Breathing for Balance

Trace how carbon dioxide sensing helps maintain blood pH.

HS-AP11-4 "Construct an explanation for maintaining blood pH via specialized carbon dioxide receptors and the respiratory response."

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline each change in carbon dioxide or pH, circle the chemoreceptors and breathing control centers, and number the steps that bring blood pH back toward its usual range.

On the Stadium Stairs

1. Halfway up a long set of stadium stairs, Maya notices that her breathing is faster. Her leg muscles are using more fuel, so their cells release more carbon dioxide (CO_2) into her blood. The blood carries that gas to her lungs. Some CO_2 also reacts with water in the blood, producing carbonic acid, which releases hydrogen ions (H^+). As the amount of CO_2 rises, the concentration of H^+ tends to rise and blood pH tends to fall. A change in pH matters because body proteins work best within a narrow range.

2. The body does not wait for Maya to decide how fast to breathe. Specialized chemoreceptors monitor the changing chemistry. Receptors in the brainstem respond to changes in the pH of fluid around the brain, caused largely by CO_2 entering that fluid. Receptors near major arteries in the neck and chest can respond to changes in blood CO_2 and pH. When CO_2 rises, these sensors send information to breathing control centers in the brainstem. Those centers increase signals to the diaphragm and other breathing muscles. The result is faster, often deeper breathing, which moves more air through the lungs each minute.

3. With more air moving through her lungs, Maya exhales CO_2 more quickly. CO_2 can then move from her blood into the air in her lungs and leave her body. As blood CO_2 falls toward its usual level, the concentration of hydrogen ions falls, and blood pH moves back toward its usual range. This response is negative feedback: a rise in CO_2 triggers breathing changes that oppose the original rise. While Maya keeps climbing, her muscles still make extra CO_2, so maintaining pH requires continued adjustment, not a single corrective breath.

2 ANSWER WITH EVIDENCE

Use the passage

1. Explain how the extra CO_2 from Maya's leg muscles can cause her blood pH to fall.

2. The chemoreceptors described in the passage monitor different fluids. Explain how both can provide information about a rise in CO_2.

3. Trace the response from a chemoreceptor signal to a change in Maya's blood CO_2 level.

4. Why is Maya's faster breathing negative feedback, and why must the response continue while she climbs?

3 YOUR TURN

Your own words

At rest, a student deliberately breathes fast and deeply for one minute, then lets breathing return to automatic control. In four or five sentences, predict how blood CO_2 and pH change, how chemoreceptors and breathing centers respond, and how that response tends to restore pH.

Breathing for Balance

PART 1 · READ AND MARK

Underline each change in carbon dioxide or pH, circle the chemoreceptors and breathing control centers, and number the steps that bring blood pH back toward its usual range. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	Explain how the extra CO_2 from Maya's leg muscles can cause her blood pH to fall.	**Some extra CO_2 reacts with water to form carbonic acid, which releases H^+. A higher H^+ concentration lowers blood pH.**
2	The chemoreceptors described in the passage monitor different fluids. Explain how both can provide information about a rise in CO_2.	**Receptors near major arteries respond to changes in blood CO_2 and pH. Brainstem receptors respond to the pH of fluid around the brain, which changes when CO_2 enters it.**
3	Trace the response from a chemoreceptor signal to a change in Maya's blood CO_2 level.	**Chemoreceptors signal breathing control centers, which send stronger signals to breathing muscles. Faster, often deeper breathing increases airflow and CO_2 exhalation, lowering blood CO_2 toward its usual level.**
4	Why is Maya's faster breathing negative feedback, and why must the response continue while she climbs?	**Rising CO_2 triggers breathing that removes CO_2, opposing the original rise and helping restore pH. Her muscles keep producing extra CO_2 while she climbs.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Breathing fast and deeply at rest removes CO_2 faster than cells replace it, so blood CO_2 falls. With less CO_2 available to form carbonic acid, hydrogen ion concentration falls and blood pH rises. Chemoreceptors detect the change in CO_2 or pH and signal the breathing control centers. When the student stops deliberately breathing fast, automatic breathing slows, less CO_2 is exhaled, and blood pH moves toward its usual range.

Accept answers that distinguish the brainstem receptors' response to surrounding fluid pH from the arterial receptors' response to blood chemistry. For Part 3, look for the reversed CO_2 and pH changes and a respiratory response that opposes them.