Pulmonary& Alveolar Ventilation

Steps of Respiration

1. Pulmonary Ventilation
   - The inflow of O_2 from the atmosphere to the alveoli and the outflow of CO_2 from the alveoli to the atmosphere.
2. Pulmonary Perfusion
   - The cardiac output of the right ventricle (≈ 5 L/min) that passes to the lungs to take up O_2 and remove CO_2.
3. Exchange of Gases
   - Occurs between pulmonary ventilation and perfusion through the pulmonary membrane by simple diffusion.
4. Gas Carriage
   - Blood carries gases to the left heart and then to all body tissues.

Respiratory Passages

I. Air Conducting Zone (Dead Space)

- Pathway: Nose → Pharynx → Larynx → Trachea → Bronchi → Bronchioles → Terminal bronchioles (16 divisions).
- No gas exchange occurs here due to the thick wall.
- Contains cartilaginous rings to prevent collapse.
- Contains elastic fibers allowing lengthening and shortening with lung expansion and collapse.
- Performs important protective functions.

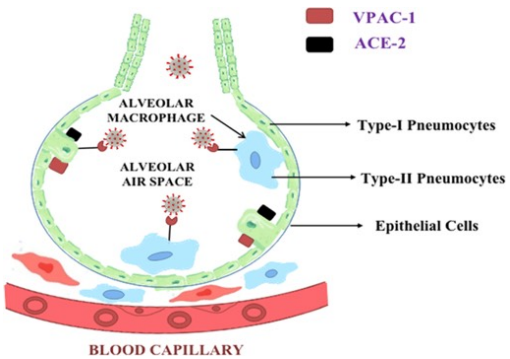
II. Respiratory Zone (Exchange Zone)

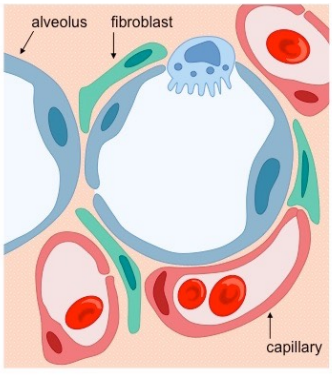
- Pathway: Respiratory bronchioles → Alveolar ducts → Alveoli (7 divisions).
- Gas exchange occurs here with blood.

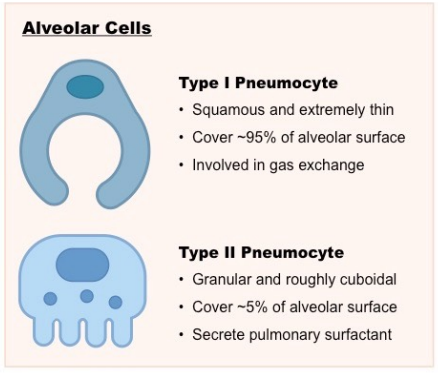
Conducting & Respiratory Zone Structures	
Conducting Zone The **conducting zone** consists of all of those structures that conduct air into and out of the lungs. The nose, pharynx, larynx, trachea, bronchi, bronchioles and terminal bronchioles are all part of the conducting zone. The function of the conducting zone is to filter, warm, moisten, and conduct the air to the lungs.	Nose
	Pharynx
	Larynx
	Trachea
	Primary Bronchi
	Secondary Bronchi
	Tertiary Bronchi
	Bronchioles
	Terminal Bronchioles
Respiratory Zone The **respiratory zone** is where gas exchange takes place in the lungs. Respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli make up the respiratory zone.	Respiratory Bronchioles
	Alveolar Ducts
	Alveolar Sacs
	Alveoli

Structure of Alveoli

1. Type I Cells (Squamous Pneumocytes):
   - Form the thin wall for gas exchange.
2. Type II Cells (Granular Pneumocytes):
   - Secrete surfactant.
3. Type III Cells (Alveolar Macrophages / Dust Cells):
   - Highly phagocytic, remove foreign particles and microorganisms.







Non-Respiratory Functions of the Respiratory System

- Smell: By olfactory receptors in the posterior nasal cavity.
- Taste: By the oral cavity and pharynx.
- Voice Production:
- Phonation & articulation by changes in thickness, vibration, and position of the vocal cords in the larynx.
- Regulation of Body Temperature:
- By heat loss during expiration.
- Regulation of pH (Acid-Base Balance):
- By controlling CO_2 levels.
- Drug Administration:
- Some drugs (e.g., anesthetics, bronchodilators) can be given by inhalation.

Protective Functions

1. Air Conditioning
   - Warming and moistening of inspired air due to rich blood supply and mucus.
   - Prevents harmful effects of cold or dry air on alveoli.

2. Protective Reflexes
   - Sneezing reflex: due to irritation of the nose.
   - Cough reflex: due to irritation of the larynx, trachea, or bronchi.

3. Presence of Lymphoid Tissue
   - In oro-pharynx and naso-pharynx for immune defense.

4. Filtration of Large Particles
   - Particles **>10** µm are trapped by nasal **hairs**.

5. **Mucous** Blanket
   - Produced by goblet cells under vagal nerve control (~100 mL/day).
   - Traps dust particles **<10** µm before reaching alveoli.
   - Contains immunoglobulin A (IgA) for immune protection.

6. Muco-Ciliary Escalator Mechanism
   - Wave-like ciliary movement of the respiratory mucosa drives mucus and trapped particles **toward the pharynx to be expelled.**

   - **Inhibited by:**
   - Cigarette smoking
   - Hypoxia
   - General anesthesia
   - Dehydration

7. **Alveolar Macrophages (Dust Cells)**
   - Engulf dust particles **<2** µm and destroy bacteria by lysosomal enzymes.

Lung Surfactant

A lipoprotein mixture mainly containing phospholipid (dipalmitoyl lecithin).

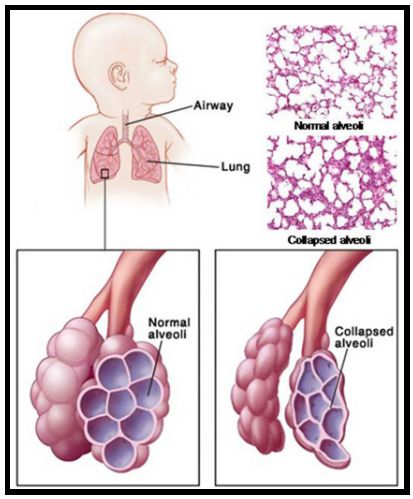
Secreted From Type **II** alveolar cells.

Functions

1. Decreases Surface Tension
   - Forms a layer between alveolar fluid and air, changing the air-water interface into an air-surfactant interface, reducing surface tension.
2. Decreases Muscular Effort during Inspiration
   - Allows easier and gradual expansion during inspiration.
   - Prevents rapid expiration and alveolar collapse.
3. Safety Factor Against Pulmonary Edema
   - Lower surface tension reduces the suction force drawing fluid from capillaries, keeping alveoli dry and preventing edema.
4. Stabilizes Alveolar Size
   - **Less** concentrated in **large** alveoli (**prevents rupture**).
   - **More** concentrated in **small** alveoli (**prevents collapse**).

Factors Affecting Surfactant Formation

- Starts: 24th week of intrauterine life
- Complete: 35th week
- Requires: Cortisol & Thyroxin

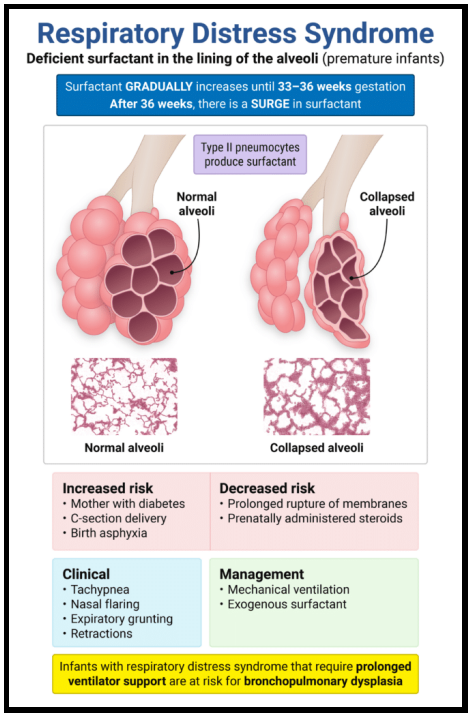


Factors That **Decrease** Surfactant:

1. Prematurity in infants
2. Decreased thyroxine and cortisone
3. Increased insulin (inhibits surfactant protein)
4. Hypoxia
5. Heavy cigarette smoking
6. Acidosis
7. Lung diseases

Hyaline Membrane Disease (Infantile Respiratory Distress Syndrome)

- Caused by decreased surfactant formation → lung expansion failure → alveolar collapse → pulmonary edema → respiratory failure → death.



Causes

- Premature infants (low cortisol & thyroxin)
- Infant of diabetic mother (high insulin)

Diagnosis

- Decreased Lecithin/Sphingomyelin (L/S) ratio in amniotic fluid:
- <1 → abnormal
- Normally = **1 at 24 weeks**, = **2 at 35 weeks**

Treatment

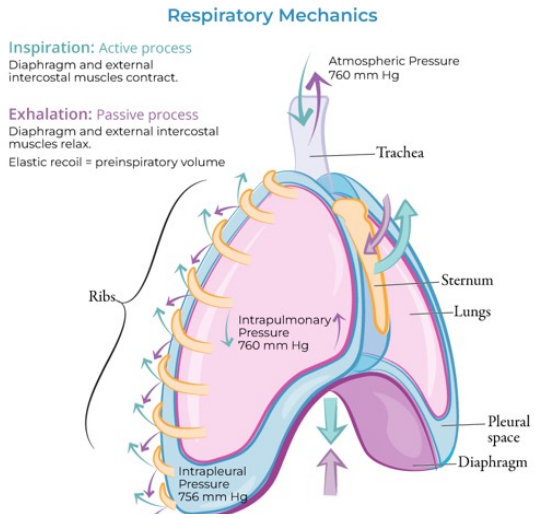
- Artificial respiration
- Cortisone and thyroxin
- Artificial surfactant administration

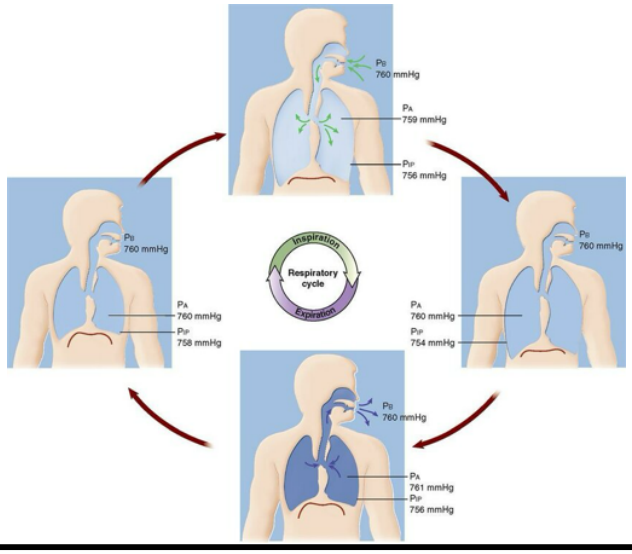
Respiratory Cycle

- Composed of active inspiration and passive longer expiration, followed by an expiratory pause.
- Normal rate: 12–16 cycles/min

Expiratory Pause Caused By:

1. Reflex stoppage of inspiratory center activity
2. Time required for CO_2 re-accumulation after it was washed out, to stimulate new inspiration



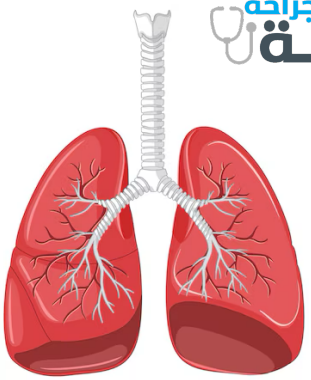


Recoil Tendency of the Lung

At the end of normal expiration (muscles relaxed):
- Lung and thoracic volume = 2.5 L
- Relaxation volume of lungs alone = 1 L

Thus, lungs are **distended** from **1** → **2.5 L** and tend to recoil.

Causes of Recoil
1. Stretched elastic fibers (1/3 of recoil)
2. Surface tension of alveolar fluid (2/3 of recoil)

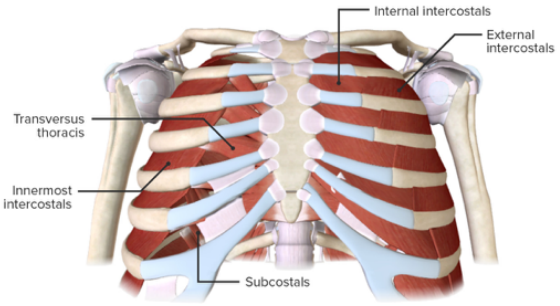


Expansion Tendency of the Chest Wall

At end of normal expiration:
- Lung & thoracic volume = 2.5 L
- Relaxation volume of chest = 5 L

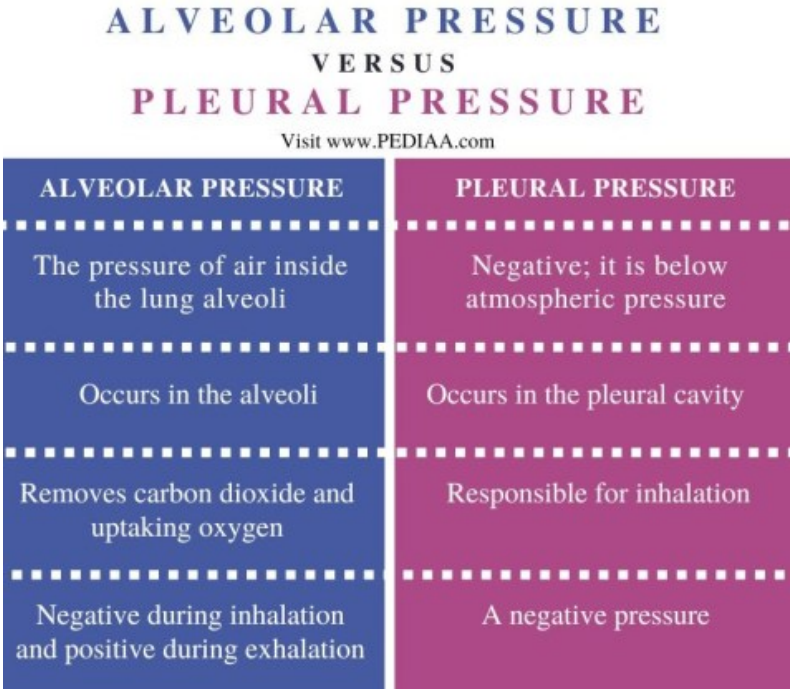
Thus, the chest is **compressed** from **5** → **2.5 L** and tends to expand.

Cause
- Elasticity of muscles, tendons, and chest tissues



Pressure Difference
- Intra-alveolar Pressure: Pressure inside the alveoli.
- Intrapleural Pressure (Intra-thoracic Pressure): Pressure within the pleural cavity — always negative compared to alveolar pressure, keeping lungs expanded.

Functions of Intrapleural Pressure (IPP)
1. Assists venous and lymphatic return against gravity
2. Helps lung expansion during inspiration
3. Maintains lung inflation and prevents collapse, especially during expiration

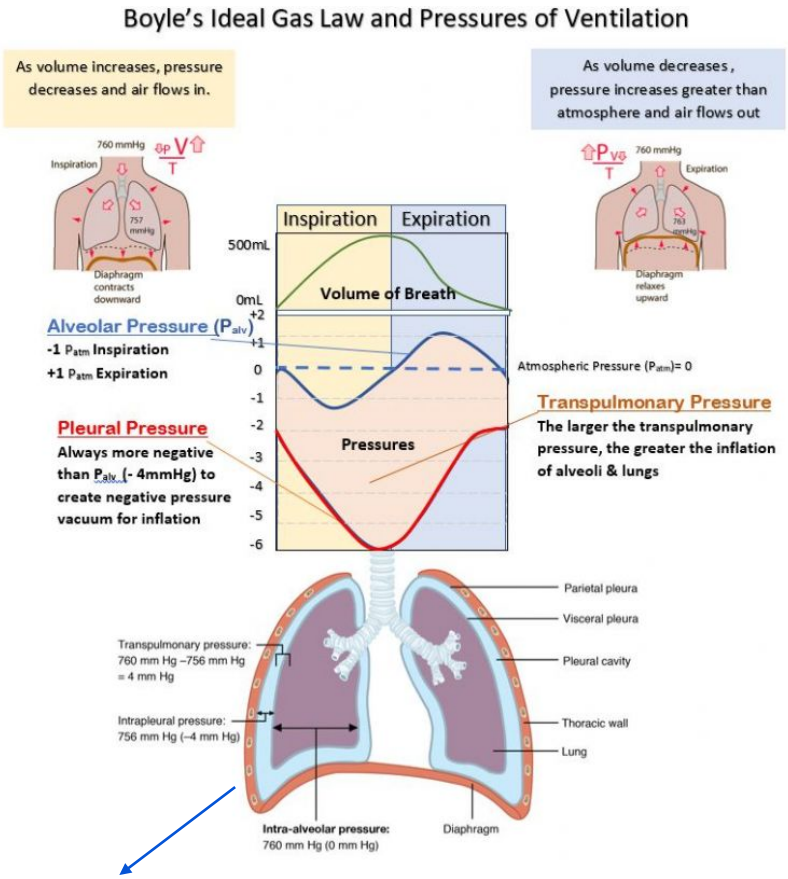


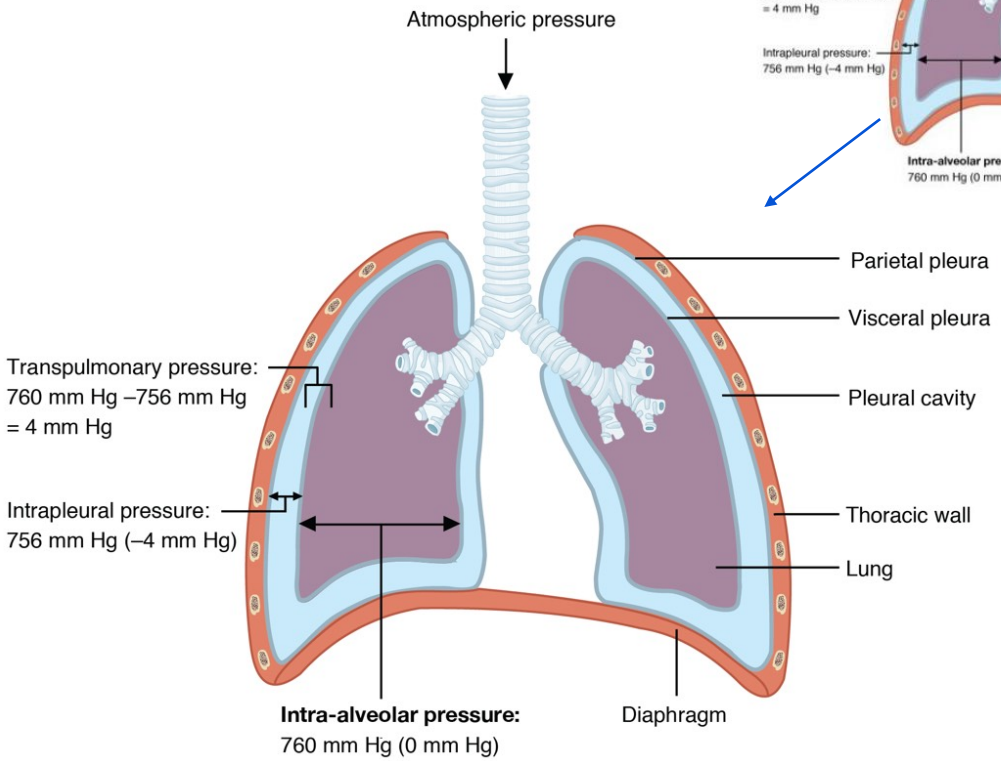
3. Respiratory Pressures

· **Intrapulmonary (Alveolar) Pressure:**
  · Definition: The pressure inside the alveoli.
  · Values:
    · At rest: Equal to atmospheric pressure (0 mmHg).
    · Inspiration: Becomes slightly negative (e.g., -1 mmHg), pulling air in.
    · Expiration: Becomes slightly positive (e.g., +1 mmHg), pushing air out.

· **Intrapleural (Intrathoracic) Pressure:**
  · Definition: The pressure in the narrow space between the visceral and parietal pleura.
  · Value: It is always negative (subatmospheric) under normal conditions (e.g., -3 to -6 mmHg at rest).
  · Cause of Negativity: It results from two opposing forces:
    1. The lungs' natural tendency to recoil and collapse inward.
    2. The chest wall's natural tendency to spring outward.

· Functions:
  · Keeps the lungs partially inflated.
  · Helps in venous return of blood to the heart.
  · A pneumothorax (air in pleural space) eliminates this pressure, causing the lung to collapse.





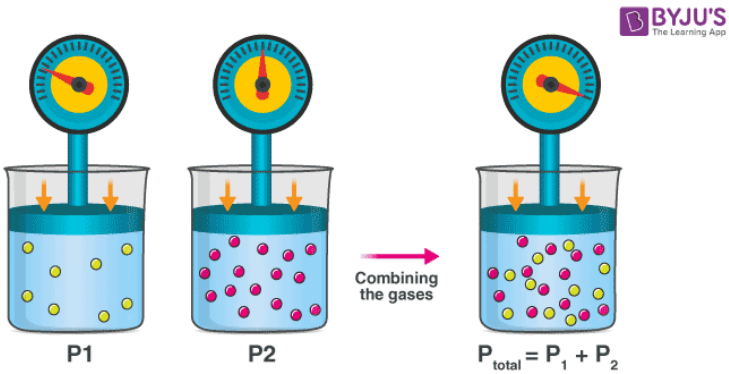
Respiratory Mechanism Summary

Result	Muscles	Activity	Phase
↑ Thoracic size, ↓ Intrapleural Pressure (IPP)	Diaphragm (vertical movement ~75%), External intercostals	**Active**	**Inspiration**
↓ Thoracic size, ↑ IPP	Relaxation of inspiratory muscles	**Passive (normal)**	**Expiration**
Air forced out	Internal intercostals, Abdominal muscles	**Active**	**Forced Expiration**

Dalton's Law of Partial Pressure

- Partial Pressure: Pressure each gas would exert if it were alone.
- Total Pressure: Sum of all individual gas pressures.

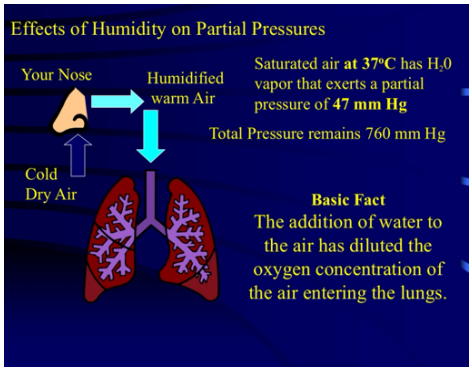
Note: Partial pressure of a gas is a major determinant of gas exchange in the alveoli.



Dalton's Law of Partial Pressures

Effects of Humidity on Partial Pressures

- Saturated air at 37°C has H_2O vapor with a partial pressure of 47 mmHg.
- Total pressure remains 760 mmHg.
- Adding water vapor dilutes oxygen concentration in the inspired air.



Dr. Nour A. Mohammed

Done by : Raghad Mohammad