

Chapter 36 Project

Inspirational Respiration

Project Goal + Timeline

We each typically take 20,000 breaths a day. The respiratory system quietly collects oxygen for delivery to your cells and expels the carbon dioxide released by your cells, generally without your conscious awareness. Since all cells require oxygen, the proper functioning of the respiratory system is essential to the proper functioning of all other body systems. As such, respiratory issues can have serious consequences throughout the body.

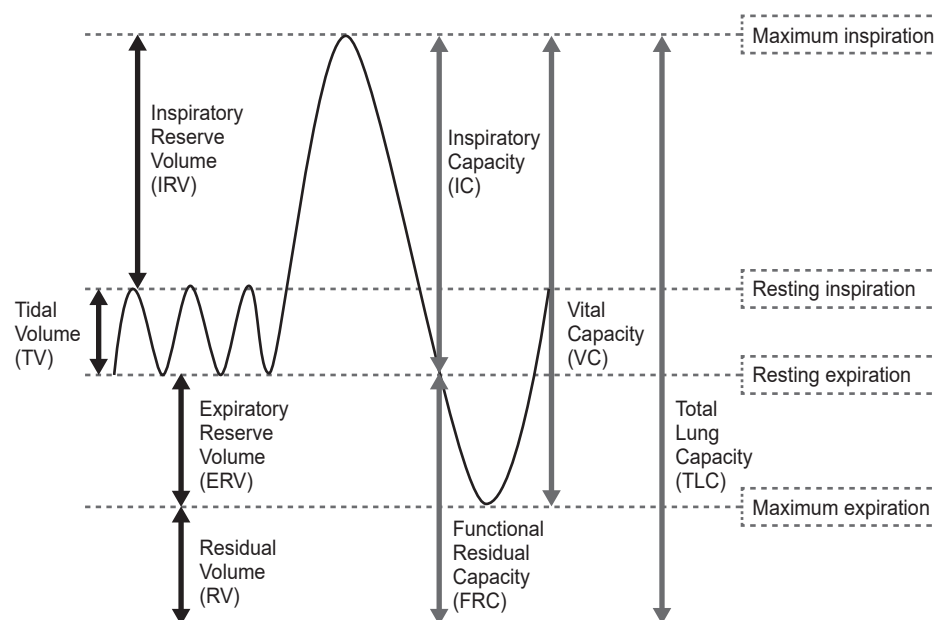
Doctors assess and monitor respiratory issues by measuring lung volumes. Lung volumes are the volumes of air in the lungs at different phases of the respiratory cycle. In this project, you will investigate your respiratory system by measuring and calculating your lung volumes. This project will take between one and two hours to complete.

Directions

In this project, you'll be measuring and calculating these lung volumes.

- tidal volume (TV): the amount of air inhaled or exhaled during a normal breath
- expiratory reserve volume (ERV): the additional amount of air that can be exhaled after a normal exhale
- inspiratory reserve volume (IRV): the additional amount of air that can be inhaled after a normal inhale
- vital capacity (VC): the sum of the tidal volume, expiratory reserve volume, and inspiratory reserve volume
- functional residual capacity (FRC): the volume of air remaining in the lungs after a normal exhalation
- residual volume (RV): the volume of air remaining in the lungs after a maximal exhalation
- inspiratory capacity (IC): the maximum amount of air that can be inhaled after a normal exhale
- total lung capacity (TLC): the maximal volume of air in the lungs after a maximal inhalation
- forced expiratory volume in one second (FEV1): volume of air that can be forced out of the lungs in 1 second

Examine the image to better visualize the relationships among lung volumes.



First, perform a series of lung volume tests using a balloon. These tests will allow you to measure your tidal volume, expiratory reserve volume, vital capacity, and forced expiratory volume for 1 second.

Complete three trials of each test described in Table 1. After each trial, measure the resulting diameter of the balloon (in centimeters). Record the diameter for each trial, then find the average balloon diameter for the three trials for each lung volume.

Take care when performing these exercises. Do not overexert yourself, and keep in mind any respiratory conditions you may have. If you feel discomfort, stop the activity, and resume normal breathing.

TABLE 1: Balloon Diameter Following Tests of Lung Volumes

Lung Volume	How to Test	Balloon Diameter Per Trial (cm)		Average Balloon Diameter (cm)
Tidal Volume (TV)	After a normal inhale, exhale normally (but not forcefully) into the balloon.	Trial 1:		
		Trial 2:		
		Trial 3:		
Expiratory Reserve Volume (ERV)	After a normal exhale, place the balloon on your mouth and exhale the remainder of the air you can force into the balloon.	Trial 1:		
		Trial 2:		
		Trial 3:		
Vital Capacity (VC)	Take a deep breath (maximum inhale) and force a maximum exhale into a balloon.	Trial 1:		
		Trial 2:		
		Trial 3:		
Forced Expiratory Volume in 1 Second (FEV1)	Take a deep breath (maximum inhale) and force a maximum exhale into a balloon for only 1 second.	Trial 1:		
		Trial 2:		
		Trial 3:		

Next, convert your average balloon diameter into a volume. To convert from diameter (d) in centimeters to volume (V) in milliliters, assume the balloon is spherical and use the formula for the volume of a sphere:

$$V = \frac{4}{3}\pi\left(\frac{d}{2}\right)^3$$

Perform this calculation for each lung volume measured in Table 1. Record the results in Table 2. Table 2 provides a reference value (the expected value for the general population) for each lung volume for comparison.

TABLE 2: Measurements of TV, ERV, VC, and FEV1

Lung Volume	Volume (mL)	Reference Value (mL)
Tidal Volume (TV)		500
Expiratory Reserve Volume (ERV)		1,200
Vital Capacity (VC)		3,100
Forced Expiratory Volume in 1 Second (FEV1)		4,500

Finally, use your data from Table 2 to calculate the lung volumes in Table 3. Apply the calculation given in the table for each volume. Record the result of the calculation in the table.

TABLE 3: Measurements of FRC, RV, IRV, IC, and TLC

Lung Volume	How To Calculate	Volume (mL)	Reference Value (mL)
Functional Residual Capacity (FRC)	Estimate by multiplying FEV1 by 0.75.		2,400
Residual Volume (RV)	FRC – ERV		1,200
Inspiratory Reserve Volume (IRV)	VC – ERV – TV		3,100
Inspiratory Capacity (IC)	IRV + TV		3,600
Total Lung Capacity (TLC)	VC + RV		6,000

Conclude this project by answering the following questions:

1. The ratio of FEV1 to FRC is often used as a diagnostic criterion in medicine. What does this ratio reveal, and what conditions could it help diagnose?
2. How do your results compare with the reference standards? How might you explain these results?
3. Why is it not possible to measure residual volume (RV) directly?
4. Your friend claims that if water is sufficiently oxygenated, humans can breathe underwater. Is their claim correct? Why or why not? **Hint:** Consider the comparative anatomy of a human and fish respiratory system.

Project Materials

- Project worksheet
- Pen or pencil
- A balloon
- A ruler that measures in centimeters

 Student Checklist

- ☐ Complete Table 1
- ☐ Complete Table 2
- ☐ Complete Table 3
- ☐ Complete all questions