acid at one position in beta-globin. The rest of the chain is unchanged, but the new amino acid changes a spot on the protein's surface. This small difference becomes especially important when oxygen levels drop.

3. When oxygen is low, hemoglobin with this altered surface can stick to other hemoglobin molecules and form long fibers. The fibers can make red blood cells stiff and curved. These cells may break apart sooner than usual or clog tiny blood vessels. Less oxygen then reaches tissues such as muscle, and blocked vessels can damage organs such as the spleen. This condition is called sickle cell disease. The chain of evidence runs from a DNA base change to a changed amino acid, then to altered protein interactions, cell shape, blood flow, and organ function.

2 ANSWER WITH EVIDENCE

Use the passage

1. How does the change in HBB lead to a change on hemoglobin's surface?

2. A mature red blood cell has no nucleus. How can its DNA instructions still affect the job it does?

3. Why can low oxygen levels make the altered hemoglobin affect blood flow?

4. Trace how the change in one protein can harm an organ named in the passage.

3 YOUR TURN

Your own words

In a different case, a DNA change replaces one amino acid in a protein that forms channels in kidney tubule cells; tests show that the changed protein folds poorly, fewer channels reach the cell surface, and these channels normally move salt from tubule fluid into cells. Write four or five sentences that use these observations to explain a possible effect on kidney function, and make clear which effect you are predicting.

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PART 1 · READ AND MARK

Underline the DNA change, circle the change in the protein, and number three effects that follow at the cell, tissue, and organ levels. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How does the change in HBB lead to a change on hemoglobin's surface?	**The DNA base change replaces glutamic acid with valine in a beta-globin chain, changing a spot on the surface of the hemoglobin protein.**
2	A mature red blood cell has no nucleus. How can its DNA instructions still affect the job it does?	**While the cell was developing, its HBB instructions helped it make beta-globin. The hemoglobin containing that chain remains after the cell loses its nucleus and affects how the cell carries oxygen.**
3	Why can low oxygen levels make the altered hemoglobin affect blood flow?	**At low oxygen levels, altered hemoglobin can stick together in fibers. The fibers can make red blood cells stiff and curved, allowing them to clog tiny blood vessels.**
4	Trace how the change in one protein can harm an organ named in the passage.	**Altered hemoglobin can form fibers that stiffen red blood cells. The cells can block tiny vessels, reducing blood flow and damaging an organ such as the spleen.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

The DNA change replaces one amino acid in a kidney cell's channel protein. Tests show that the changed protein folds poorly and that fewer channels reach the cell surface. Because these channels normally move salt from tubule fluid into cells, fewer channels may allow less salt to move. I predict that more salt could remain in the fluid and leave the body in urine, reducing the kidney's ability to balance salt.

Accept explanations that connect DNA sequence, amino acid sequence, protein structure, and effects on cells and organs. For Part 3, accept a supported prediction about reduced salt movement without requiring a claim about water movement.