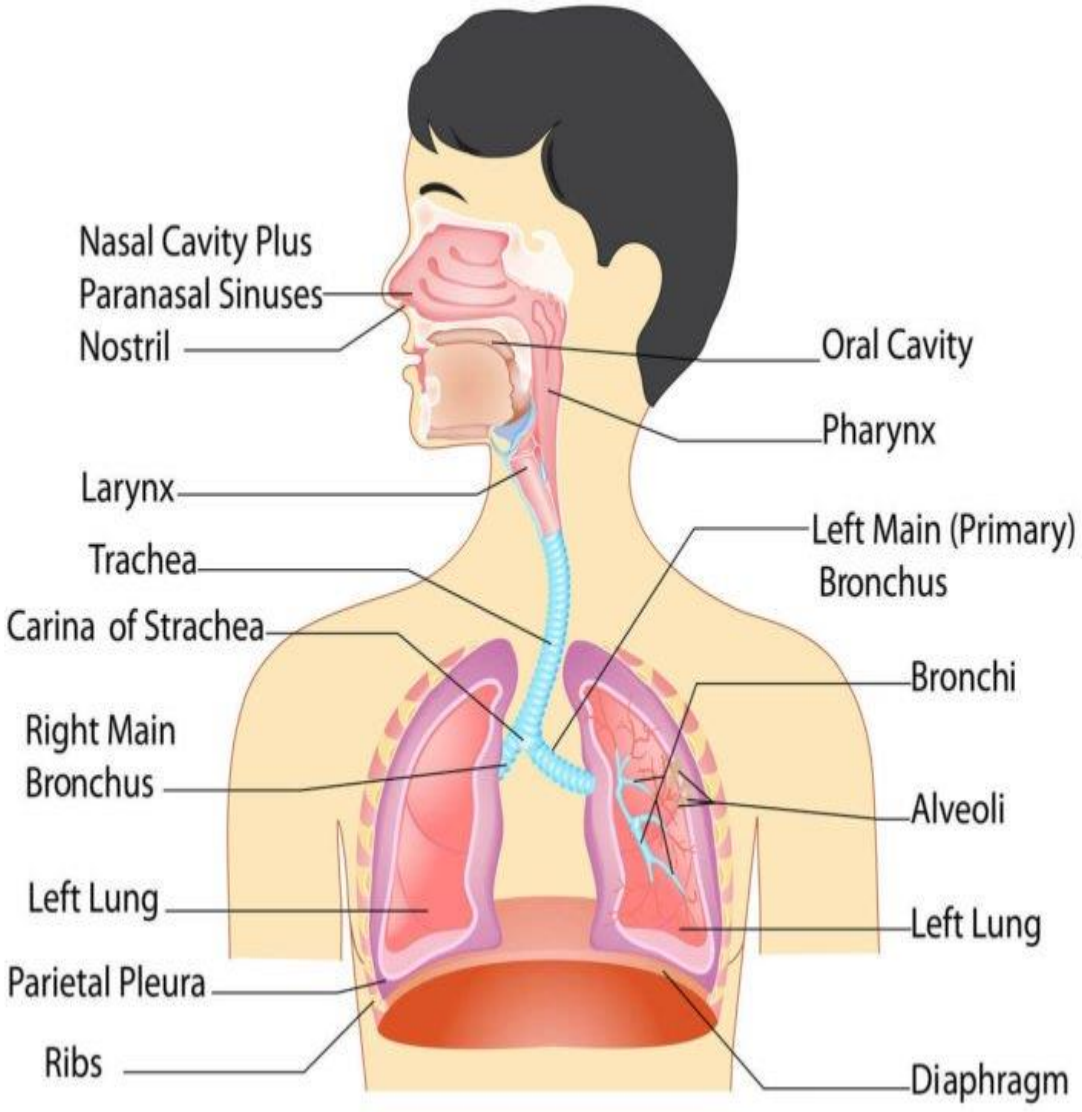
Respiratory Physiology

Organization of the respiratory system

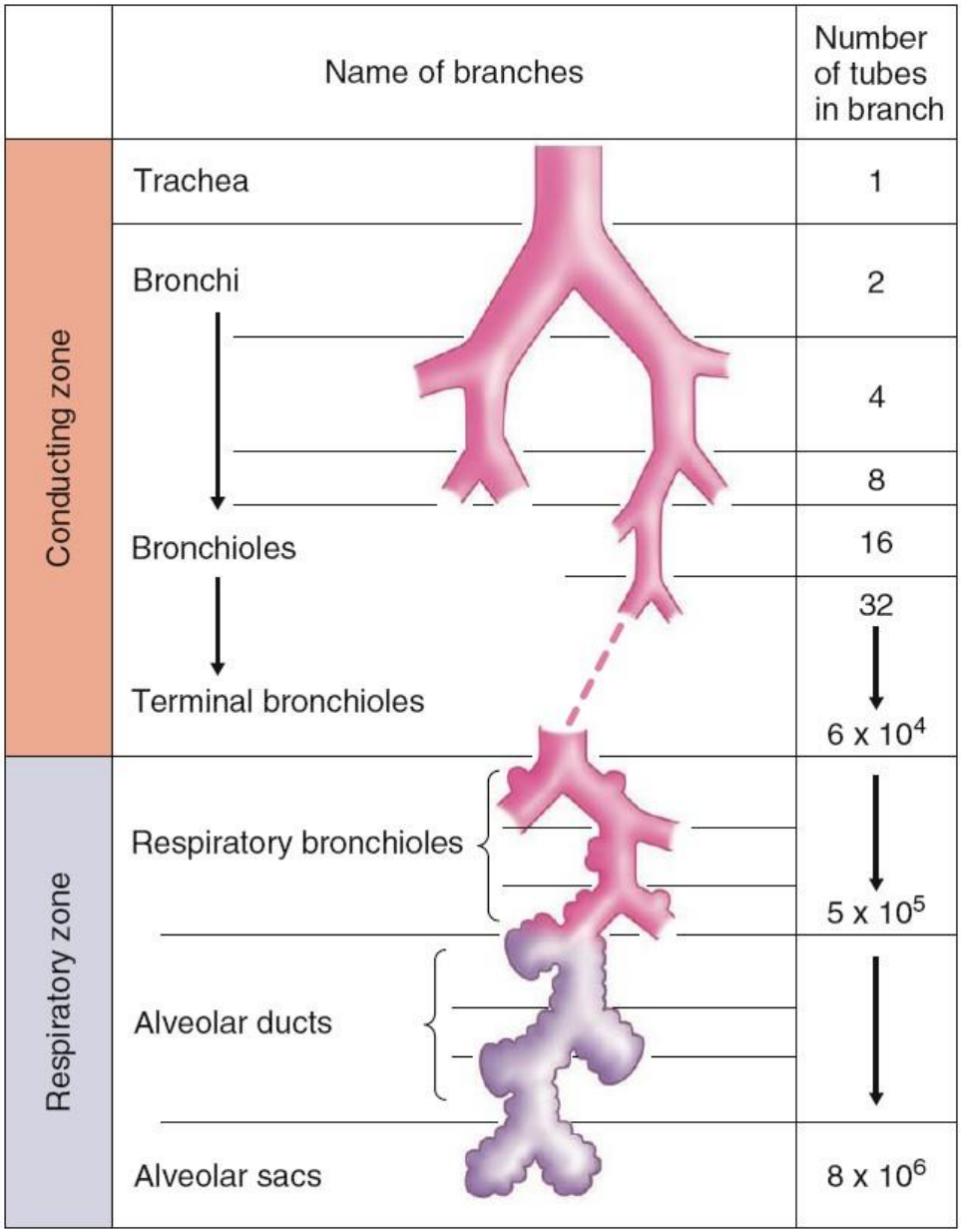


The respiratory system (also referred to as the ventilator system) is a complex biological system comprised of several organs as shown, that facilitate the inhalation and exhalation of oxygen and carbon dioxide in living organisms (or, in other words, breathing).

Inspiration (inhalation) is the movement of air from the external environment through the airways into the alveoli during breathing. **Expiration** (exhalation) is air movement in the opposite direction.

An inspiration and expiration constitute a **respiratory cycle.**

Airway Branching



The nose, mouth, pharynx, and larynx are collectively termed the **upper airways.** The larynx opens into a long tube, the **trachea,** which in turn branches into two **bronchi** (singular, **bronchus**), one of which enters each lung. Within the lungs, there are more than 20 generations of branchings, each resulting in narrower, shorter, and more numerous tubes.

The airways beyond the larynx can be divided into two zones:

Conducting Zone: extends from trachea to the beginning of respiratory bronchioles; it does not involve in exchange of gases

Respiratory zone: From respiratory bronchioles to alveolar sacs; they are involved in gas exchange

Airway Branching (continue)

Tracheobronchial tree: The lower respiratory tract (which is forming a conducting zone) is also called the **respiratory tree** or **tracheobronchial tree**, to describe the branching structure of airways supplying air to the lungs, and includes the **trachea, bronchi and bronchioles**.

Functions of conducting zone of airways:

1. Provides a low resistance pathway to air flow
2. Defends against microbes, toxic chemicals, and other foreign matter. These functions are performed by cilia, mucus and macrophages.
3. Warms and moistens the air

Site of Gas Exchange: The Alveoli

The **alveoli** are tiny, hollow sacs with open ends that are continuous with the lumens of the airways. Typically, a single alveolar wall separates the air in two adjacent alveoli. Most of the air-facing surfaces of the wall are lined by a continuous layer, one cell thick, of flat epithelial cells termed **type I alveolar cells (structural cells).** Interspersed between these cells are thicker, specialized cells termed **type II alveolar cells** that produce a detergent-like substance called surfactant that, is important for preventing the collapse of the alveoli.

Mechanics of breathing

Thoracic Cavity

Diaphragm:

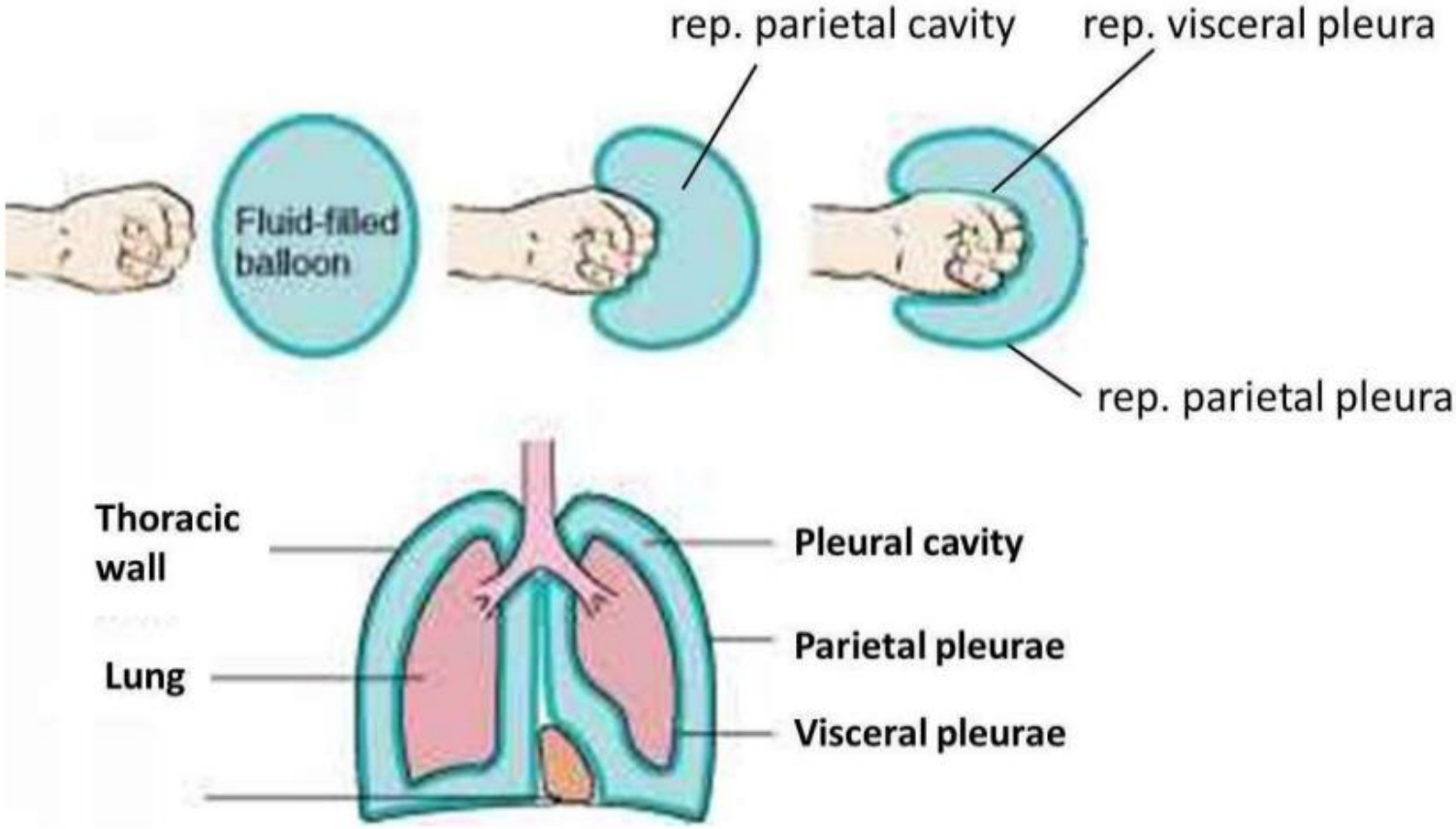
Sheets of striated muscle divides anterior body cavity into 2 parts.

Above diaphragm: thoracic cavity:

Contains heart, large blood vessels, trachea, esophagus, thymus, and lungs.

Below diaphragm: abdominopelvic cavity:

Contains liver, pancreas, GI tract, spleen, and genitourinary tract.



The pleural cavities are lined by the pleural membranes - Visceral pleura → covers the lungs. attaches directly to the lungs. Parietal pleura → lines thoracic wall including the diaphragm

The two layers of Pleura are separated by a thin layer of fluid called **Intrapleural fluid** and the change s in hydrostatic pressure of intrapleural fluid is called **intrapleural pressure (P_{ip})**

Ventilation: the exchange of air between the atmosphere and alveoli

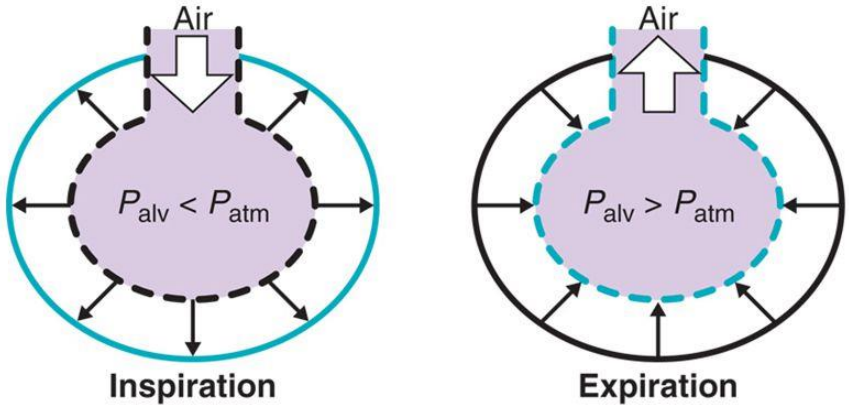
According to Boyle's law, the pressure exerted by a constant number of gas molecules (at constant temperature) is inversely proportional to the volume of the container. During ventilation, air moves into and out of the lungs due to change in atmospheric pressure and alveolar pressure

Air flows into and out of the lungs due to pressure gradient

F = Change in pressure/Resistance

Air enters the lungs when :Palv< Patm

Air exits the lungs when : Palv > Patm



$$F = \frac{P_{alv} - P_{atm}}{R}$$

Alveolar pressure (P_{alv})

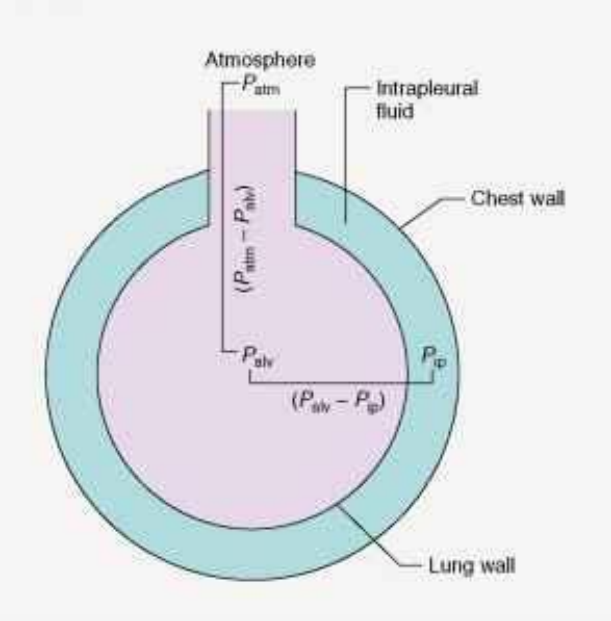
Atmospheric pressure (P_{atm})

Pressure Systems in the lungs

- Pressure in the lungs (alveoli) = intra pulmonary pressure (Palv)
- Pressure within intrapleural cavity = intra pleural pressure (Pip)
- Pressure outside the lungs = atmospheric pressure (Patm)

(Palv) - (Pip) = transpulmonary pressure

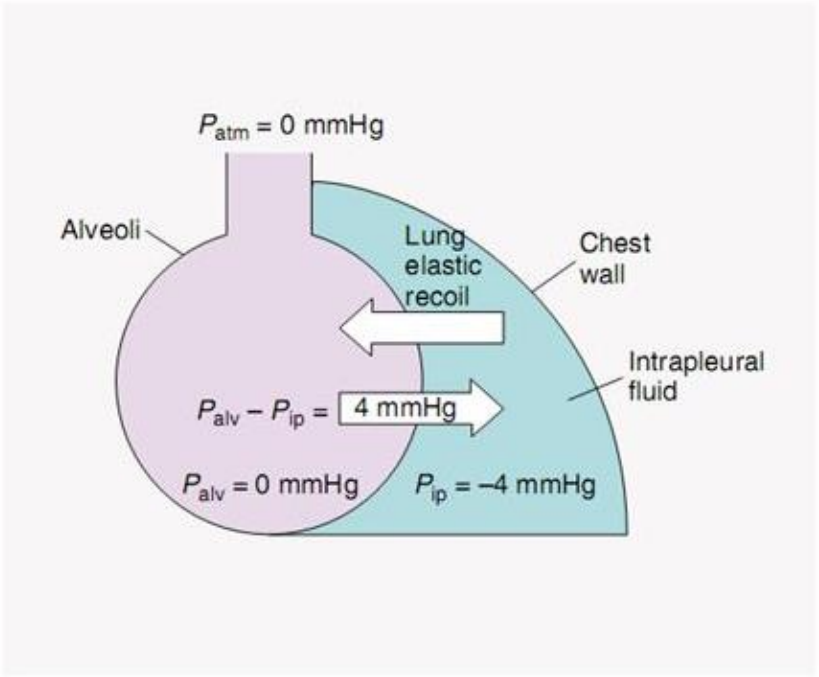
Hence transpulmonary pressure in the difference in pressure between inside and outside of the lungs



Two pressure differences involved in ventilation.

Pav-Pip is a determinant of lung size and Patm-Palv is a determinant of air flow

In between the breaths



- P_{alv}- P_{ip}= 0- (-4)=4mmHg
- P_{atm}-P_{ip}=0-(-4)=4mmHg
- The transpulmonary pressure exactly opposes the elastic recoil of lung- lung volume remains stable

The figure represents Alveolar, intrapleural and transpulmonary pressures at the end of unforced expiration.
Patm is 0mmHg
Pip is approximately 4 mmHg less than atmospheric pressure

Sequence of events during inspiration and expiration