#7 - Respiratory System

Important
- scaning objective in place
- slide removed and returned
- power cord wrapped
- stage centered
- stage lowered
- voltage lowered
- power off

Objectives:

- Study the parts of the respiratory system
- Observe slides of the lung and trachea
- Perform spirometry to measure lung volumes
- Define and understand the lung volumes and capacities and how to calculate them

Equipment: *Remember to bring photographic atlas.*

I. Respiratory System

Introduction

The function of the respiratory system is to exchange gases with the environment in a process known as *ventilation* (breathing). Breathing has two phases, *inhalation* and *exhalation*. Air travels through the structures of the respiratory system to the small air sacs called *alveoli* where the gases O_2 and CO_2 can be exchanged with the blood (*external respiration*). The oxygen is needed by the tissues (*internal respiration*) so that cells can make ATP. Carbon dioxide is a waste product of metabolism and must be removed from the body by exhalation.

II. Tissue Slides

Observe the slides of the *lung* and *trachea*. Draw each in the space provided in the laboratory report. Label your diagram with the structures listed. Get your instructor to check the microscope for storage in the lab report.
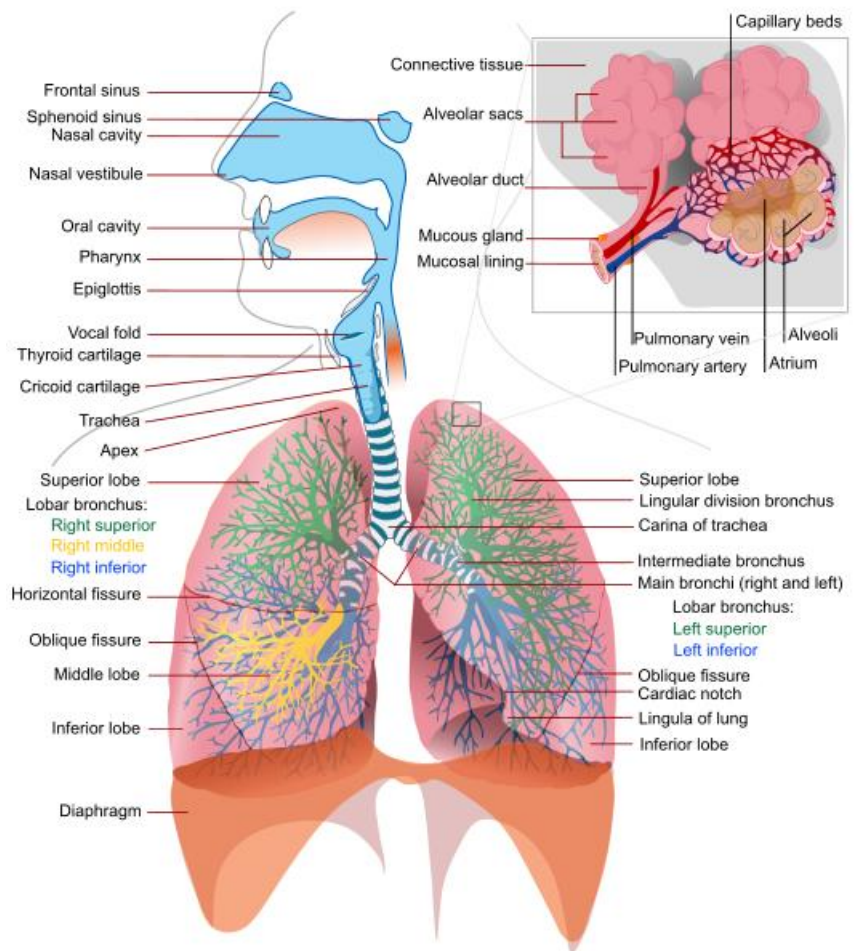

Figure 1. Structures of the respiratory system.

Lung	Trachea
Alveolus with: *simple squamous epithelium* **bronchiole**	**lumen** **hyaline cartilage** **ciliated pseudostratified columnar epithelium**

III. Spirometry using BIOPAC®

A. Introduction.

A machine called a spirometer is used to measure lung volumes. The subject breathes into a mouthpiece and the machine measures the volume of air that is moved. Depending on how the subject breathes, different volumes can be measured generating a spirogram (Figure 2). Find the definitions for the following volumes:

Tidal Volume (TV):

Inspiratory Reserve Volume (IRV):

Expiratory Reserve Volume (ERV):
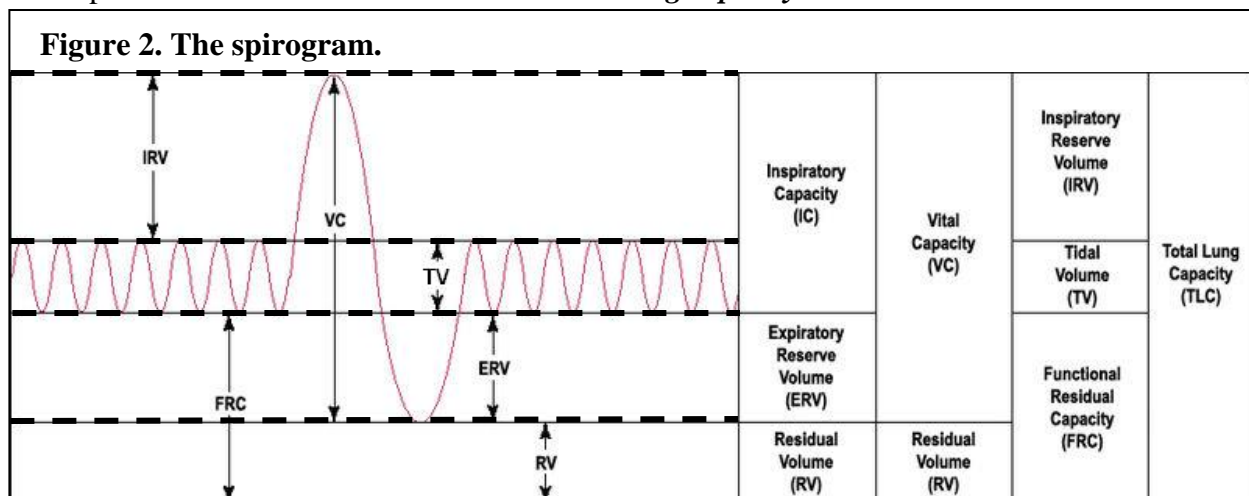
Residual Volume (RV):

Vital Capacity (VC):

Total Lung Capacity (TLC):

*Function Residual Capacity (FRC):*

Inspiratory Capacity (IC):

You should understand the relationship between the lung volumes depicted in Figure 2. For example how: ***IRV + TV + ERV + RV = total lung capacity***

Figure 2. The spirogram.

B. BIOPAC® Equipment Setup:

1. The BIOPAC® MP45 unit will already be plugged into the computer (Channel 1).

2. Log on to the computer using your DCCC login so that you may print your results at the end. Make sure that the "Workstation only" box is **NOT** checked.

3. Start the **BIOPAC® Student Lab** program by finding the icon on the desktop and double-clicking it.

4. Select the lesson: **L12-Pulmonary Function I**, click *OK*.

5. Type in a name for the file you will recognize (ie. the subject's name), click *OK*.
   Enter subject's details – click *OK*

**Figure 3. Spirometry equipment.**
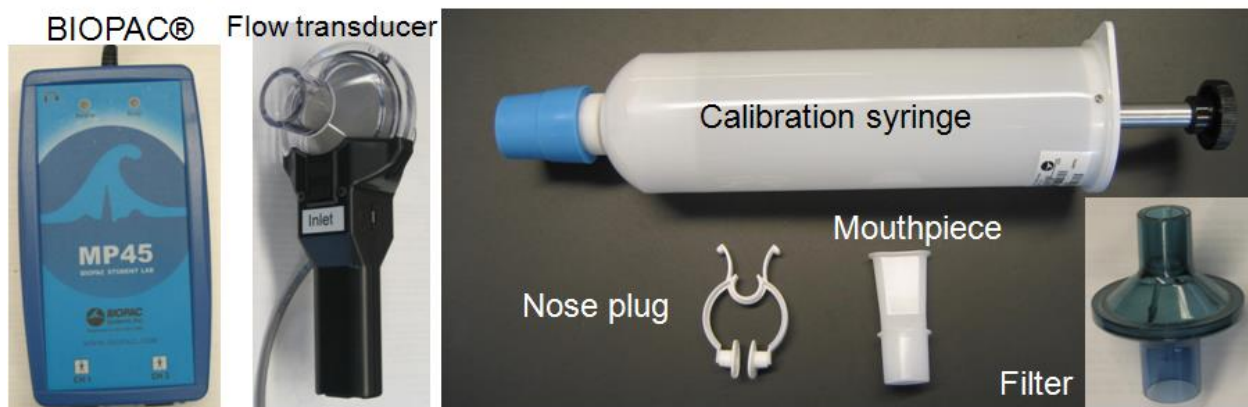
PART I. Calibration STEP A

Hold the airflow transducer vertically, as in the photo on the screen, and keep it completely STILL, click *Calibrate*.

This will take about 4 seconds and will stop automatically.
The screen should look like Figure 4.

Note: The airflow transducer is sensitive. It must be held STEADY during calibration and recording.

Figure 4. Calibration procedure STEP A.

PART I. Calibration STEP B
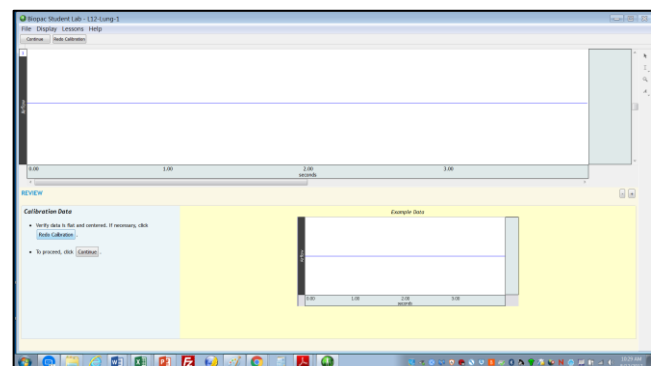
Figure 5. Calibration procedure STEP B.

1. Place the *wide* end of a clean filter on to the end of the calibration syringe, fit until snug.

2. Attach the other end of the filter to the $\boxed{Inlet}$ side of the airflow transducer (Figure 3). Hold on to the calibration syringe firmly. If you hold on to only the airflow transducer the tip may break off the syringe due to the weight.

3. Pull the plunger of the syringe all the way **OUT**.

4. Hold the calibration syringe steady with one hand on the barrel and one on the plunger (Figure 5) place it in your lap and parallel to the ground.

5. BEFORE Clicking *Calibrate* (upper left): *read the directions below and be ready to proceed*.

You will simulate five breaths by pushing the plunger in and out. One cycle being one *IN* and one *OUT*. The plunger must be pushed in and out as smoothly as possible taking about 2 seconds between each stroke.

Remember to hold the filter assembly firmly in your lap. Ask your instructor to demonstrate this procedure. You should end with the plunger OUT.

Figure 6. Calibration STEP B screen.
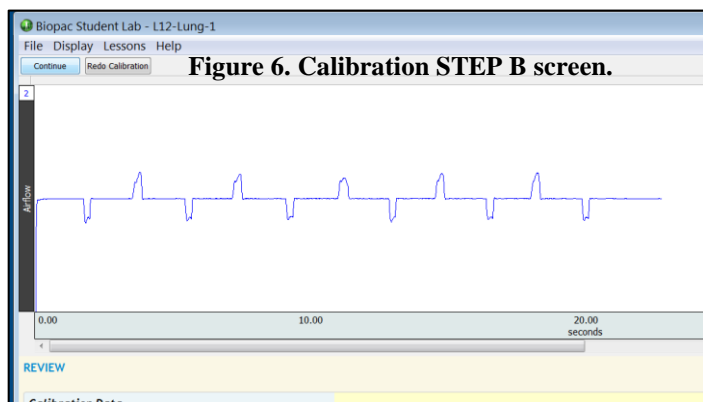
6. When you are ready, click *Calibrate*. Perform 5 cycles.
7. When you have completed the cycles, click *End Calibration*.
8. Observe the calibration data recorded on the screen. It should look similar to Figure 6, and if so, click *Continue* to go the next section. If the data do not appear similar, click *Redo Calibration* which will start back to Calibration STEP A.

Figure 7. Equipment setup.

PART II. Recording Data

1. Remove only the calibration syringe from the assembly. (*Make sure that the blue rubber gasket stays on the syringe*)
2. Attach a clean *mouthpiece to the filter* where you removed the syringe (Figure 7).
Do not attach mouthpiece directly to the flow transducer or you will contaminate it!

Last updated 08/2019
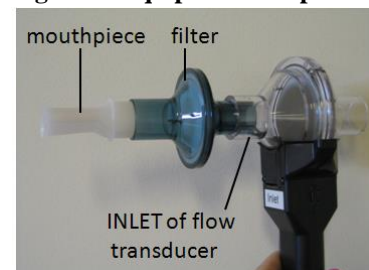
Subject Preparation:

1. The subject should be seated comfortably facing **away** from the computer screen.
2. Put a clean nose-plug (clip) on the subject's nose.
3. The subject should practice making a tight seal around the mouthpiece (air should not leak out from the sides) while breathing normally. The assembly should be held **vertically.**
DO NOT break the seal with the mouthpiece until –AFTER- all of the recording is done.

Recording:

A group member will direct the subject what to do, following the sequence of events listed below *without pausing and maintain the seal with the mouthpiece.*

1. Practice the sequence below at least once before recording. For the best results, the subject should be verbally encouraged during the procedure to enhance their performance. Breathe normally for 20 seconds prior to recording.

> **a. Normal Breathing: take 5 normal breaths (1 inhale and 1 exhale is one breath)**
> **b. Maximal Inhalation: inhale as much air as possible!!**
> **c. Maximal Exhalation: exhale as much air as possible!!**
> **d. Normal Breathing: take 5 normal breaths**

2. When the subject is ready, click ***Record*** (upper left) and perform the procedure (a-d) above.

3. Click ***Stop*** (upper left) when the subject is finished.

4. The data should appear somewhat similar to the spirogram in Figure 8. If so, click, | ***Done*** | , a window will pop-up. Click, **yes** to save the data.

*If the data appear abnormal, click ***Redo*** when the subject is ready and repeat steps 1-3.

**DO NOT Dispose of the mouthpiece and nose plug until you have printed good results –
you may want to check with your instructor.**

Figure 8. Recording screen.

Dispose of the mouthpiece, nose pug, and filter in the provided Biohazard bin.
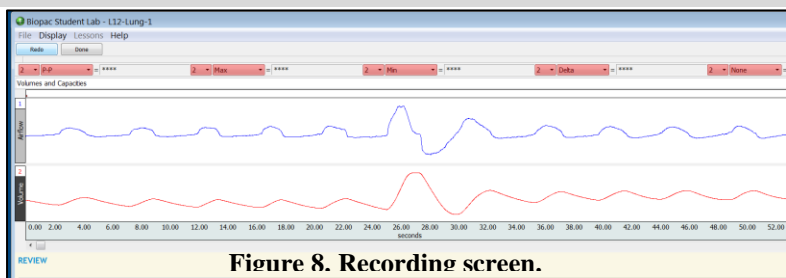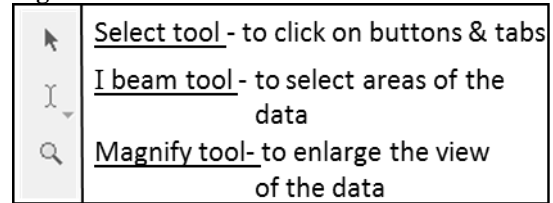
5. If you would like to continue to data analysis click, ***Analyze current data file***.

PART III. Data Analysis

At the right side of the window, are the tools you will use to help analyze your data (Figure 9).

Figure 9. BIOPAC toolbar.

➤	Select tool - to click on buttons & tabs
I	I beam tool - to select areas of the data
🔍	Magnify tool- to enlarge the view of the data

Measuring Tidal Volume (TV)

1. Using the I-beam tool [I], pick the first part of the spirogram with Normal Breathing, click and drag from one trough (A) to the next peak (B) to select this interval (Figure 10 & 11). This is called the tidal volume (TV) and represents the volume of air breathed in during one quiet breath. The computer will calculate the volume in Liters (*P-P*). This value is displayed in the boxes across the top of the screen. Record this value in Table 1 to the nearest 0.001L.

2. Repeat this procedure for one more normal breath and record in Table 1.
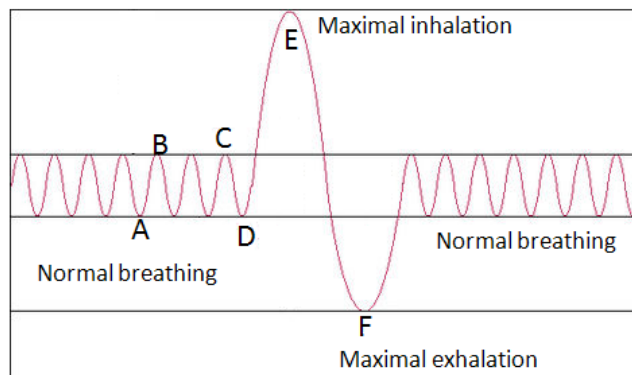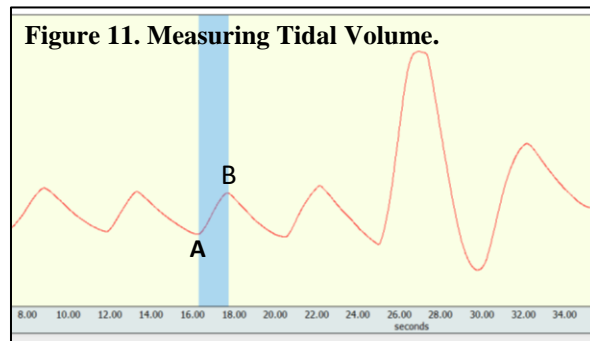
Figure 10. Spirogram analysis.

Figure 11. Measuring Tidal Volume.

Inspiratory Reserve Volume (IRV)

Use the I-beam tool to select the interval from the end of the last inhalation (C) to the top of the maximal inhalation (E) (Figure 10). This is the inspiratory reserve volume (IRV) and is the difference between the two peaks. This value is displayed in the boxes across the top of the screen in the window called **"*Delta*"**. Record this value in Table 1 to the nearest 0.001L.

Expiratory Reserve Volume (ERV)

Use the I-beam tool to select the interval from maximal exhalation (F) to the bottom of the trough of the last normal breath exhalation (D). This is the expiratory reserve volume (ERV) and is the difference between the two volumes. This value is displayed in the boxes across the top of the screen in the window called **"*Delta*"**. Record this value in Table 1 to the nearest 0.001L.

Print copies of the spirogram for each student in your group. You should label it similarly to Figure 2 (TV, ERV, IRV, VC) and hand it in with your lab report. First click **File, Print, Preferences,** set to **Landscape**, and keep fit to 1 page**.**
When finished, click "**File**", "**quit**".
Perform the directed calculations in Table 1 to find VC, IC, FRC, and TLC.

IV. Calculation of Predicted Vital Capacity

Using the provided formula, calculate your theoretical VC according to your height, gender, and age. Place the answer in Table 3.

V. Forced Vital Capacity (FVC) and FEV$_1$

One method of evaluating lung function is to measure the total amount of air that can be forcibly exhaled after maximum inhalation - forced vital capacity **(FVC)**. One important measure for lung function is how much of that air can be expelled in the first second of expiration –forced expiratory volume in 1 second **(FEV$_1$)**. Most of the air should be normally exhaled in the first second – usually up to 80% or better in an average individual (**% = FEV$_1$ / FVC x 100**). The amount that can be exhaled and how fast, changes with various lung diseases. The FVC and FEV$_1$ is measured using a spirometer and creates a graph such as in figure 12. Some lung diseases **(restrictive)** affect the FVC and FEV1 amounts proportionally (they will both drop) and the FEV$_1$ / FVC percentage remains close to normal (See table below). These people will have a drop in the FVC and TLC values. Other diseases **(obstructive)** tend to drop FEV$_1$ faster than FVC and therefore the percentage is reduced as well. This is one way that pathologies can be detected. Below is a table showing the types of pathologies and how they are characterized by spirometry analysis. A combination of these two types of pulmonary abnormalities (**restrictive-obstructive**) also occurs.

Table A.[3, 4, 5]

Obstructive
  - airway obstruction
	Restrictive
	  - restricted lung expansion

Emphysema Asthma Bronchitis COPD – chronic bronchitis & emphysema	Pulmonary fibrosis Asbestosis Infant respiratory distress syndrome (lack of pulmonary surfactant) Acute respiratory distress syndrome
FEV$_1$/ FVC % **<75%** (lower than normal 80%) FVC – **normal > 80% of predicted value** (may be reduced when severe) RV - increased	FEV$_1$/ FVC % **>75%** (close to normal 80%) FVC – **reduced <80% of predicted value** TLC – decreased

For the graph on the following page (Figure 12), calculate FEV$_1$/FEV % and % predicted FVC, for each subject and determine whether the subject is likely to have a restrictive or obstructive disease. Put all your answers in Table 4 of the laboratory report. Base your "diagnoses" of the subjects A and B on the values provided in Table A above. ***Note: none of the results obtained in the laboratory should be used for actual diagnostic purposes.***

Figure 12. Graph of forced exhalation obtained through spirometry.
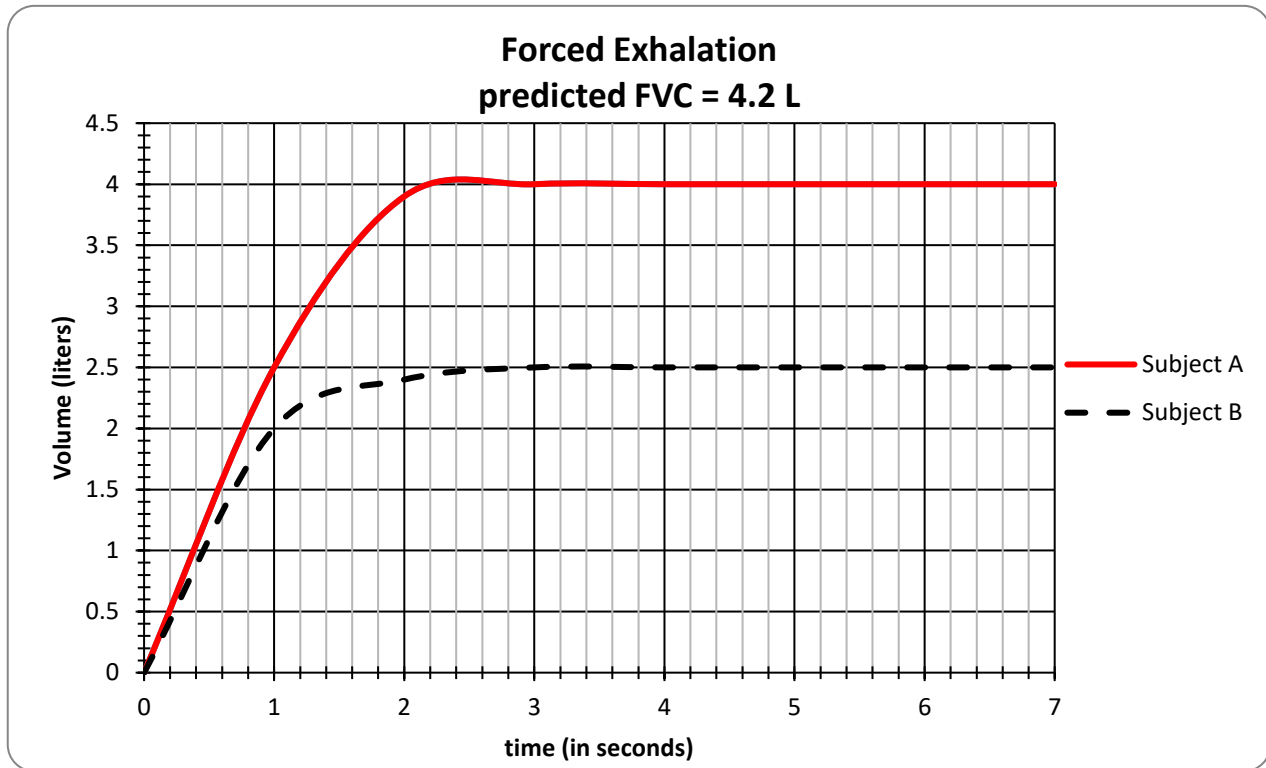
References:

1. Gore CJ, Crockett AJ, Pedersen DG, and Booth ML, Bauman A, Owen N. 1995. Spirometric standards for healthy adult lifetime nonsmokers in Australia. Eur Respir J. 8: 773–782

2. Morris JF, Koski A, and Johnson LC. 1971. Spirometric standards for healthy nonsmoking adults. Am Rev Respir Dis. 103:57-67.

3. Morris JF. 1976. Spirometry in the evaluation of pulmonary function. West J Med. 125:110-118.

4. LoRusso TJ, Belman MJ, Elashoff JD, and Koerner SK. 1993. Bhest. 104:1748-1757.

5. Pierrce R. 2005. Spirometry and essential clinical measurement. Australian Family Physician. 34:535-539.

Laboratory #7 Report   Name:_____

II. Tissue Slides
Lung

a) Draw using the 10x objective.

b) Label:

    alveolus with
      simple squamous epithelium

    bronchiole

Trachea

a) Draw using the 10x objective:
b) Label:

    lumen
    hyaline cartilage
    ciliated pseudostratified
      columnar epithelium

Microscope check

_____

III. Spirometry using BIOPAC®

Table 1.

Spirogram Measurements (volumes in Liters)			
Tidal volume (TV) *(p-p)*	breath 1	breath 2	Average
Inspiratory Reserve Volume (IRV) *(Delta)*			
Expiratory reserve volume (ERV) *(Delta)*			

*** Attach your printed spirogram that you have <u>labeled (as in Figure 2).</u>***

Table 2.

Lung Volume Calculations (in Liters)		
Inspiratory Capacity (IC)	= TV + IRV	
Vital Capacity (VC)	= TV + IRV + ERV	
Residual Volume (RV)	use average theoretical values: Females: **1.1 L** Males: **1.2 L**	
Functional Residual Capacity (FRC)	= ERV + RV	
Total Lung Capacity (TLC)	= TV + IRV + ERV + RV OR = VC + RV	

IV. Calculation of Predicted Vital Capacity (Table 3).

Predicted VC (in Liters)	
Age in years	**Height in inches**
Gender	**Formula** [1]**Female: (0.118872 x Height in inches) - (0.000252 x Age^2) - 3.598** [2]**Male: (0.148 x Height in inches) - (0.025 x Age) - 4.2421**
VC =	**Show work:**

Questions:

1. How does your measured VC compare to the predicted VC?

_____

2. What types of factors can affect VC?

_____

3. Why do you think height can affect VC?

_____

4. Why do you think the residual volume is provided for you as a theoretical value?

_____

V. Forced Vital Capacity (FVC) and FEV$_1$ (from pgs 7 & 8)

	Record: FVC value from table (maximum volume attained)	Record: FEV$_1$ value from table (volume after 1 second)	Calculate: FEV$_1$ / FVC % = (FEV$_1$ / FVC x 100)	Calculate: % of predicted FVC = (FVC/ 4.2L) x100	Diagnosis: obstructive or restrictive
Subject A					
Subject B					