3. Air Pressure and the Lungs

Take a Breath

Driving Question

How do you inhale and exhale with your lungs?

Materials and Equipment

For each student or group:

- ☐ Data collection system
- ☐ Absolute pressure sensor
- ☐ Metabolism chamber
- ☐ Quick-release connector
- ☐ Tubing
- ☐ 1-hole rubber stopper, #6 (2)
- ☐ Syringe, 60 mL
- ☐ Balloon, at least 12" diameter
- ☐ Tape
- ☐ Marker

Safety

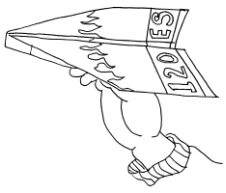
Follow all standard lab safety procedures.

Thinking about the Question

To investigate this question, you are going to use a model.

Have you ever made a paper airplane or played with a toy car or doll? These are models which in some way resemble their real counterparts. Have you ever used a flight simulator? Again, this is a model made to help people learn how to fly an aircraft. Often scientists make models, picking and choosing what aspects are most important to include in the model.

Look at the paper airplane below. How does this model resemble or behave like the real thing?



_____

_____

How does it differ from a real airplane?

_____

_____

Look at the list below and add a check mark for each of the items that represent a model.

___Matchbox car
___Guitar
___Soccer video game
___Area of rectangle = length x width
___Clock
___Pen
___Tree

Get together with the other members in your group and write a list of as many types of models as you can. Include your list below.

_____

_____

Sequencing Challenge

☐ **The steps below are part of the Procedure for this lab activity. They are not in the right order. Determine the proper order and write numbers in the circles that put the steps in the correct sequence.**

Pull out the plunger of the syringe to increase the volume and inflate the model "lung."	Make certain that each lab group member is aware of the safety rules and procedures for this lab activity.	Hang the large balloon down inside the metabolism chamber; stretch its opening over the mouth of the chamber.	Insert the stopper attached to the syringe into the side of the metabolism chamber.	Label a large balloon with the word "Lung."

Investigating the Question

☐ **Note:** When you see the symbol "" with a superscripted number following a step, refer to the numbered Tech Tips listed in the Tech Tips appendix that corresponds to your PASCO data collection system. There you will find detailed technical instructions for performing that step. Your teacher will provide you with a copy of the instructions for these operations.

Part 1 – Make a model of your lung

1. ☐ Use a marker to label a large balloon "Lung."

2. ☐ Place the large balloon down into the metabolism chamber bottle and carefully stretch the open end of the balloon over the mouth of the bottle.

3. ☐ Connect the 60-mL syringe to the rubber stopper with the shorter tubing.

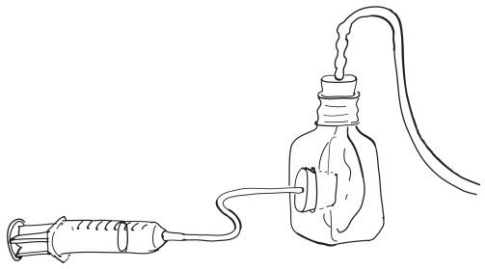
   ☐ **Note:** The plunger of the syringe should be pushed in all the way.

4. ☐ Connect the absolute pressure sensor to the longer piece of tubing.

5. ☐ Insert the rubber stopper connected to the syringe into the hole in the side of the metabolism chamber bottle.

6. ☐ Use a piece of tape to label the syringe "diaphragm."

7. ☐ Use another piece of tape to label the metabolism chamber bottle "Chest Cavity."



8. ☐ Start a new experiment on the data collection system. (1.2)

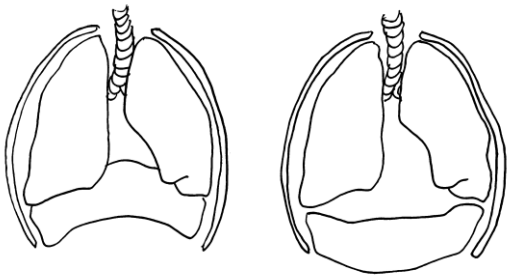
9. ☐ Connect the absolute pressure sensor to the data collection system. (2.1)

10. ☐ Display Absolute Pressure on the y-axis of a graph with Time on the x-axis. (7.1.1)

11. ☐ Change the sample rate to 2 samples per second. (5.1)

Part 2 – How do you inhale and exhale

12. ☐ Take a deep breath using your diaphragm.



a. When you inhale, what happens to your diaphragm?

_____

b. What do you think happens to the volume of your lungs when you take a deep breath using your diaphragm?

_____

13. ☐ Gently pull the plunger of the syringe until it reaches the maximum volume. What happens to the "lung" in the model when you pull the plunger on the syringe "diaphragm?" Why do you think this happens?

_____

_____

14. ☐ Insert the rubber stopper connected to the absolute pressure sensor into the balloon to close the top of the metabolism chamber bottle, being very careful not to tear the balloon.

15. ☐ Now, without touching the "diaphragm" of your model, start data recording to measure the air pressure in the balloon or "lung." ◆(6.2) Write the pressure in the space provided.

Pressure in the balloon "lung": _____ kPa

16. ☐ After measuring the pressure, stop data recording. ◆(6.2)

17. ☐ Return your lung model to its initial condition.

a. Remove the stopper connected to the absolute pressure sensor from the bottle.

b. Depress the plunger of the syringe so it is at minimum volume.

18. ☐ Replace the stopper connected to the absolute pressure sensor in the mouth of the metabolism chamber bottle.

19. ☐ Begin data recording. ◆(6.2)

20. ☐ Measure the air pressure inside the "lung" as you slowly pull out on the syringe plunger "diaphragm," hold it at maximum volume for a few seconds, and then slowly depress the syringe plunger "diaphragm" back to its minimum volume.

21. ☐ Repeat this series of volume changes three times to make sure your results are consistent. Each time you move the plunger of the syringe observe the balloon "lung" very carefully for any changes in the volume of air inside the "lung." What have you just modeled with this series of changes in volume?

_____

22. ☐ Stop data recording. ◆(6.2)

23. ☐ Review your graph of absolute pressure versus time. Select which happens to the volume of air in the "lung" when the pressure in the "chest cavity" decreases?

____ When pressure decreases in the chest cavity the air volume in the lung increases.

____ When pressure decreases in the chest cavity the air volume in the lung decreases.

____ When pressure decreases in the chest cavity the air volume in the lung stays the same.

24. ☐ Using what you understand about air pressure, explain why the balloon inflates. Be prepared to share your answer with the class.

_____

_____

25. ☐ If you wanted the "lung" balloon to inflate even more, what would you need to do to the air pressure in the "chest cavity"?

____ Raise it

____ Lower it further

26. ☐ Explain your choice above. Be prepared to share your answer with the class.

_____

_____

_____

Answering the Question

Analysis

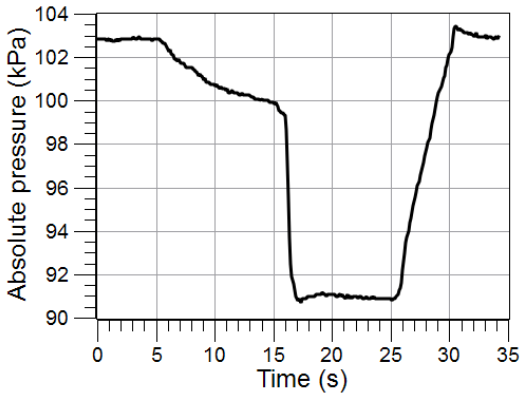
1. How did using a model help you better understand what is happening when you breathe?

_____

_____

_____

2. Using your chest cavity and lung model, someone created the following graph by measuring air pressure in the "chest cavity."



Select which of the following is a possible explanation for the graph.

____ The "diaphragm" plunger was pulled out quickly and then released.

____ The "diaphragm" plunger was pulled out slowly for about 11 seconds then pulled out further quickly and held for 9 seconds, and then depressed back in.

____ The "diaphragm" plunger was pulled out quickly, held, and then depressed over a period of 12 seconds.

3. What must happen inside the body in order for the lungs to take a breath? Use evidence from this lab activity to support your reasoning.

_____

_____

_____

4. The forces exerted by the air on the lungs are either balanced forces or unbalanced forces. Review your pressure data again carefully. According to your graph, when are the forces acting on the model lung balanced? How can you tell?

_____

_____

_____

5. Describe the forces acting on your own lungs when you hold your breath for a few seconds. Are the forces balanced or unbalanced?

_____

_____

6. Take a deep breath and then exhale the breath slowly. At what point in this deep breath is the pressure inside your chest cavity the lowest? How does this compare to the volume of air in your lungs?

_____

_____

_____

Key Term Challenge

☐ **Fill in the blanks from the randomly ordered words below:**

diaphragm	model	chest cavity	rib cage
lungs	gas	pressure	kilopascals
decrease	greater	volume	

1. In the human body the _____ are found within the_____,

which is protected by the bones of the_____.

2. During breathing the _____ lowers to expand the volume of the chest cavity,

which causes the_____to_____.

3. Scientists often use a _____ to represent specific aspects of something

they are investigating.

4. For a given amount of _____, the pressure will increase as the_____ decreases.

5. In the SI system of measurement _____, or kPa, is a unit of pressure.

6. The _____ the volume of a fixed amount of gas, the lower its pressure will be, as long as it is held at a constant temperature.