**Function:**

*Exchange respiratory gases* (O₂ & CO₂)

- 4 Processes Involved:
  1. **Ventilation:** Movement of air in and out of lungs
  2. **External Respiration:** Exchange of gases between air in alveoli and blood
  3. **Transport:** Respiratory gases in blood
  4. **Internal Respiration:** Exchange of gases between blood and tissues
Produced by changes in **Lung Pressure**

- **Intrapulmonary Pressure**
- Air always moves from **HIGH** to a **LOW** pressure
  - a. **Inspiratory**: Air moves **INTO** lungs
    - **Outside** pressure **HIGHER**
    - At sea level = 760 mmHg (1 ATM)

- **Intrapulmonary pressure** is **LOWER**
  - 3 mm Hg lower = 757 mm Hg
  - Air moves from outside **into** lungs
b. **Expiration**: Air moves **OUT** of lungs
   - **Outside pressure LOWER**
     - STILL = 760 mmHg (1 ATM)
   - **Intrapulmonary pressure** is **HIGHER**
   - Air moves from *Lungs to outside

   - **3 mm Hg higher** = 763 mm Hg

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**Mechanism**: Pressure changes produced by alterations in **LUNG VOLUME**

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**BOYLE’S LAW**:

- Low volume: HIGH pressure → Smaller space
- High volume: LOW pressure → Larger space

• Gas Pressure: Inversely proportional to volume
a. **Inspiration**: \( \uparrow \text{Volume} = \downarrow \text{Pressure} \\
b. **Expiration**: \( \downarrow \text{Volume} = \uparrow \text{Pressure} \\

Which x-ray represents inspiration? A or B

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\( \text{NO Air movement when pressure are EQUAL}\) \\
\( \star \text{Atmospheric pressure} = 760 \text{ mmHg}\) \\
\( \star \text{Intrapulmonary pressure} = 760 \text{ mmHg}\)

\[ 760 \text{mmHg} \]

\( \uparrow \text{Inspiration}: \\
\text{a. Diaphragm Contracts: Flattens & lowers} \\
\text{b. External Intercostals Contract: Raises ribs} \\
\text{\( \implies \text{Thoracic cavity LARGER} \)
**Expiration:**
- Diaphragm Relaxes: Raises
- External Intercostals Relax: Lowers Ribs

**Adhesive Property of Lungs**

**Question:** “How are the lungs expanded by the change in thoracic cavity volume?”

**Answer:** Lungs are adhered to the internal thoracic cavity wall
- Lungs are covered with serous membranes
  - Secrete: Serous fluid
  - Visceral Pleura
- Thoracic cavity lined with serous membranes
  - Secrete: Serous fluid
  - Parietal Pleura
• **Forms: Pleural Cavity**
  - Lungs fill pleural cavity (space)

  - Pleural Space: Filled with thin layer of serous fluid

• **Serous Membranes adhere together**
  - Serous fluid Hydrogen Bonds together
  - Results in adhesion force: Surface tension

• **Clinical Application:**
  - **Pneumothorax:** “Collapsed Lung”

• **Separation of visceral & parietal layers**

  - Left Lung Collapse
Results from:
- Decrease in surface tension
- Reduction in adhering forces
- Inward pull of lungs Elastic recoil

**Causes:**

a. **Injury:** Opening pleural cavity to outside pressures

Pneumothorax

b. **Surface irregularities:** BLEBS

c. **Pre-existing lung disease:** COPD, Cystic Fibrosis, Emphysema
Physical Properties of the Lungs

**Ventilation:** Dependant upon ability of lungs to *expand & recoil*

a. **Compliance:** *Distensible* or able to stretch
   - Affects lung filling / Inhalation

b. **Elasticity:** Degree of *recoil* following stretch
   - Affects lung emptying / Exhalation

c. **Alveolar Surface Tension:** Inward force produced by water within alveoli
   - Affects lung emptying / Exhalation
   - Intra-alveolar water forms: **Hydrogen bonds**
     * Surface tension: Draws alveoli inwardly
     * Causing alveolar collapse

> Surfactant = “**Surface Active Agent**”

- Reduces surface tension & alveolar collapse
  - **Phospholipoprotein:** Reduces surface tension
  - *Reduces Hydrogen Bonding*
Respiratory Distress Syndrome (RDS): Neonatal

Occurs in infants born prior to 37–39 wks

Cause: Immature lung: Decreased Surfactant production

Symptoms:
- Bluish skin & mucous membranes
- Rapid, shallow breathing

Treatment:
- Warm moist oxygen
- CPAP: Continuous Positive Airway Pressure
- Synthetic Surfactant

Ventilatory Measurements:

- Spirometry: Evaluates Pulmonary Function

Spirometry measures the amount and rate of air a person breathes in order to diagnose illness or determine progress in treatment

- Quantifies lung air volumes
  - Stored Volumes
  - Inhaled or Exhaled Volumes
• Most useful Spirometry Technique:
  
  **Forced Expiration Test**
  
  * Ratio of:
  
  1. **Forced Vital Capacity (FVC)**: Maximal volume of air expired after forced inspiration
      ✓ Normal = ~ 5 liters Air / 4 secs
  
  2. **Forced Expiratory Volume in one second (FEV1)**
     Maximal volume of air expired in FIRST second
      ✓ Normal = ~ 4 liters Air / 1 sec

  * Healthy Forced Expiration Test:

  \[
  \frac{\text{FEV1}}{\text{FVC}} = 80\%
  \]

  ✓ **Exhale 80% of breath in first second**

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**Pulmonary Dysfunction:**

2 Main Categories:

1. **Obstructive Disorder**: Lung conducting passages are occluded

   * Emphysema, bronchitis, & asthma

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FVC = 5.0 L
FEV1 = 4.0 L/s
Total Breath = 4 secs
**COPD: Chronic Obstructive Pulmonary Disease**

* Difficulty moving air rapidly into & out of the lungs

**LUNG PROBLEM: FLOW**

- FVC: Lower than normal
- FEV1: Lower than normal
- Total Breath time: Longer than normal

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**Obstructive Expiration Test: LOW**

- FEV1 / FVC = 40%
  - Exhale only 40% in first second
  - Reduced overall vital capacity

- ONLY 3 liters (not 5 liters)

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2. **Restrictive Disorder**: Actual damage & "scar tissue" to the lung

- Pulmonary fibrosis
* Lung Compliance is decreased
  ✓ Lung doesn’t stretch

* Lung Problem: FILLING
  FVC: Lower than normal
  FEV1: Approximately normal or greater
  Total Breath time: Approximately normal

* Restrictive Expiration Test: HIGH
  \( \text{FEV}_1 / \text{FVC} = 90\% \)

  ✓ Exhale 90% of breath in first second
  ✓ Reduced overall vital capacity

  ~ ONLY 3 liters
  (not 5 liters)

FVC: Lower than normal
FEV1: Approximately normal or greater
Total Breath time: Approximately normal

Pulmonary Dysfunction: X-ray

The one in the middle is normal. The one on your right is an example of restrictive lung disease and the one on your left is an example of obstructive.