

I. TEACHER NOTES & GUIDELINES

TITLE OF LAB: Investigating Breathing Volumes

DEVELOPERS OF LAB

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OVERVIEW OF LAB

DESCRIPTION:

Human lung capacity can be measured several ways. One way to measure the capacity is to use a piece of laboratory equipment called a spirometer. A spirometer measures the volume of air that passes through it. In addition, lung capacity also can be measured by using a balloon. The data you obtain using a balloon may not be as accurate as that obtained using a spirometer.

Several different lung volume measurements can be made. The largest possible amount of air, which can be exhaled after drawing in a deep breath, is the vital capacity. The amount of air that remains in the lungs after exhaling normally but which can be expelled is the respiratory reserve. The volume of air taken in or expelled during normal breathing about 500cm^3 . This volume of air is called the tidal volume. A certain amount of air in the lungs cannot be expelled. This amount is the residual volume.

CURRICULUM CONSIDERATIONS: This lab can be used in General Biology or Regents Biology before or during the study of human respiration.

REAL WORLD APPLICATIONS: This lab demonstrates the variation of lung capacities from one individual to another. Effects of such variations as humidity, altitude, age, sex, habits(smoking or not), physical condition(fitness), and physiological condition(health conditions) can be tested and graphed.

SAFETY CONSIDERATIONS:

- ◆ Be careful with the balloons and spirometer mouthpieces.
- ◆ Do Not swallow them.
- ◆ Do Not inhale air from the balloon.
- ◆ Do Not share balloons or the spirometer mouthpieces. Everyone should have their own.

BACKGROUND INFORMATION

A. SCIENTIFIC VIEWPOINT:

An individual's lungs have a definite volume. The amount of gases that moves in and out of the lungs varies from one individual to another.

B. COMMON MISCONCEPTIONS:

- ◆ Lungs are totally empty when you exhale.
- ◆ Lungs are muscular and stretch when you inhale.
- ◆ Lungs function, literally, like a balloon.
- ◆ Lungs inhale and exhale by themselves.

OBJECTIVES

Upon completion of this lab, students will be able to:

- ◆ Measure, define, and distinguish among tidal volume, respiratory reserve, and vital capacity.
- ◆ Compare experimental data obtained with the balloon with lung capacity data obtained from a spirometer.
- ◆ Explain why differences may exist between your data, and the data provided for average lung capacities.
- ◆ Measure length in the metric system.
- ◆ Use a graph to convert data to other units.
- ◆ Compare data gathered using high tech and low-tech equipment.
- ◆ Recognize human and equipment error, and be able to synthesize a list of examples from this lab activity.
- ◆ Accurately record data into chart format
- ◆ Create a list of factors that influence lung volume.

EQUIPMENT/MATERIALS

PROVIDED BY SOTM:

- ◆ Spirometers Kimwipes
- ◆ Mouthpieces 70% alcohol

PROVIDED LOCALLY:

- ◆ 9" round balloons, 1 per student
- ◆ ruler

ADVANCE PREPARATION

- ◆ Order equipment from SOTM and buy balloons

II. PRE-LAB

PRE-LAB EXERCISE TO ELICIT STUDENTS' PRIOR KNOWLEDGE AND MISCONCEPTIONS

- ◆ Have students breath in and out, and then ask them what is happening in their respiratory system.
- ◆ What are the mechanisms involved in the process of inhalation and exhalation when somebody inhales smoke from a cigarette?
- ◆ Have students bring in magazine and newspaper articles related to breathing, smoking, and the respiratory system. Divide the class into groups. Based on their knowledge of biology and the article, ask students to prepare a 3-minute presentation on "How the Lungs Work."

DISCUSSION OF PRECONCEPTIONS

- ◆ Do you remove all the air from your lungs when you exhale? Explain why you think this?
- ◆ What happens to the air when it enters your lungs?

III. EXPLORATION OF SCIENTIFIC PRINCIPLE & INTRODUCTION OF EXPERIMENTAL PROTOCOL

PROBLEM

How can we measure and compare the data collected with a balloon to that collected using a spirometer for vital capacity, respiratory reserve, and tidal capacity?

EXPERIMENT AND TECHNICAL OPERATION OF EQUIPMENT

Part A: Vital Capacity

- ◆ Stretch a balloon several times.
- ◆ Take as deep a breath as possible. Then exhale all the air you can into the balloon (spirometer) and pinch the balloon closed to prevent air from escaping.
- ◆ Measure and record the diameter of the balloon in column A of Table 1. Use Figure 1 as a guide for measuring balloon diameter.
- ◆ Deflate the balloon and run four more trials. Record the diameter of the balloon for each trial.

Part B: Respiratory Reserve

- ◆ Read all of this part before starting
- ◆ Exhale normally

- ◆ Without inhaling as you normally would, put the balloon (spirometer) in your mouth and exhale all the air still left in your lungs. NOTE: This step is different from what you did for vital capacity
- ◆ Measure and record the diameter of the balloon in Column B of Table 1.
- ◆ Run four more trials.
- ◆ Record the diameter of the balloon for each trial.

Part C: Tidal Volume

- ◆ Take in a normal breath. Exhale into the balloon (spirometer) only as much air as you normally exhale. DO NOT force your breathing.
- ◆ Record the diameter of the balloon in centimeters in Column C of Table 1.

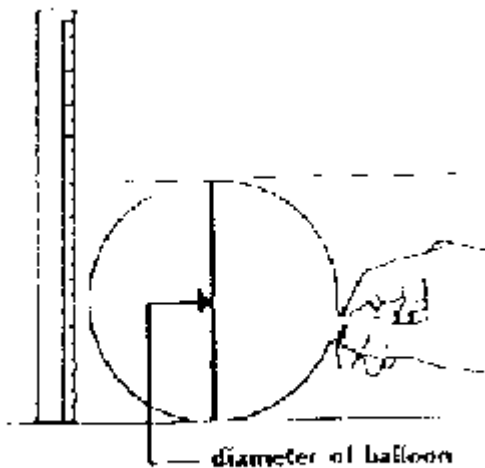


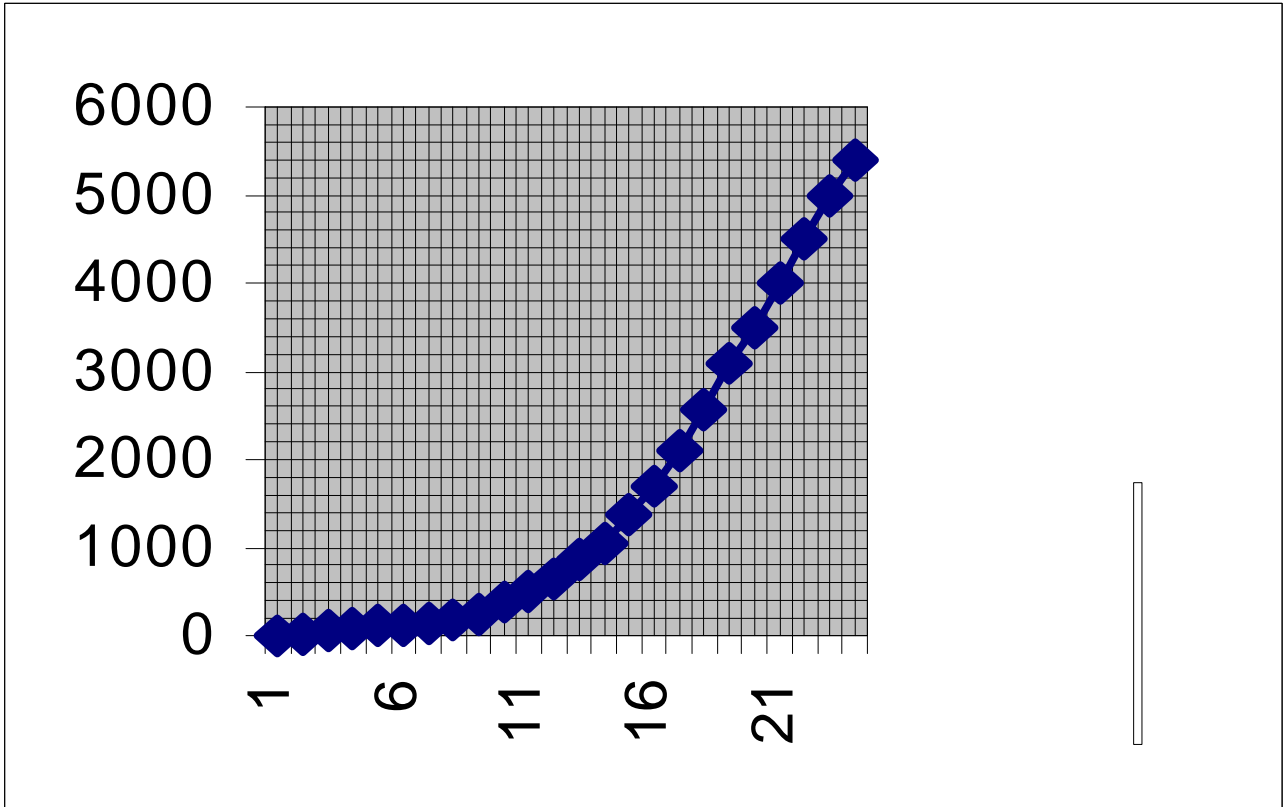
FIGURE 1

- ◆ Run four more trials.
- ◆ Measure and record each balloon diameter in Table 1.

Conversion of Diameters to Volume

- ◆ Lung volume is expressed in cubic centimeter units (cm^3).
- ◆ To convert from balloon diameter to volume, locate the balloon diameter on the horizontal axis of Figure 2. Follow this number up to the heavy line, and then move across to locate the corresponding volume. For example, if your balloon diameter is 14.5 cm, then the corresponding lung volume is 1500 cm. Use the dashed lines of Figure 2 as an example of how this procedure is done.
- ◆ Convert each diameter for vital capacity, tidal volume, and respiratory reserve to volume.
- ◆ Record the volumes in Column D, E, and F of Table 1.
- ◆ Calculate and record your average lung volume for each of the three measurements.

Lung
Volume
(cubic cm)



Balloon Diameter (cm)

TABLE 1: BALLOON DIAMETERS AND LUNG VOLUMES

TRIAL	BALLOON DIAMETER			LUNG VOLUME IN CUBIC CENTIMETERS		
	A VITAL CAPACITY	B RESPIRATORY RESERVE	C TIDAL VOLUME	D VITAL CAPACITY	E RESPIRATORY RESERVE	F TIDAL VOLUME
1						
2						
3						
4						
5						
				TOTAL		
				AVERAGE		

Using the Spirometer

- ◆ Obtain one of the spirometers and a clean mouthpiece.
- ◆ Attach the mouthpiece to the spirometer and set the dial to the zero. Don't forget to zero the spirometer before each trial!
- ◆ Following the procedures in parts A, B, and C, find your vital capacity, respiratory reserve and tidal volume using the spirometer.
- ◆ Record your data in Table 2. This data does not need to be converted.

TABLE 2: SPIROMETER RESULTS

TRIAL	SPIROMETER VOLUME		
	A VITAL CAPACITY	B RESPIRATORY RESERVE	C TIDAL VOLUME
1			
2			
3			
4			
5			
	TOTAL		
	AVERAGE		

IV. ELABORATION OF SCIENTIFIC PRINCIPLE: INQUIRY-BASED STUDENT INVESTIGATION

PROBLEM

How much air do your lungs hold? Leads to questions about how to do this, what equipment to use (balloons, flask and pan of water), spirometer.

When you exhale, does all the air exit your lungs?

Whose lungs hold more air:

- A smoker or non-smoker?
- An athlete or couch potato?
- A younger or older person?
- A small framed or large framed person?
- A female or male?

HYPOTHESIS

Using the results of the lab, use questions to help lead the students to formulate a hypothesis about the effects of one of the previously stated factors on breathing volume, or some other measurable aspect of breathing, and to make predictions about the results.

EXPERIMENTAL DESIGN

For the experiment(s) the student designs:

1. What are the control(s) and variable(s)?
2. What is the hypothesis?
3. What procedure will you use to test the hypothesis? What is an appropriate sample size?
4. What will you measure in the experiment to attain your outcome?
5. What safety precautions need to be addressed in your experiment?

Checkpoint (Have your experimental design approved by the teacher before proceeding) SEE RUBRIC FOR ASSESSMENT.

6. Students should have a written lab with specific materials and procedures at this point.

PLAN FOR DATA COLLECTION & ANALYSIS

1. Which of the following forms do you think is best to present your data? table(s), chart(s), graph(s).
2. Which of the forms will be best for interpreting your data?
3. How will your chart be labeled? What units are appropriate? Is the sample size appropriate?
4. In your experiment, what is the independent variable? (the part of the experiment that you vary or manipulate)
5. In your experiment, what is the dependent variable?
6. Analyze the relationship between the independent and dependent variables.

Checkpoint (Teacher checks students' plan for feasibility.)

CONDUCTING THE EXPERIMENT

The students should be engaged in the experiment. The teacher will monitor the students by checking their progress and safety considerations.

Checkpoint (Teacher monitors students' investigations in progress.)

ANALYSIS OF DATA

Checkpoint :Teacher uses the analysis portion of the rubric to assess student's lab.

Rubric for Assessment of Student Inquiry Lab

Student Name(s) _____

	Title of Lab	Evaluation			Teacher Checkpoints	
		Excellent (3 pts)	Satisfactory (2 pts)	Unsatisfactory (1 pt)	Completion Date	Teacher Initials
PROBLEM	Students have proposed a question.					
EXPERIMENTAL DESIGN	Students have proposed a hypothesis.					
	Students have stated a reason for predicted outcome.					
	Students have created procedure					
	Students have considered safety and viability.					
	Students have identified controls.					
CONDUCTING	Students have created a material list.					
	Students have successfully run procedure.					
	Students have recorded data correctly					
	Students have completed calculations.					
ANALYSIS	Students have listed % error and sources of error.					
	Students have proposed ways to improve the procedure.					

Have students tested their hypothesis?					
Are the student's conclusions consistent with their data?					
Are student's data, calculations and outcome logical and consistent with known scientific concepts?					
What new questions have arisen during this lab?					

DISCUSSION OF RESULTS

COMPARE

- ◆ Was your hypothesis confirmed or refuted? (supported or rejected?)
- ◆ How do your results compare to your preconceptions of what would happen?
- ◆ What experimental conclusions can you now draw from your data?
- ◆ List several examples of human error in this experiment, and explain how you could avoid that error.
- ◆ List several examples of equipment error in this experiment, and explain how you could avoid that error.

PERSUADE

Using the information in the preconception, misconception, and problem section, the teacher will formulate questions to guide students during discussion.

RELATE

- ◆ Students could create scenarios to be presented to elementary aged students to persuade the elementary students not to smoke.
- ◆ Students could create a collage of tobacco advertising, newspaper and magazine articles about smoking.

V. EVALUATION

POST-LAB SURVEY OF STUDENTS' CONCEPTIONS

Have students retake the Pre-Lab Exercise. Compare pre-lab and post-lab responses.

TRADITIONAL

I. MATCHING:

- | | |
|----------------------------|--|
| ___ 1. Exhale | A. Air entering lungs. |
| ___ 2. Respiratory reserve | B. Air leaves the lungs. |
| ___ 3. Inhale | C. Amount of air that usually move in and out of the lungs during breathing. |
| ___ 4. Lung capacity | D. Amount of air that usually stays in the lungs. |
| ___ 5. Residual volume | E. Amount of air that usually stays in the lungs after breathing out. |
| ___ 6. Tidal volume | F. The largest amount of air that can be exhaled from lungs after taking in a deep breath. |
| ___ 7. Vital capacity | G. The total amount of air that the lungs can hold. |

II. ESSAYS

1. In a complete sentence or two, describe and explain one way you accounted for your (and your partners) safety while doing the lab.
2. Explain in a complete sentence or two, why a physically fit Olympic athlete (like Florence Griffith Joiner) would have a larger vital capacity than an overweight, non-athletic couch potato.
3. Explain in a complete sentence or two the difference in the data obtained from the 2 types of instrumentation.
- 4a. List one reason why the data you collected using one of the types of equipment wasn't as accurate as it could be.
 - b. Explain in a complete sentence or two how the equipment could be adapted (changed) or substituted to eliminate the inaccuracy.

ALTERNATIVE ASSESSMENT #1

Create and Record an Infomercial on the Dangers of Smoking

Your task is to create a short infomercial on the danger(s) of smoking. Your target audience is elementary-age students. Your infomercial will be reviewed by the Surgeon General of the United States and her/his staff. They will vote on the two top infomercials and the ones selected will be aired on television or radio on Saturday morning.

You are given artistic freedom to produce this infomercial in any form. It can be in the form of rock lyrics, rhythm and blues, or a rap. It may also be a commercial video or interactive audience skit. Other project ideas may also be acceptable with teacher approval.

You and your production staff are to use the following guidelines:

- ◆ Your project should include current information that is biologically accurate.
- ◆ The infomercial should be a minimum of 3 and a maximum of 5 minutes.
- ◆ Your staff size should be a maximum of 4, including yourself.
- ◆ You must indicate a minimum of 5 facts about the anatomy (parts) and physiology (function) of the human respiratory system.
- ◆ You must indicate a minimum of 2 diseases associated with smoking and describe which anatomical features of the human respiratory system is affected and how each is affected.
- ◆ If you choose an interactive skit, you must list a minimum of 3 questions with possible answers appropriate to your audience.
- ◆ You must hand in an appropriate written or AV copy of your project (script, videotape, audiotape, etc)

Rubric for assessment of alternate 1:

Student Name(s) _____	Excellent	Satisfactory	Unsatisfactory
Presentation time within parameters			
Provided assigned facts about anatomy			
Provided assigned facts about physiology			
Provided assigned associated diseases			
Adequately explained effects of diseases			
Assignment uses appropriate form			
Provided current info on smoking			
Presentation was age appropriate			
Interactive skits included possible questions			
Project met time deadline(s)			

ALTERNATIVE 2: INFORMATION GATHERING ON THE INTERNET

Use the computer to search the Web to find information about smoking, quitting, preventing, tobacco companies, economic aspects of the tobacco industry, the historical aspect of the tobacco industry.

Web site address _____

1. What search engine did you use? _____
2. What word(s) did you use to begin your search?
3. How does this relate to the biology topic we are presently studying?
4. In a well-developed paragraph, describe the contents of this site.
5. Of the hyperlinks you found on this site, select one link that you believe warrants further investigation and would give us information about this unit of biology.
 - a. List one group or organization that would agree with the information found in this site.
 - b. List one group or organization that would disagree with the information found in this site.

Rubric for assessment of alternate 2

Student Name(s) _____

	Excellent	Satisfactory	Unsatisfactory
Web site address was correct			
Search engine was correct and appropriate			
Words for search engine were correct and appropriate			
Information at site was related to biology topic			
Student described site well			
Paragraph was well developed			
Student selected an appropriate hyperlink			
Student named an appropriate approving group or organization			
Student named an appropriate disapproving group or organization			

*This material is based upon work supported by the National Science Foundation under Grant No. ES1 9618936. Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

Name _____

Date _____

YOU ARE MY INSPIRATION

OVERVIEW OF LAB

DESCRIPTION: Human lung capacity can be measured several ways. One way to measure the capacity is to use a piece of laboratory equipment called a spirometer. A spirometer measures the volume of air that passes through it. In addition, lung capacity also can be measured by using a balloon.

Several different lung volume measurements can be made. The largest possible amount of air, which can be exhaled after drawing in a deep breath, is the vital capacity. The amount of air that remains in the lungs after exhaling normally but which can be expelled is the respiratory reserve. The volume of air taken in or expelled during normal breathing is called the tidal volume. A certain amount of air in the lungs cannot be expelled. This amount is the residual volume.

PROBLEM: How can we measure and compare the data collected with a balloon to that collected using a spirometer for vital capacity, respiratory reserve, and tidal capacity?

SAFETY CONSIDERATIONS

- ◆ Be careful with the balloons and spirometer mouthpieces.
- ◆ Do Not swallow them.
- ◆ Do Not inhale air from the balloon.
- ◆ Do Not share balloons or the spirometer mouthpieces. Everyone should have their own.

OBJECTIVES

Upon completion of this lab, students will be able to:

- ◆ Measure, define, and distinguish among tidal volume, respiratory reserve, and vital capacity.
- ◆ Compare experimental data obtained with the balloon with lung capacity data obtained from a spirometer.
- ◆ Explain why differences may exist between your data, and the data provided for average lung capacities.
- ◆ Measure length in the metric system.
- ◆ Use a graph to convert data to other units.
- ◆ Compare data gathered using high tech and low-tech equipment.
- ◆ Recognize human and equipment error, and be able to synthesize a list of examples from this lab activity.
- ◆ Accurately record data into chart format
- ◆ Create a list of factors that influence lung volume.

EQUIPMENT/MATERIALS

- ◆ Spirometers
- ◆ Mouthpieces
- ◆ 9" round balloons, 1 per student
- ◆ ruler
- Kimwipes
- 70% Alcohol

EXPERIMENTAL PROCEDURE

Vital Capacity

- ◆ Stretch a balloon several times.
- ◆ Take as deep a breath as possible. Then exhale all the air you can into the balloon (spirometer) and pinch the balloon closed to prevent air from escaping.
- ◆ Measure and record the diameter of the balloon in column A of Table 1. Use Figure 1 as a guide for measuring balloon diameter.
- ◆ Deflate the balloon and run four more trials. Record the diameter of the balloon for each trial.

Respiratory Reserve

- ◆ Read all of this part before starting
- ◆ Exhale normally
- ◆ Without inhaling as you normally would, put the balloon (spirometer) in your mouth and exhale all the air still left in your lungs. NOTE: This step is different from what you did for vital capacity
- ◆ Measure and record the diameter of the balloon in Column B of Table 1.
- ◆ Run four more trials.
- ◆ Record the diameter of the balloon for each trial.

Tidal Volume

- ◆ Take in a normal breath. Exhale into the balloon (spirometer) only as much air as you normally exhale. DO NOT force your breathing.
- ◆ Record the diameter of the balloon in centimeters in Column C of Table 1.
- ◆ Run four more trials.
- ◆ Measure and record each balloon diameter in Table 1.

FIGURE 1

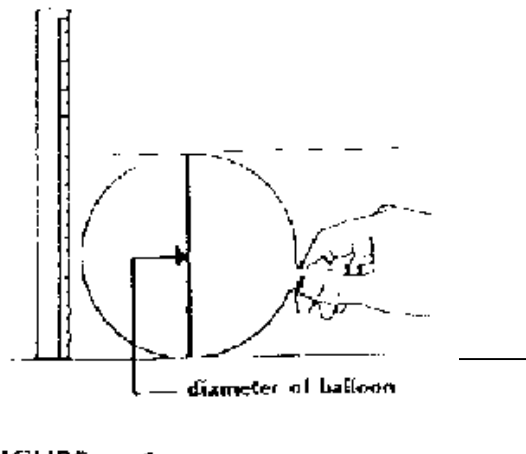


FIGURE 1

Conversion of Diameters to Volume

- ◆ Lung volume is expressed in cubic centimeter units (cm³).
- ◆ To convert from balloon diameter to volume, locate the balloon diameter on the horizontal axis of Figure 2. Follow this number up to the heavy line, and then move across to locate the corresponding volume. For example, if your balloon diameter is 14.5 cm, then the corresponding lung volume is 1500 cm. Use the dashed lines of Figure 2 as an example of how this procedure is done.
- ◆ Convert each diameter for vital capacity, tidal volume, and respiratory reserve to volume.
- ◆ Record the volumes in Column D, E, and F of Table 1.
- ◆ Calculate and record your average lung volume for each of the three measurements.

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Using the Spirometer

- ◆ Obtain one of the spirometers and a clean mouthpiece.
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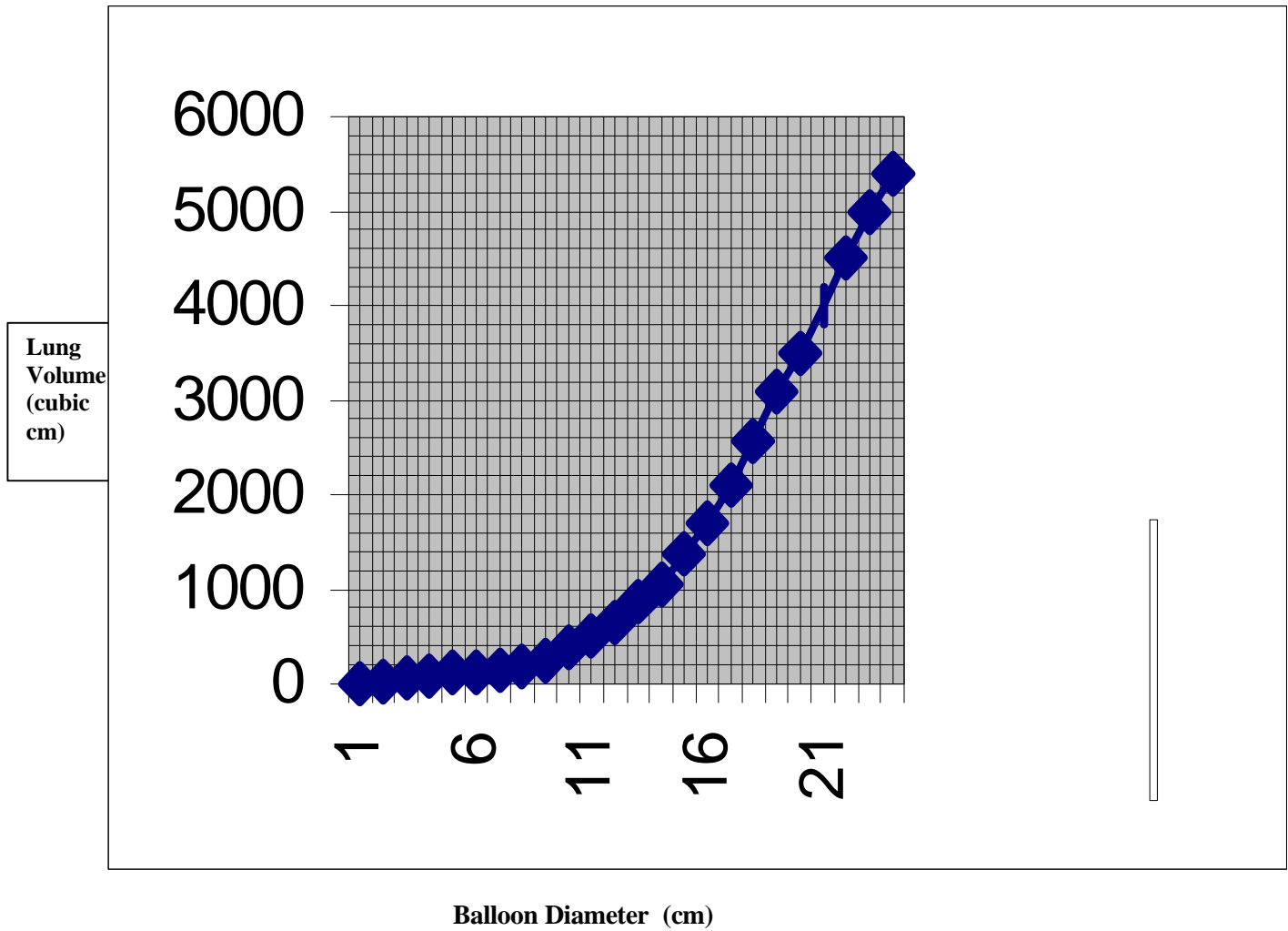


TABLE 2 SPIROMETER RESULTS

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POST-LAB EVALUATION

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