Respiratory system

The primary function of respiration is to obtain O2 for use by the body cells and to eliminate the CO2 the cells produce.

The respiratory system does not participate in all steps of respiration.

Most people think of respiration as the process of breathing in and breathing out. In physiology Respiration encompasses two separate but related processes: cellular respiration and external respiration.

1- Cellular Respiration

The term **cellular respiration** refers to the intracellular metabolic processes carried out within the mitochondria, which use O2 and produce CO2 while deriving energy from nutrient molecules .

2- External Respiration

The term external respiration refers to the entire sequence of events in exchange of O2 and CO2 between the external environment and tissue cells.

External respiration encompasses:

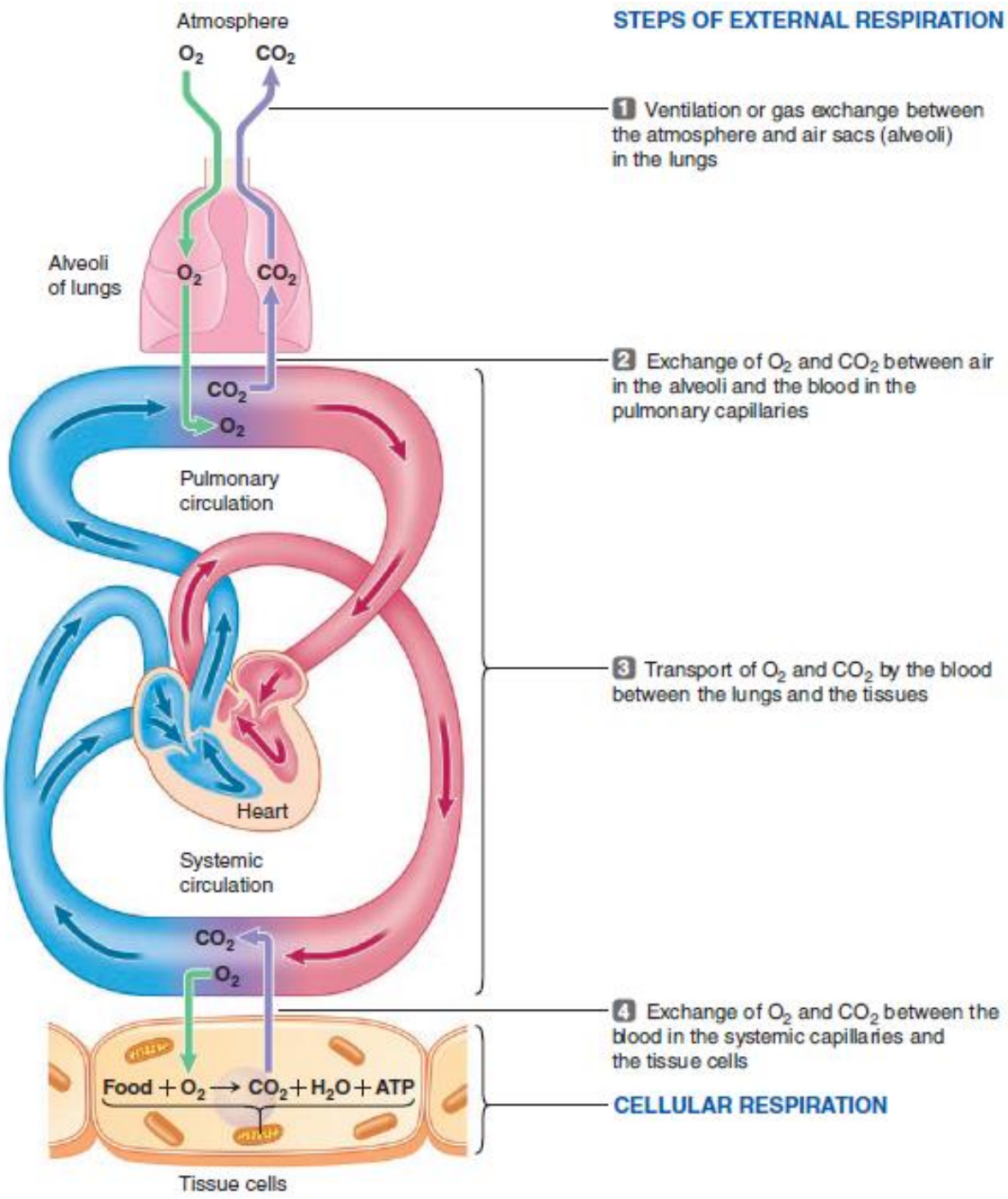
Step 1 : Air is alternately moved into and out of the lungs so that air can be exchanged between the atmosphere (external environment) and air sacs (*alveoli*) of the lungs. This exchange is accomplished by the mechanical act of **breathing**, or **ventilation**.

Step 2 : O2 and CO2 are exchanged between air in the alveoli and blood within the pulmonary (*pulmonary* means “lung”) capillaries by the process of diffusion.

Step 3 : The blood transports O2 and CO2 between the lungs and the tissues.

Step 4 : O2 and CO2 are exchanged between the tissue cells and blood by the process of diffusion across the systemic (tissue) capillaries.

The respiratory system does not accomplish all steps of respiration; it is involved only with ventilation and exchange of O2 and CO2 between the lungs and blood (steps 1 and 2). The circulatory system is involved in step 2 and carries out steps 3 and 4 .



The respiratory system also fills these non-respiratory functions:

1. It is a route for water loss and heat elimination.
2. It enhances venous return .
3. It helps maintain normal acid–base balance by altering the amount of H-generating CO2 exhaled.
4. It enables speech, singing, and other vocalization.
5. It defends against inhaled foreign matter .
6. It removes, modifies, activates, or inactivates various materials passing through the pulmonary circulation.

The respiratory airways :

They are tubes that carry air between the atmosphere and the air sacs. If all the airways were lined up end to end, they would extend 1500 miles.

The airways begin with the **nasal passages (nose)**.

The nasal passages open into the **pharynx (throat)**, which serves as a common passageway for both the respiratory and digestive systems.

Two tubes lead from the pharynx : the **trachea** , through which air is conducted to the lungs, and the **esophagus**, the tube through which food passes to the stomach.

The **larynx**, or **voice box**, is located at the entrance of the trachea. The anterior protrusion of the larynx forms the "Adam's apple."

The **vocal folds**, two bands of elastic tissue that lie across the opening of the larynx. Air passes into the larynx through the space between the vocal folds, they vibrate to produce the many sounds of speech.

Beyond the larynx, the trachea divides into two main branches, the right and left **bronchi**, which enter the right and left lungs, respectively. Within each lung the bronchus continues to branch into progressively narrower, shorter, and more numerous airways, like the branching of a tree.

The smaller branches are known as **bronchioles**.

Clustered at the ends of the terminal bronchioles are the **alveoli**, the tiny air sacs where gases are exchanged between air and blood.

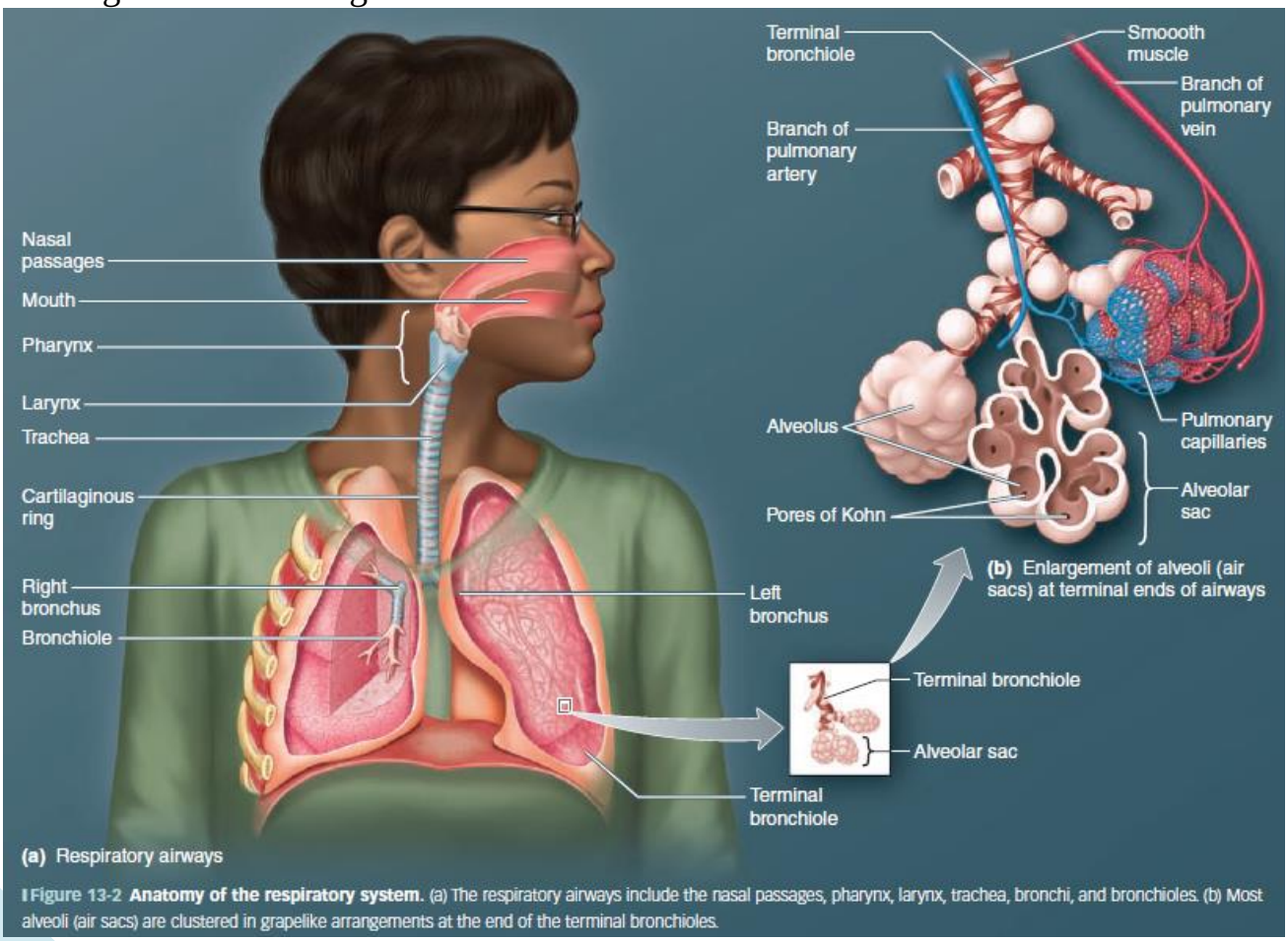


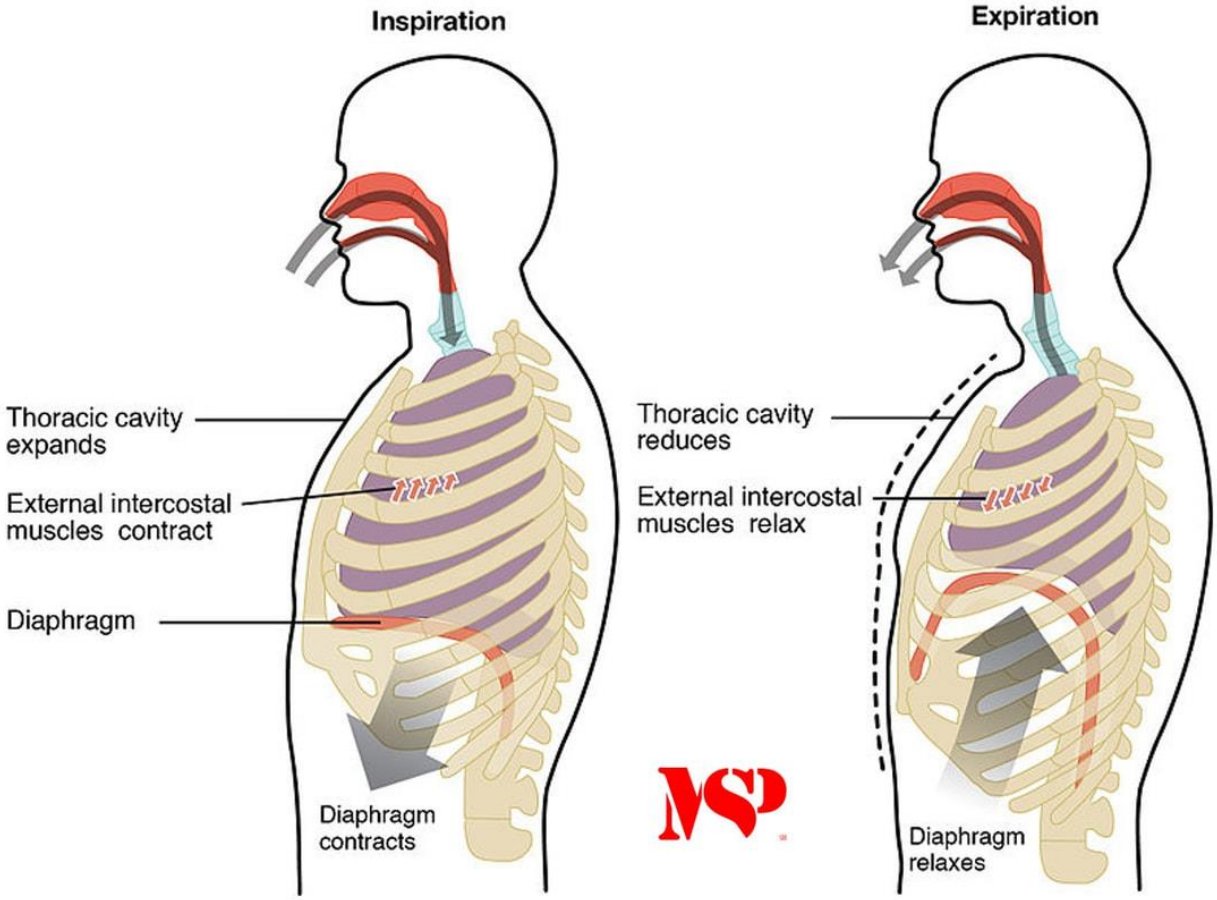
Figure 13-2 **Anatomy of the respiratory system.** (a) The respiratory airways include the nasal passages, pharynx, larynx, trachea, bronchi, and bronchioles. (b) Most alveoli (air sacs) are clustered in grapelike arrangements at the end of the terminal bronchioles.

The lungs occupy much of the thoracic cavity.

The two **lungs** are each divided into several lobes and each is supplied by one of the
The lungs occupy most of the volume of the **thoracic (chest) cavity**. The outer chest wall **(thorax)** is formed by 12 pairs of curved **ribs**, which join the **sternum** (breastbone) anteriorly and the **thoracic vertebrae** (backbone) posteriorly. The rib cage provides bony protection for the lungs and heart. Skeletal muscles connect these bony structures and enclose the thoracic cavity. The **diaphragm**, which forms the floor of the thoracic cavity, is a large, dome shaped sheet of skeletal muscle that separates the thoracic cavity from the abdominal cavity. It is penetrated only by the esophagus and blood vessels traversing the thoracic and abdominal cavities.

Inspiratory Muscles

The major **inspiratory muscles** include the *diaphragm* and *external intercostal muscles*. The relaxed diaphragm has a dome shape that protrudes upward into the thoracic cavity. The diaphragm descends downward when it contracts , enlarging the volume of the thoracic cavity by increasing its vertical (top-to-bottom) dimension.
During quiet breathing, the diaphragm descends about 1 cm during inspiration, but during heavy breathing, it may descend as much as 10 cm.
The **intercostal muscles** lie between the ribs.
Contraction of the **external intercostal muscles**, enlarges the thoracic cavity in both the lateral (side-to-side) and the anteroposterior (front-to-back) dimensions. When contract, they elevate the ribs and subsequently the sternum upward and outward



Lung Volumes and Capacities

The following lung volumes and capacities can be determined:

■ **Tidal volume (TV):** The volume of air entering or leaving the lungs during a single breath. Average value under resting conditions = **500** mL.

■ **Inspiratory reserve volume (IRV):** The extra volume of air that can be maximally inspired over and above the typical resting tidal volume. The IRV is accomplished by maximal contraction of the diaphragm, external intercostal muscles, and accessory inspiratory muscles. Average value = **3000** mL.

■ **Inspiratory capacity (IC):** The maximum volume of air that can be inspired at the end of a normal quiet expiration (IC = IRV + TV). Average value = **3500** mL.

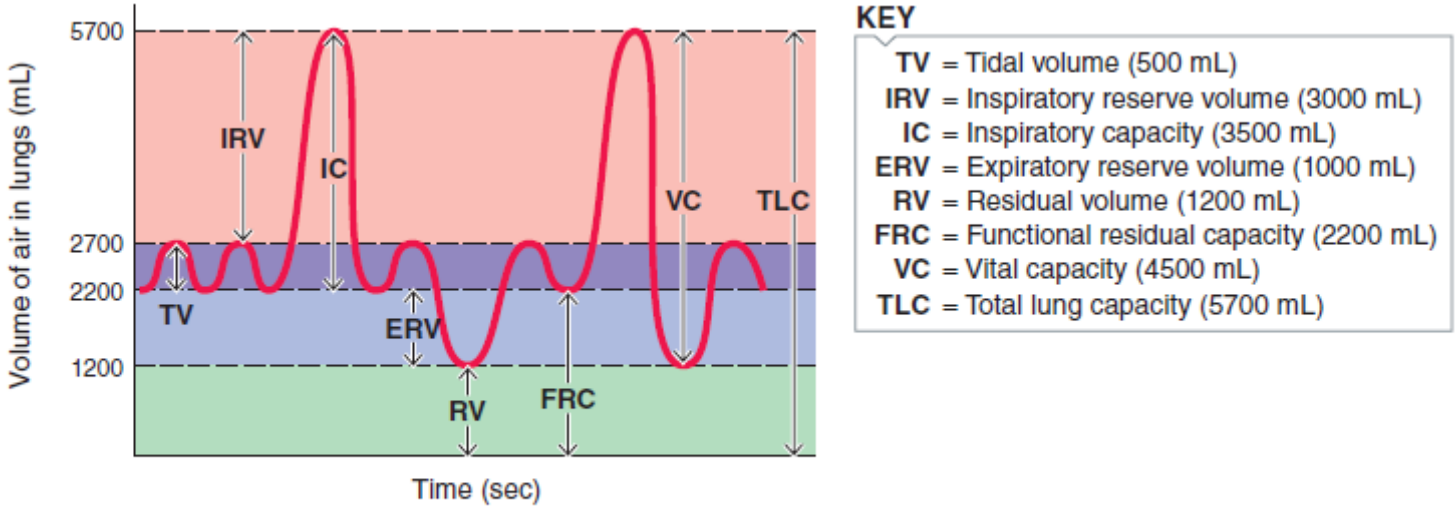
■ **Expiratory reserve volume (ERV):** The extra volume of air that can be expired by maximally contracting the expiratory muscles beyond that normally passively expired at the end of a typical resting tidal volume. Average value = **1000** mL.

■ **Residual volume (RV):** The minimum volume of air remaining in the lungs even after a maximal expiration. Average value = **1200** mL.

■ **Functional residual capacity (FRC):** The volume of air in the lungs at the end of a normal passive expiration (FRC = ERV = RV). Average value = **2200** mL.

■ **Vital capacity (VC):** The maximum volume of air that can be moved out during a single breath following a maximal inspiration. The subject first inspires maximally and then expires maximally (VC = IRV + TV + ERV). The VC represents the maximum volume change possible within the lungs . Average value = **4500** mL.

■ **Total lung capacity (TLC):** The maximum volume of air that the lungs can hold (TLC= VC + RV). Average value **5700** mL.



(b) Normal variations in lung volume in a spirogram in a healthy young adult male

Gas Transport

Oxygen picked up by the blood at the lungs must be transported to the tissues for cell use. Conversely, CO2 produced at the cell level must be transported to the lungs for elimination.

TABLE 13-6 Methods of Gas Transport in the Blood

Gas	Method of Transport in Blood	Percentage Carried in This Form
O_2	Physically dissolved	1.5
	Bound to hemoglobin	98.5
CO_2	Physically dissolved	10
	Bound to hemoglobin	30
	As bicarbonate (HCO_3^-)	60