Build a Breath

Model chest movement, pressure, and airflow

HAP.12.4 "Enrichment: Use an engineering design process to develop a model of the mechanisms that support breathing and illustrate the inverse relationship between volume and pressure in the thoracic cavity.*"

NAME _____ DATE _____

1 READ AND MARK

Read it twice

YOUR JOB Underline one action that enlarges the chest and one that enlarges the model's sealed space, then circle the pressure change linked to each. Write 1 beside the sentence where air enters the balloon and 2 beside the sentence where air leaves it.

A Breathing Model Under Test

1. At a school science fair, a student wants to show how a quiet breath begins. During inhalation, the diaphragm contracts and moves downward. The external intercostal muscles lift the ribs up and outward. These actions enlarge the thoracic cavity, the space within the chest. As this space expands, pressure around the lungs drops. The lungs expand with the chest because thin pleural membranes and a film of fluid help couple their movement to the chest wall. Expansion lowers air pressure inside the lungs below atmospheric pressure, so air flows inward. Air moves because of a pressure difference, not because the lungs pull it in.

2. For a tabletop model, the student puts a small balloon inside a rigid container with openings at both ends. The balloon's neck passes through the top opening and remains open to room air. A flexible membrane seals the bottom opening. Pulling the membrane down increases the volume of the sealed space around the balloon. Its pressure falls, allowing air from the room to enter and inflate the balloon. Pushing the membrane back up decreases that space's volume and raises its pressure. The balloon then shrinks as air exits. The membrane represents the diaphragm, but the rigid container cannot show moving ribs.

3. Before building, the student sets a criterion: the balloon must inflate when the membrane moves down and deflate when it moves up. The model must also use only a container, balloon, membrane, and reusable sealing material. In the first test, the balloon barely moves. A gap around the balloon's neck lets outside air enter the container, so the pressure around the balloon does not drop enough. The student seals that gap and repeats the same pull to check for a larger change. Even after this revision, the container remains rigid. The student records this limitation instead of claiming the model shows every breathing muscle.

2 ANSWER WITH EVIDENCE

Use the passage

1. How do diaphragm and rib movements during inhalation lead to air entering the lungs? Include volume and pressure in your answer.

2. In the model, what happens to the sealed space's volume and pressure when the membrane is pushed up? Explain the balloon's response.

3. Which model part represents the diaphragm, and what movement of that part models inhalation? Explain why the balloon inflates.

4. Why does the student seal the gap and repeat the same pull rather than pull farther? What result would show the revision helped?

3 YOUR TURN

Your own words

In two labeled panels, redesign the rigid container so your model can show rib movement during inhalation and exhalation. Below the panels, write two sentences explaining the volume-pressure changes and one way to test your redesign.

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PART 1 · READ AND MARK

Underline one action that enlarges the chest and one that enlarges the model's sealed space, then circle the pressure change linked to each. Write 1 beside the sentence where air enters the balloon and 2 beside the sentence where air leaves it. Accept any marking that follows this job and points at the right text.

PART 2 · ANSWERS

#	QUESTION	ANSWER
1	How do diaphragm and rib movements during inhalation lead to air entering the lungs? Include volume and pressure in your answer.	**The diaphragm moves down and the ribs move up and outward, increasing thoracic volume. Pressure around the lungs drops, the lungs expand, and their internal pressure falls below atmospheric pressure, so air enters.**
2	In the model, what happens to the sealed space's volume and pressure when the membrane is pushed up? Explain the balloon's response.	**The sealed space's volume decreases and its pressure rises. The balloon shrinks as air leaves it.**
3	Which model part represents the diaphragm, and what movement of that part models inhalation? Explain why the balloon inflates.	**The flexible bottom membrane represents the diaphragm. Pulling it down increases the sealed space's volume and lowers pressure around the balloon, allowing room air to enter it.**
4	Why does the student seal the gap and repeat the same pull rather than pull farther? What result would show the revision helped?	**Repeating the same pull keeps the movement comparable while testing whether sealing the leak helps pressure drop. Greater balloon inflation would show the revision helped.**

PART 3 · YOUR TURN (SAMPLE ANSWER)

Panel 1, inhalation: flexible airtight side wall pulled outward by hinged supports labeled ribs; bottom membrane lowered; balloon larger. Panel 2, exhalation: supports moved inward; bottom membrane raised; balloon smaller. With the side wall pulled outward and the membrane lowered, enclosed volume rises and pressure falls, so the balloon inflates. When the wall moves inward and the membrane rises, volume falls and pressure rises, so the balloon deflates; I would also hold the membrane still and move only the supports to test whether they change balloon size.

Accept other feasible designs with a sealed, movable wall that represents rib movement. The explanation should link greater enclosed volume to lower pressure and smaller enclosed volume to higher pressure, and the test should identify an observable result.