

The Respiratory System



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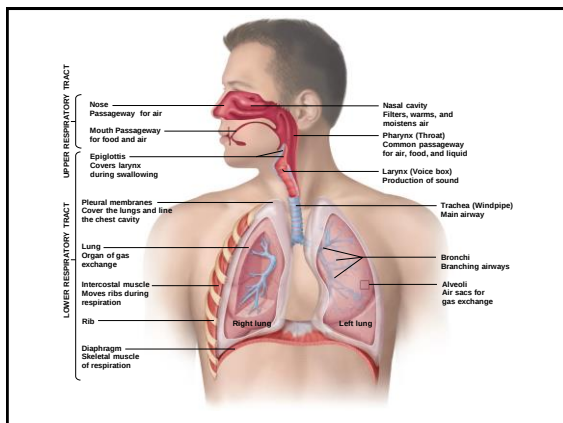
Respiration

- **Breathing:** movement of air into and out of the lungs
- **External respiration:** O_2 and CO_2 exchange between the lungs and the blood
- **Transport:** O_2 and CO_2 in the blood
- **Internal respiration:** O_2 and CO_2 exchange between systemic blood vessels and tissues
- **Cellular respiration:** oxygen use to produce ATP, carbon dioxide as waste

Respiratory system

Circulatory system

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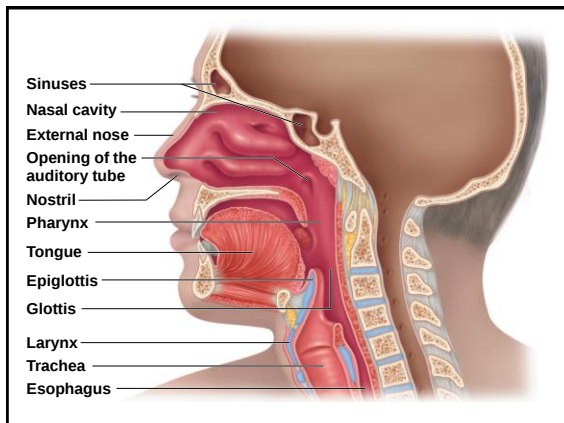


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Upper Respiratory Tract

- Functions
 - Acts as passageway for respiration
 - Has receptors for smell
 - Filters larger foreign material from incoming air, inhaled microorganisms are entrapped in mucus
 - Moistens and warms incoming air
 - Has resonating chambers for voice

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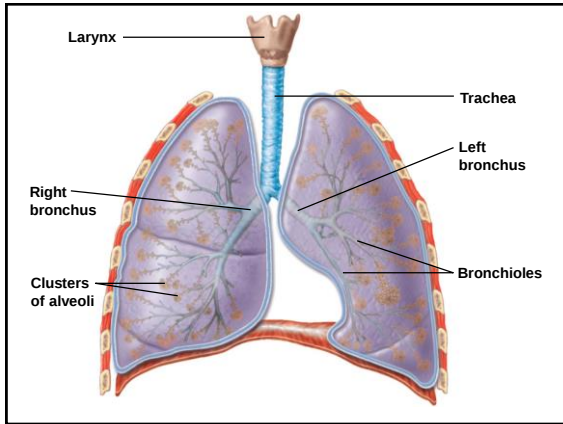


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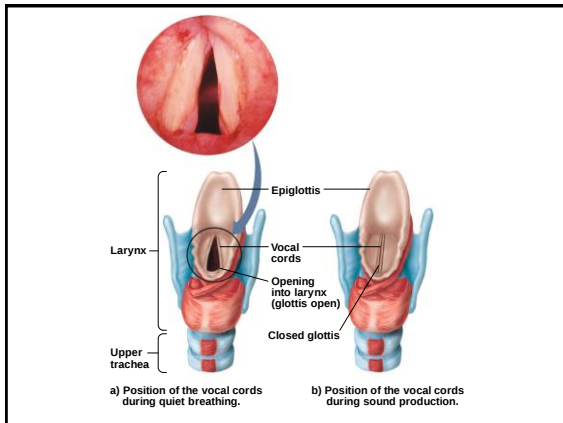
Lower Respiratory Tract

- Functions
 - **Larynx**
 - Maintains an open airway
 - Routes food and air appropriately
 - Assists in sound production
 - **Trachea**
 - transports air to and from lungs
 - **Bronchi**
 - branch into lungs
 - **Lungs**
 - transport air to alveoli for gas exchange

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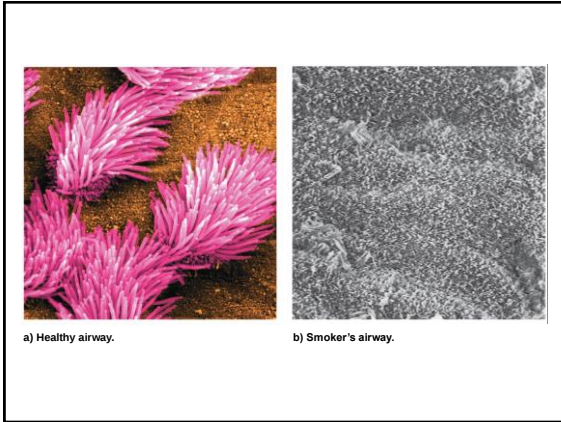


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Defenses of the Respiratory Tract

- **Mucus** – entraps microorganisms
- **Cilia** – push microorganisms and mucus up and out of respiratory tract
 - Smoking – damages cilia, impairs this defense
- **Cough reflex**

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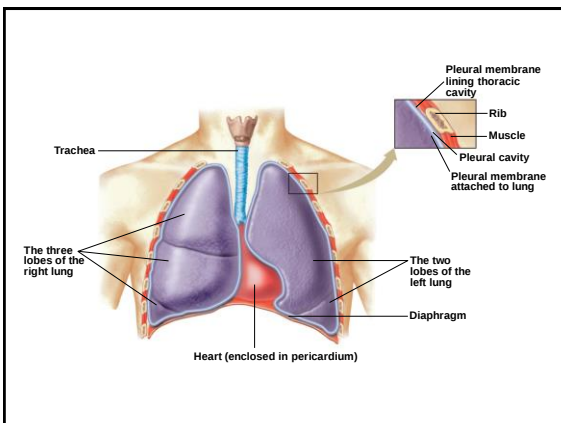


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The Lungs Are Organs of Gas Exchange

- Located within thoracic cavity
- Surrounded by pleural membranes
- Bronchioles terminate in clusters of alveoli
- Alveoli
 - Tiny air-filled sacs
 - Gas exchange occurs here
- Pulmonary capillaries in alveolar walls – bring blood and air into close contact

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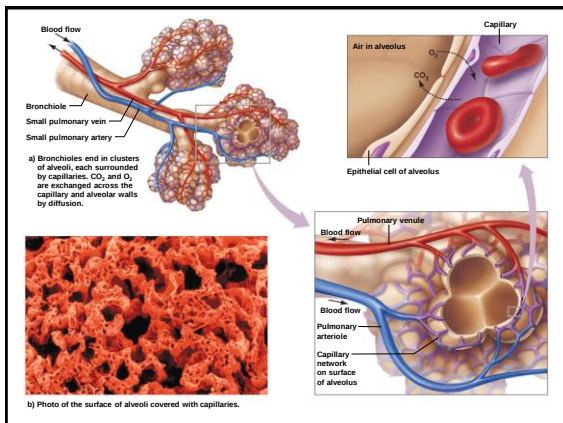


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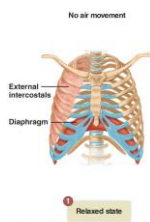
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The Process of Breathing Involves a Pressure Gradient

- Inspiration/expiration: air in/air out cycle
 1. Relaxed state
 - Diaphragm and intercostal muscles relaxed

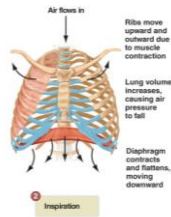


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The Process of Breathing Involves a Pressure Gradient

2. Inspiration (inhale)

- Diaphragm contracts, pulling muscle down; intercostal muscles contract, elevating chest wall and expanding volume of chest, lowering pressure in lungs, pulling in air

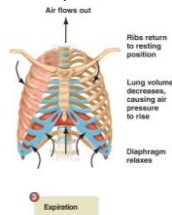


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The Process of Breathing Involves a Pressure Gradient

3. Expiration (exhale)

- Muscles relax; diaphragm resumes dome shape; intercostal muscles allow chest to lower, resulting in increase of pressure in chest and expulsion of air



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Lung Volumes and Vital Capacity Measure Lung Function

- **Tidal volume**
 - Volume of air inhaled and exhaled in a single breath
- **Dead space volume**
 - Volume of air that remains in the airways and does not participate in gas exchange
- **Vital capacity**
 - Maximal volume that can be exhaled after maximal inhalation

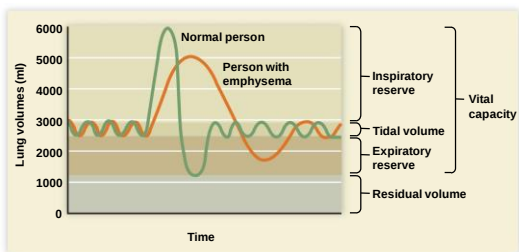
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Lung Volumes and Vital Capacity Measure Lung Function

- **Inspiratory reserve volume**
 - Volume of air that can be inhaled beyond the tidal volume
- **Expiratory reserve volume**
 - Volume of air that can be forcibly exhaled beyond the tidal volume
- **Residual volume**
 - Volume of air remaining in the lungs, even after a forceful maximal expiration
- Measured by **spirometer**

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a) A recording of lung capacity. After several normal breaths, the person inhales and then exhales maximally. The volumes indicated by the green line are for a normal person. The orange line is typical of a patient with emphysema.



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Gas Exchange and Transport Occur Passively: Partial Pressure

- **Partial Pressure:** The pressure exerted by one particular gas in a mixture of gases
- Partial pressure of a gas is proportional to its percentage of the total gas composition
- **A gas always diffuses down its partial pressure gradient, from higher to lower partial pressure**

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External Respiration: Exchange of Gases Between Air and Blood (in lungs)

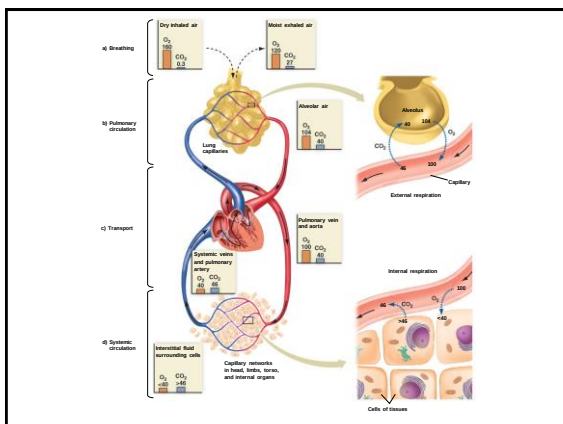
- O_2 diffuses from alveoli (P_{O_2} : 104 mmHg) into blood (P_{O_2} : 40 mmHg), down its partial pressure gradient
- CO_2 diffuses from blood (P_{CO_2} : 46 mmHg) into alveoli (P_{CO_2} : 40 mmHg), down its partial pressure gradient

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Internal Respiration: The Exchange of Gases with Tissue Fluids (in body tissues)

- O_2 diffuses down its pressure gradient from capillaries to interstitial fluid and then to cells
- CO_2 diffuses down its pressure gradient from cells to interstitial fluid to capillaries

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Hemoglobin Transports Most O₂

- 98% of O₂ in blood is carried bound to hemoglobin molecules in red blood cells

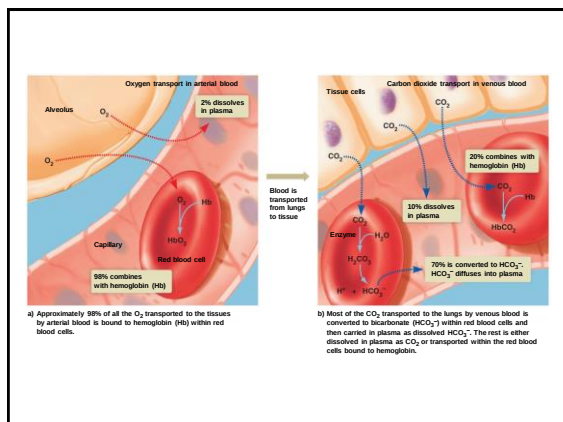
$$\text{Hb} + \text{O}_2 \rightarrow \text{HbO}_2$$
 hemoglobin + oxygen → oxyhemoglobin
- 2% of O₂ is dissolved in plasma

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Most CO₂ Is Transported in Plasma as Bicarbonate

- 70% of CO₂ is converted to and transported in the plasma as bicarbonate
- 10% of CO₂ is dissolved in plasma
- 20% of CO₂ binds to hemoglobin for transport

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The Nervous System Regulates Breathing

- Respiratory center is located in the medulla oblongata (brain stem)
 - Establishes basic breathing pattern
 - Neurons in medulla generate impulses every 4 – 5 seconds
 - Stimulates intercostal muscles and diaphragm

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Chemical Receptors Monitor CO_2 , H^+ , and O_2 levels

- Monitoring of CO_2 levels
 - Receptors in medulla oblongata monitor CO_2 levels indirectly
 - $\uparrow P_{\text{CO}_2}$ in arterial blood will cause $\uparrow$ in H^+ in cerebrospinal fluid, which will signal medulla oblongata to $\uparrow$ respiratory rate
 - This is the primary regulator of respiration under normal conditions

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Chemical Receptors Monitor CO_2 , H^+ , and O_2 levels

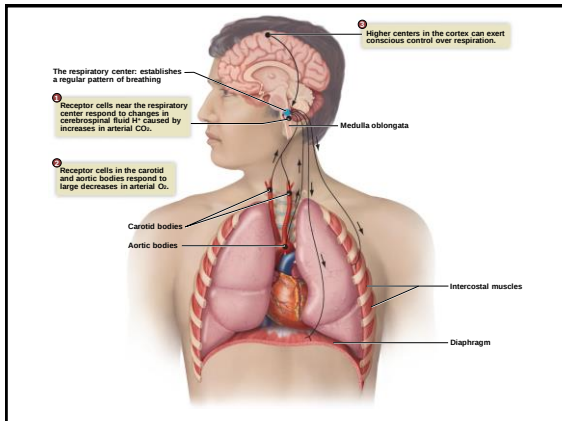
- Monitoring P_{O_2}
 - Aortic and carotid bodies monitor P_{O_2}
 - Become activated if P_{O_2} falls by at least 20%
 - Will increase rate and depth of breathing in response to sufficiently lowered arterial P_{O_2}
- The rate and depth of normal breathing is determined by the need to get rid of CO_2 rather than the need to obtain O_2

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We Can Exert Some Conscious Control

- Conscious control resides in the cerebral cortex
 - Able to modify breath to speak and sing
 - Able to hold breath temporarily, but can't override automatic controls located in medulla oblongata indefinitely

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Disorders of Respiratory System: Reduced Air Flow or Gas Exchange

- **Asthma:** spasmodic contraction of bronchi
 - Caused by episodic allergic responses
 - Controlled by bronchodilators and corticosteroids
- **Emphysema:** alveoli permanently impaired
 - Breathlessness due to decreased surface area for gas exchange
 - Most cases result from smoking

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Disorders of Respiratory System: Reduced Air Flow or Gas Exchange

- **Bronchitis:** inflammation of bronchi
 - May be acute or chronic
 - Most cases related to smoking or air pollution
- **Cystic Fibrosis:** an inherited condition
 - Abnormally thick mucus in lungs impedes air flows
 - Frequent pulmonary infections
 - Other organ systems may be affected

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Disorders of Respiratory System: Respiratory Infections

- Upper respiratory infections
 - **Colds and flu**
 - Caused by viruses
 - Antibiotics not effective
 - **Pneumonia:** infection of the lungs
 - May be caused by bacteria or viruses
 - One of the top 10 causes of death in the United States
 - Treatment depends on cause

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Disorders of Respiratory System: Respiratory Infections and Intoxications

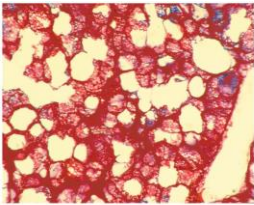
- **Tuberculosis:** bacterial infection that scars the lungs
 - May be active infection with symptoms, or dormant infection that will reactivate later
 - Diagnosis: tuberculin skin test and chest X-ray
 - Treatment: antibiotics

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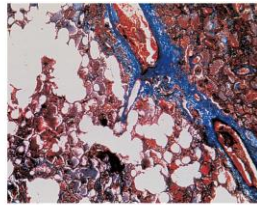
Disorders of Respiratory System: Lung Cancer

- Cancer
 - uncontrolled growth of abnormal cells
- Impairs air flow, gas exchange, blood flow
- 1/3 of all U.S. cancer deaths
- Causes
 - **90%** of cases associated with smoking
 - Radon gas
 - Workplace chemicals such as asbestos

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a) Normal lung.



b) Cancerous lung.

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Pneumothorax and Atelectasis

- **Pneumothorax:** collapse of one or more lobes of the lungs
 - Most often due to penetrating wound
 - Inability to inflate the lung → poor gas exchange
 - Treatment: remove air from pleural cavity

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Congestive Heart Failure Impairs Lung Function

- Congestive heart failure
 - heart becomes a less efficient pump
- Failure of left side of heart
 - Blood pressure increases within pulmonary capillaries
 - Fluid build-up occurs in pulmonary interstitial spaces and alveoli
 - Impaired gas exchange
- Treatment: improve pumping action of heart and remove fluid
