Using Vernier Equipment to Convert Didactically Taught Human Respiration Lab to Inquiry Based Human Respiration Lab

Timothy J. Bradshaw[1], *Samuel P. Carmichael II*[2], *Jason A. Collett*[3], *Alma F. Ferrier*[4], *& Jeffrey L. Osborn*[5]

101 TH Morgan Building
University of Kentucky
Department of Biology
Lexington, KY, 40506

[1] ttbrad2@uky.edu
[2] spcarm2@uky.edu
[3] jacoll2@uky.edu
[4] ferrier@email.uky.edu
[5] jlosbo3@email.uky.edu

Abstract: The University of Kentucky used Vernier equipment to convert a didactically taught human respiration lab into a guided inquiry activity. The original version consisted of an extremely guided lab developed by Vernier that left little room for student experimentation. We redesigned this lab with the 5 E framework developed by Bybee *et al.* (2006), creating an inquiry based lab with emphasis on student led investigations. We will demonstrate both labs, identify key areas that were changed, and examine the effects of the new lab on student achievement and attitudes. Training on Vernier equipment will be provided.

Contents

Introduction

The University of Kentucky purchased Vernier interfaces, probes, and software to promote an inquiry style of learning in their introductory biology laboratory series. Included with the purchase were 24 Vernier lab exercises, highlighting the various Vernier probes (Gordon & Gordon, 2005). While the equipment lends itself to an inquiry based approach, the Vernier exercises follow a more traditional, didactic approach to science education. Since it is well documented that students learn most productively when engaged in inquiry (Schwab, 1966; Lawson, 1989; Leonard et al 2001), and inquiry based science education has been endorsed by multiple educational organizations, including the American Association for Advancement of Science (AAAS) and the National Research Council (NRC), we redesigned the Vernier aerobic respiration exercise to incorporate a more inquiry based approach in order to maximize the benefits of the Vernier equipment and improve student instruction.

From the beginning of the course, guided inquiry activities utilizing Vernier equipment are presented to the students. Lessons are designed around the inquiry based 5 E framework, which has been shown to not only increase student content knowledge but also to expand students depth of knowledge and overall understanding of science concepts (Bybee et al 2006). Students are introduced to the scientific method during the first lab session, by measuring hand grip strength with Vernier hand dynamometers. Other lab topics preceding the respiration unit include an introduction to microscopes and cells, and a vertebrate anatomy lab that didactically examines fetal pig physiology.

The respiration exercise utilizes a spirometer probe for measuring air flow rate and lung volume, and is based on Vernier lesson 19: Lung Volumes and Capacities. The objectives of the redesigned lab are: 1) to utilize the scientific method with respect to experimental design and data collection, 2) to provide an understanding of respiratory physiology in humans, and 3) to understand how obstructive lung diseases affect different lung volume components. This lab is designed to be carried out over two class periods, both of which require a minimum of two hours. Students develop experiments, collect data, and present their findings to the class. The level of difficulty for this lab is appropriate for a freshman biology course.

Student Outline

Lung Volumes and Capacities I

Measurement of lung volumes provides a tool for understanding normal function of the lungs as well as disease states. The breathing cycle is initiated by expansion of the chest. Contraction of the diaphragm causes it to flatten downward. If chest muscles are used, the ribs expand outward. The resulting increase in chest volume provides a negative pressure that induces inward air flow to the lungs through the nose and mouth. Normal exhalation is generally passive, resulting from "recoil" of the chest wall, diaphragm, and lung tissue. In normal breathing at rest, approximately one-tenth of the total lung capacity is used. Greater portions of the overall lung capacity are used as needed (i.e., with exercise). We can measure the components that comprise lung volume with a spirometer.

Lab objectives

1. Students will understand how to measure lung volumes using spirometer
2. Students will understand basic physiology of pulmonary function.
3. Students will understand lung volume components
4. Students will understand how to calculate components of lung volume

Using the Equipment

1. Open LoggerPro from the desktop. Wait for the flow volume vs. time graph to appear. Click the Next Page button  to see the volume vs. time graph. Attach the larger diameter side of a bacterial filter to the "Inlet" side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter (Figure 1)

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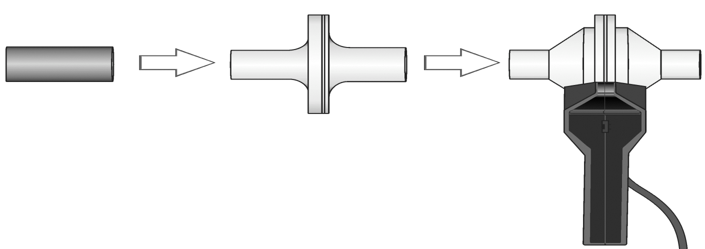
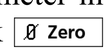


Figure 1

2. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click  to zero the sensor. **Note**: The Spirometer must be held straight up and down, and not moved during data collection.

3. Collect inhalation and exhalation data.

   a. Put on the nose plug.

b. Click ▶ Collect to begin data collection.
c. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After four cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes*.
d. Follow this with at least one additional recovery breath.

4. Click ■ Stop to end data collection.
5. If the graph is too large to see, click the Autoscale graph button. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes closer to zero, as in Figure 2.

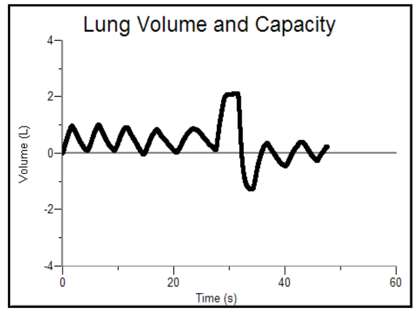


Figure 2

Calculating Lung Volume Components

1. Select a representative peak and valley in the Tidal Volume (TV) portion of your graph. Place the cursor on the peak and click and drag down to the valley that follows it. The Δy value displayed in the lower left corner of the graph is Tidal Volume. Write all of your data values on a separate sheet.

2. Move the cursor to the peak that represents your maximum inspiration. Click and drag down the side of the peak until you reach the level of the peaks graphed during normal breathing. The Δy value displayed in the lower left corner of the graph is Inspiratory Reserve Volume (IRV).

3. Move the cursor to the valley that represents your maximum expiration and drag up the side of the peak until you reach the level of the valleys graphed during normal breathing. The Δy value displayed in the lower left corner of the graph is Expiratory Reserve Volume (ERV).

4. The Vital Capacity (VC) is the sum of the TV, IRV, and ERV.

$$VC = TV + IRV + ERV$$

5. The Total Lung Capacity (TLC) is the sum of the VC and the residual volume (RV ~ 1.5 L)

$$TLC = VC + RV$$

Student Experiments
Using what you have learned about basic lung volumes and function, design experiments to answer the following questions. Your Instructor or Teaching Assistant (TA) must approve your experimental design before you can proceed.

Experiment 1: Are men full of hot air?
Do men have larger or smaller total lung capacities than women? Why or why not?

Experiment 2: Battle of the Sexes
Do women recover faster from exercise than men?

Lung Volumes and Capacities II

Lab Objectives

1. Students will understand how lung diseases influence lung volume components.
2. Students will understand the affects of exercise on patients with lung diseases.
3. Learn how to interpret scientific data sets.
4. Reinforce scientific method for designing experiments and testing hypotheses.

Presentation of disease

You and your group will present background information on your assigned disease to the class. Presentations should last 3-5 minutes and cover the four points (causes, symptoms, pathophysiology and treatment) investigated.

Experiments

1. Disease and Flow Rate

Today, you will examine how your respiratory disease affects lung flow rates. Make a prediction about your disease and design an experiment. Be sure to create a data table or other meaningful presentation of your data. Your TA will collect these data at the end of the experiment.

2. Disease and Exercise

What sort of challenge does disease pose to exercise? Make a testable prediction regarding your disease and its affect upon exercise. Conduct your experiment and be sure to create a data table or other meaningful presentation of your data. Your TA will collect this data at the end of the experiment.

If you finish this early, how might your disease play into recovery from exercise?

Spirometer Use

1. Open LoggerPro from the desktop. Wait for the flow volume vs. time graph to appear. Click the Next Page button to see the volume vs. time graph. Attach the larger diameter side of a bacterial filter to the "Inlet" side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter.

2. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click Zero to zero the sensor. **Note**: The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.

3. Collect inhalation and exhalation data.

   e. Put on the nose plug.
   f. Click Collect to begin data collection.
   g. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After 4 cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes*.
   h. Follow this with at least one additional recovery breath.

4. Click Stop to end data collection.

5. If the graph is too large to see, click the Autoscale graph button. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes

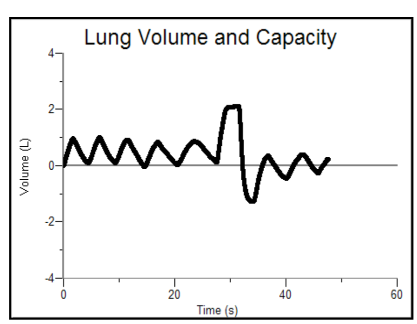


Figure 3

closer to zero, as in Figure 3.

6. Record your TV, IRV, ERV, VC, and TLC from the graph.

Materials

Materials for this lab include enough computers (PC or Macintosh) and Vernier set-ups for each group. Vernier set-ups include interface (LabPro or Go!Link), software (LoggerPro 3.4 or newer), and spirometer. Vernier equipment is available at www.vernier.com (see appendix). Additionally, each group will need parafilm, cotton balls, or other materials that can be used to obstruct mouthguard. In order to allow all students to participate in laboratory, groups should consist of no more than four students.

Notes for the Instructor

Instructor should always trouble-shoot Vernier set-up before beginning of lab exercise. A teaching assistant version of the lab is attached (Appendix B) that will help the instructor perform the exercise. This version also includes sample answers to student homework and possible solutions for experimental designs. Listed below are the most common problems the authors encountered while performing this lab, as well as solutions.

1. Problem: Spirometer reading varies from student to student
   Solution: Have students hold spirometer upright and still. Placement of the spirometer is critical to obtaining replicable data.
2. Problem: Students obtain tidal volumes greater than the expected average.
   Solution: Students tend to breather deeper than normal while wearing a nosepiece. Emphasize that they need to breathe normally when taking baseline readings.
3. Problem: Graph is too large to fit on screen or drifts up or down while recording.
   Solution: After students take reading, use the baseline adjustment if the graph has drifted and the autoscale button if the graph is too large.

Other Vernier labs can be adapted in a similar fashion. Key inquiry elements missing from the majority of Vernier labs are engaging activities and the opportunity for students to investigate their own questions. This exercise can be used as a stand alone laboratory or as a framework for redesigning other Vernier labs.

Information for the mini-lecture on aerobic respiration physiology is available in any standard introductory biology textbook (e.g. Campbell & Reece, 2002).

Acknowledgements

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About the Authors

Timothy J. Bradshaw is a second year graduate student at the University of Kentucky in the laboratory of Dr. Jeffrey L. Osborn. As the inaugural member of the bioscience education track at UK, Tim is active in both physiology bench research and education research. Tim's research interests include science education reform, effects of TA training on student performance, and AT1 receptor expression in genetic hypertensive rats. Tim's future plans include teaching at the collegiate level.

Samuel P. Carmichael II is a second year graduate student at the University of Kentucky in the laboratories of Drs. Jeffrey L. Osborn (Department of Biology) and Sean D. Stocker (Department of Physiology), with training in science education and physiology. Currently, Sam is a teaching assistant for a laboratory section of introductory biology, in addition to his own coursework and research responsibilities. Sam's current research in physiology involves the role of central neural pathways and receptors in the control of arterial blood pressure. Sam's future goals entail a career in basic biomedical research and teaching on the collegiate level.

Jason A. Collett is a first year graduate student at the University of Kentucky in the laboratory of Dr. Jeffrey L. Osborn with training in physiology and science education. In addition to his coursework and research responsibilities, Jason is a teaching assistant for a laboratory section of introductory biology. Jason's current physiological research involves the role of renal sympathetic nerve activity in the control of intrarenal blood flow and arterial blood pressure. Jason's future career goals involve physiological research and teaching at the collegiate level.

Alma F. Ferrier obtained her B.S. in Biology from St. Mary's College, Notre Dame, Indiana, and a Ph.D. in Molecular and Cellular biology from the University of Kentucky Biology Department. She performed her post-doctoral work in cancer research at the National Cancer Institute at NIH. She is currently the Academic Coordinator for the introductory laboratories for Biology Majors at the University of Kentucky. She has received recognition from the University of Kentucky for outstanding contributions to education through TA development and as a First Year Teaching Scholar.

Jeffrey L. Osborn is Professor of Biological Science in the UK College of Arts & Sciences and science outreach professor in the Partnership Institute for Math and Science Education Reform. Dr. Osborn also is principal investigator of a $2 million grant entitled “Newton’s Universe” that evaluates the impact of providing inquiry based professional development to rural middle school teachers with distance learning on student achievement. He has written over 150 abstracts, journal articles and book chapters and is a noted lecturer in his specialty of physiology and science education. In 2007, he was awarded the UK Alumni Association Great Teacher Award and the Arthur C. Guyton Educator of the Year Award from the American Physiological Society. Osborn earned a bachelor’s degree in biology from Amherst College and a master’s and doctoral degree in physiology from Michigan State University. He has served previously, as Associate Professor of Physiology at the Medical College of Wisconsin and was the founding director of the Greater Hartford Academy of Math and Science in Hartford, CT.

Appendix A

Lung Volumes and Capacities (Vernier Version)

Measurement of lung volumes provides a tool for understanding normal function of the lungs as well as disease states. The breathing cycle is initiated by expansion of the chest. Contraction of the diaphragm causes it to flatten downward. If chest muscles are used, the ribs expand outward. The resulting increase in chest volume creates a negative pressure that draws air in through the nose and mouth. Normal exhalation is passive, resulting from “recoil” of the chest wall, diaphragm, and lung tissue. In normal breathing at rest, approximately one-tenth of the total lung capacity is used. Greater amounts are used as needed (i.e., with exercise). The following terms are used to describe lung volumes (see Figure 1):

Tidal Volume (TV):	The volume of air breathed in and out without conscious effort
Inspiratory Reserve Volume (IRV):	The additional volume of air that can be inhaled with maximum effort after a normal inspiration
Expiratory Reserve Volume (ERV):	The additional volume of air that can be forcibly exhaled after normal exhalation
Vital Capacity (VC):	The total volume of air that can be exhaled after a maximum inhalation: VC = TV + IRV + ERV
Residual Volume (RV):	The volume of air remaining in the lungs after maximum exhalation (the lungs can never be completely emptied)

Total Lung Capacity (TLC):	= VC + RV
Minute Ventilation:	The volume of air breathed in 1 minute: (TV)(breaths/minute)

In this experiment, you will measure lung volumes during normal breathing and with maximum effort. You will correlate lung volumes with a variety of clinical scenarios.

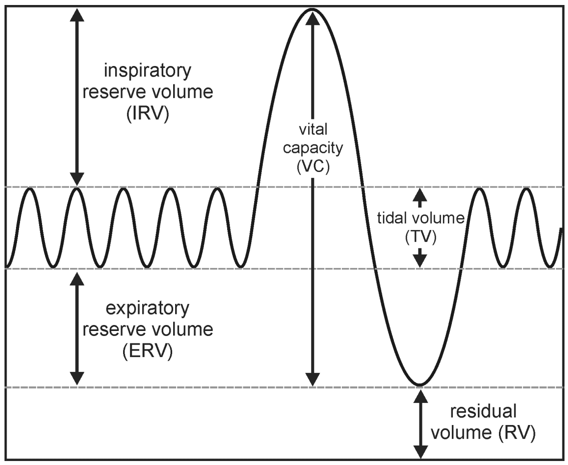

Figure 1

Objectives:

In this experiment, you will

- Obtain graphical representation of lung capacities and volumes.
- Compare lung volumes between males and females.
- Correlate lung volumes with clinical conditions.

Materials:
Computer
Vernier computer interface
Logger *Pro*
Vernier Spirometer
Disposable mouthpiece
Disposable bacterial filter
Nose clip

Procedure:
Important: Do not attempt this experiment if you are currently suffering from a respiratory ailment such as the cold or flu.

1. Connect the Spirometer to the Vernier computer interface. Open the file "19 Lung Volumes" from the *Human Physiology with Vernier* folder.

2. Attach the larger diameter side of a bacterial filter to the “Inlet” side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter (see Figure 2).

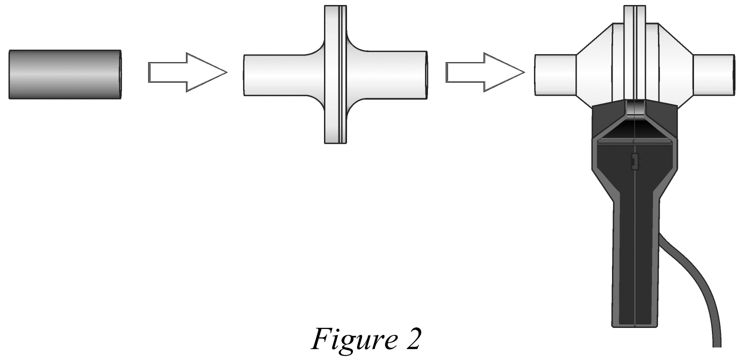

Figure 2

3. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click Ø Zero to zero the sensor. **Note**: The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.

4. Collect inhalation and exhalation data.

   i. Put on the nose plug.

   j. Click ▶ Collect to begin data collection.

   k. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After four cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes*.

   l. Follow this with at least one additional recovery breath.

5. Click ■ Stop to end data collection.

6. Click the Next Page button, , to see the lung volume data. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes closer to zero, as in Figure 3.

7. Select a representative peak and valley in the Tidal Volume portion of your graph. Place the cursor on the peak and click and drag down to the valley that follows it. Enter the Δ*y* value displayed in the lower left corner of the graph to the nearest 0.1 L as Tidal Volume in Table 1.

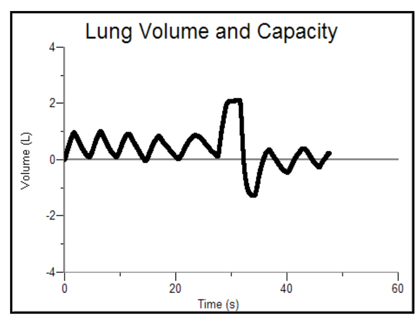

Figure 3

8. Move the cursor to the peak that represents your maximum inspiration. Click and drag down the side of the peak until you reach the level of the peaks graphed during normal breathing. Enter the Δ*y* value displayed in the lower left corner of the graph to the nearest 0.1 L as Inspiratory Reserve Volume in Table 1.

9. Move the cursor to the valley that represents your maximum expiration. Click and drag up the side of the peak until you reach the level of the valleys graphed during normal breathing. Enter the Δ*y* value displayed in the lower left corner of the graph to the nearest 0.1 L as Expiratory Reserve Volume in Table 1.

10. Calculate the Vital Capacity and enter the total to the nearest 0.1 L in Table 1.

$$VC = TV + IRV + ERV$$

11. Calculate the Total Lung Capacity and enter the total to the nearest 0.1 L in Table 1. (Use the value of 1.5 L for the RV.)

$$TLC = VC + RV$$

12. Share your data with your classmates and complete the Class Average columns in Table 1.

Data:

Table 1

Volume measurement (L)	Individual (L)	Class average (Male) (L)	Class average (Female) (L)
Tidal Volume (TV)			
Inspiratory Reserve (IRV)			
Expiratory Reserve (ERV)			
Vital Capacity (VC)			
Residual Volume (RV)	≈1.5	≈1.5	≈1.5
Total Lung Capacity (TLC)			

DATA ANALYSIS

1. What was your Tidal Volume (TV)? What would you expect your TV to be if you inhaled a foreign object which completely obstructed your right mainstem bronchus?

2. Describe the difference between lung volumes for males and females. What might account for this?

3. Calculate your Minute Volume at rest.

   $$(TV \times \text{breaths/minute}) = \text{Minute Volume at rest}$$

   If you are taking shallow breaths (TV = 0.20 L) to avoid severe pain from rib fractures, what respiratory rate will be required to achieve the same minute volume?

4. Exposure to occupational hazards such as coal dust, silica dust, and asbestos may lead to *fibrosis*, or scarring of lung tissue. With this condition, the lungs become stiff and have more "recoil." What would happen to TLC and VC under these conditions?

5. In severe emphysema there is destruction of lung tissue and reduced recoil. What would you expect to happen to TLC and VC?

6. What would you expect to happen to your Expiratory Reserve Volume when you are treading water in a

lake?

EXTENSION

Repeat the experiment with the chest or abdomen constricted (use a girdle or ace bandage).

Appendix B
Lung Volumes and Capacities
TA Version Day 1

Lab Objectives

1. Students will understand how to measure lung volumes using spirometer
2. Students will understand basic physiology of aerobic respiration.
3. Students will understand lung volume components (TV, IRV, ERV, etc.)
4. Students will understand how to calculate components of lung volume (TV, IRV, ERV, etc) from a graph.

Tidal Volume (TV):	The volume of air breathed in and out without conscious effort (~0.4 – 1.0 L)
Inspiratory Reserve Volume (IRV):	The additional volume of air that can be inhaled with maximum effort after a normal inspiration (~2.5 - 3.5 L)
Expiratory Reserve Volume (ERV):	The additional volume of air that can be forcibly exhaled after normal exhalation (~1.0 – 1.5 L)
Vital Capacity (VC):	The total volume of air that can be exhaled after a maximum inhalation: VC = TV + IRV + ERV (~4.8 – 6.0 L)
Residual Volume (RV):	The volume of air remaining in the lungs after maximum exhalation (the lungs can never be completely emptied) (~1.2 L)
Total Lung Capacity (TLC):	Total volume of air that the lungs can hold. TLC = VC + RV

Engage Activity

Exercise and respiration – to interest students in lab

Ask students how exercise affects respiration (i.e. how much air can your lungs hold before vs. after exercise, how fast you respire before vs. after exercise). Take down a few ideas on the chalkboards. DON'T GET INTO TERMINOLOGY YET (TV, IRV, ERV). They should have a general idea from personal experience.

- 1 volunteer needed, come to the TA station computer.
- LoggerPro will be queued up on the computer as well as on projector screen.
- Have person conduct respiration test: breath normally 3 times into spirometer followed by one deep inhalation and deep exhalation, followed by normal recovery breaths until the end of the graph
- Go to "Experiment" and "Store latest run" on the taskbar. This function will allow TA to record next respiration test on top of old one
- Have person do forty jumping jacks at a fast rate as exercise.
- Make sure baseline run is stored and have person do a second respiration test on the same graph → store run

Questions

1 What happened to the rate of respiration?
2 Why are the patterns in the respiration peaks different before and after exercising?
3 Can a person fit more air into their lungs before or after exercise?

Students Practice with Equipment

Now that students have some ideas about respiration, they will graph their own lung volumes by using the spirometers.
TA will correct student mistakes in data collecting. Common mistakes include:
Not holding spirometer level, not exerting maximum force for IRV and ERV, breathing too deeply on TV, not collecting values after each person.
Students will work in groups of three to four, depending on class size.

1. Open LoggerPro from the desktop. Wait for the flow volume vs. time graph to appear. Click the Next Page button to see the volume vs. time graph. Attach the larger diameter side of a bacterial filter to the "Inlet" side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter.

2. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click Zero to zero the sensor. **Note**: The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.

3. Collect inhalation and exhalation data.

   m. Put on the nose plug.
   n. Click Collect to begin data collection.
   o. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After 4 cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes*.
   p. Follow this with at least one additional recovery breath.

4. Click Stop to end data collection.

5. If the graph is too large to see, click the Autoscale graph button. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes closer to zero, as in Figure 3.

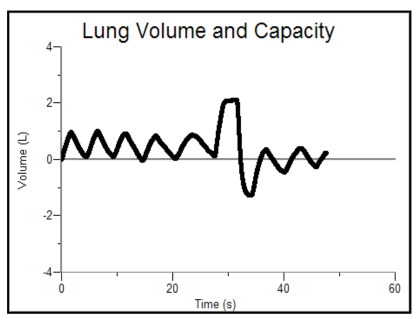

Figure 3

Mini-Lecture

Physiology of Aerobic Respiration/Lung Components
After TA has provided information with PowerPoint lecture, students will determine their baseline lung components.
Ask students, by using their own graphs, to determine their TV, IRV, and ERV.
Details on how to determine this are listed below.
Post average values for TV, IRV, etc for student comparison.

6. Select a representative peak and valley in the Tidal Volume portion of your graph. Place the cursor on the peak and click and drag down to the valley that follows it. The Δy value displayed in the lower left corner of the graph is Tidal Volume. Write all of your data values on a separate sheet.

7. Move the cursor to the peak that represents your maximum inspiration. Click and drag down the side of the peak until you reach the level of the peaks graphed during normal breathing. The Δy value displayed in the lower left corner of the graph is Inspiratory Reserve Volume (IRV).

8. Move the cursor to the valley that represents your maximum expiration and drag up the side of the peak until you reach the level of the valleys graphed during normal breathing. The Δy value displayed in the lower left corner of the graph is Expiratory Reserve Volume (ERV).

9. The Vital Capacity is the sum of the TV, IRV, and ERV.

$$VC = TV + IRV + ERV$$

10. The Total Lung Capacity is the sum of the VC and the residual volume (RV ~ 1.5 L)

$$TLC = VC + RV$$

Student Experiments
(These will help students reinforce the concepts of lung volume components and experimental design).
Students will design experiments to answer questions listed below. It is up to the TA to decide if the protocol developed by the student is appropriate. Questioning skills are critical. Do not give students the answers or design an experiment for them. Question them so they arrive at proper experimental design on their own. Quiz them on their dependent and independent variables, how they would analyze their results, etc.

Experiment 1 Are men full of hot air?
Do men have larger or smaller total lung capacities than females? Why?
Using spirometers, students will determine if males or females have larger total lung capacities. (On average, men do have larger total lung capacities).
Students will have to formulate a hypothesis for why they think men or women have larger TLC, and test their hypothesis. This means they probably will have to do more than just measure multiple men and women. (Example: If their hypothesis is that since men are larger than women on average, than men have larger lungs and thus larger TLC, they could not simply compare gender. They would have to account for body size as well). TA's will determine if the protocol designed by the students is sufficient to answer the question.

Experiment 2 Battle of the Sexes
Do women recover faster from exercise than men?
In order to answer this question, students will have to determine how to explain "recover" (i.e. TV returns to baseline, respiration rate slows down to baseline, etc.), students will have to decide the length of time they will exercise, how they will exercise, and how long of a recovery period they will allow. TA's will determine if the protocol designed by the students is sufficient to answer the question. Question them to find out if they understand what they are doing and why they have designed their protocol the way they have. **NOTE**: for exercise, students can use stair steppers and metronome, jumping jacks, push-ups. Running up and down the stairs or jogging around the building is not an option.

Conclusions
Assign student groups one of eight airway diseases (Asthma, Emphysema, Chronic Bronchitis, Bronchiectasis, Asbestosis, Tuberculosis (pulmonary), Black lung disease, Silicosis). Hand out the 10 pt. assessment, due by the next class. Students will present their findings on their diseases at the beginning of the next class period.

Lung Disease
TA Version Day 2

Lab Objectives

1. Students will understand how obstructive lung diseases influence lung volume components.
2. Students will understand the affects of exercise on patients with obstructive lung diseases.
3. Learn how to interpret scientific data sets.
4. Reinforce scientific method for designing experiments and testing hypotheses.

TA background information

All of the students' diseases can be qualified for the purposes of this lab as **obstructive lung disorders**. These impairments are characterized by increased airway resistance causing reduced expiratory airflow rates. Obstructive disorders are associated with airway dysfunction. At the end of the lab, call students together to reinforce information on obstructive lung disorders.

Engage Activity

Split students into their groups. Each group will explain in 2-3 minutes about the diseases they researched. Each group should mention the name of the disease, causes, symptoms, pathophysiology, treatment and any other relevant information that they want to share.
Diseases include: Asthma, Emphysema, Chronic Bronchitis, Bronchiectasis, Asbestosis, Tuberculosis (pulmonary), Black lung disease, Silicosis.

Student Experiments I

Students will examine how their respiratory disease affects lung flow rates. In order to do this, they will have to "re-create" their disease. This can be done by placing material (i.e. cotton balls, parafilm, paper towels, etc.) inside the bacterial filter guard and trying to breathe. However, students must decide on their own how they will attempt to replicate their disease. TAs should be walking around assisting students with the equipment and their experimental design.

Elements students need to include:

1. appropriate replication of disease
2. control measurements
3. repeated trials
4. data table.

Students must show you their protocol before they proceed. Question them on their design to see if they understand why they are doing what they are doing and if they can explain how this simulates their diseased state. Everyone in the group should be able to explain the disease to you.

Student Experiments II

Students will examine how their diseases affect respiration before and after exercise. It is up to the TA to decide if the protocol developed by the student is appropriate. Questioning skills are critical. Do not give students the answers or design an experiment for them. Question them so they arrive at proper experimental design on their own. Once the students design their experiments and collect their data, have them present their results to you, using their data to support their conclusions about the affect of obstructive lung diseases on lung volume.

Elements students need to include:

1. baseline measurements to compare to experiment measurements

2. appropriate exercise – strenuous enough to increase respiration rate (Ex. jumping jacks, aerobic steps)
3. have students create a table with their measurements.
4. students need to show you their experimental design before they proceed.

Optional extension: for groups moving quickly, recovery from exercise could also be examined.

Spirometer Use

1. Open LoggerPro from the desktop. Wait for the flow volume vs. time graph to appear. Click the Next Page button to see the volume vs. time graph. Attach the larger diameter side of a bacterial filter to the "Inlet" side of the Spirometer. Attach a gray disposable mouthpiece to the other end of the bacterial filter.

2. Hold the Spirometer in one or both hands. Brace your arm(s) against a solid surface, such as a table, and click Zero to zero the sensor. **Note**: The Spirometer must be held straight up and down, as in Figure 2, and not moved during data collection.

3. Collect inhalation and exhalation data.

   q. Put on the nose plug.

   r. Click Collect to begin data collection.

   s. Taking normal breaths, begin data collection with an inhalation and continue to breathe in and out. After 4 cycles of normal inspirations and expirations fill your lungs as deeply as possible (maximum inspiration) and exhale as fully as possible (maximum expiration). *It is essential that maximum effort be expended when performing tests of lung volumes*.

   t. Follow this with at least one additional recovery breath.

4. Click Stop to end data collection.

5. If the graph is too large to see, click the Autoscale graph button. If the baseline on your graph has drifted, use the Baseline Adjustment feature to bring the baseline volumes closer to zero, as in Figure 3.

6. Record your TV, IRV, ERV, VC, and TLC from the graph.

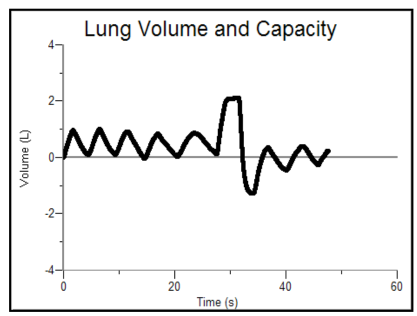

Figure 3

Appendix C

At the time of submission, the order numbers for equipment needed for this lab listed on the Vernier website (www.vernier.com) were:

Item	Order Code	Price
LabPro Interface (or comparable interface)	LABPRO	$220.00
Spirometer	SPR-BTA	$199.00

Optional Extras

Disposable Bacterial Filter (10)	SPR-FIL	$30.00
Disposable Mouthpiece (30)	SPR-MP	$10.00
Noseclip (10)	SPR-NOSE	$10.00
Spirometer Flow Head	SPR-FLOW	$60.00