Chapter 19
Respiratory System

FYI
- 480,000 deaths annually from cigarette smoke
- On average, smokers die 10 years earlier than non-smokers
- 53,000 deaths per year from secondhand smoke exposure
- Secondhand smoke is responsible for increased respiratory infections (pneumonia & bronchitis), asthma, ear infections and lower birth rates in children

Introduction
- Respiration is the process of exchanging gases between the atmosphere & body cells
- Respiratory system consists of passages that filter incoming air & transport it into the lungs, then to the air sacs where gases are exchanged
- It consists of the following events:
  - Ventilation (breathing) - moving air in/out of lungs
  - External respiration - exchange of gases between lungs & blood
  - Transport of gases - from lungs into blood & into body cells
  - Internal respiration - exchange of gases between blood & cells
  - Cellular respiration - process where cells use O₂ to produce energy (ATP) & release CO₂. Occurs in mitochondria
**Functions of Respiratory System**
- Provides O\(_2\) for cellular respiration
- Enables cells to access the energy in the chemical bonds of nutrients
- Expels CO\(_2\) from the body
- Maintains pH of the blood

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**Organs of the Respiratory System**
- The organs of the respiratory system fall into 2 groups:
  - Upper respiratory tract:
    - Nose
    - Nasal cavity
    - Sinuses
    - Pharynx
  - Lower respiratory tract:
    - Larynx
    - Trachea
    - Bronchial tree
    - Lungs

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**Nose**
- Provides opening for air to enter & leave
- Hairs trap large particles from being carried forward
- Nostrils - also known as nares are the openings where air enters & leaves
**Nasal Cavity**
- Hollow space behind nose
- Divided by nasal septum
- Separated from cranial cavity by the cribiform plate
- Separated from oral cavity by the hard palate
- Nasal conchae curl out from lateral walls to increase surface area
- Mucus captures dust & debris
- Olfactory receptor provides smell

**Nasal Cavity**
- Network of blood vessels warm air as it enters
- The mucus membrane lining the cavity has pseudostratified epithelial tissues
- Has goblet cells & cilia

**Sinuses**
- The sinuses are air-filled spaces in the maxillary, frontal, ethmoid, & sphenoid bones of the skull
- Reduces wt. of head
- Resonating chambers
**Pharynx**
- Pharynx is posterior to the oral cavity & between the nasal cavity & the larynx
- Passageway for food & air
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx

**Larynx**
- Enlargement in the airway superior to the trachea & inferior to the pharynx
- Houses the vocal cords
- Composed of muscles & cartilages bound by elastic tissue
- Epiglottis stands up to allow air to enter larynx & folds down to prevents food from entering trachea

**Trachea**
- The trachea (windpipe) is a flexible cylindrical tube about 2.5 cm in diameter
- Held open by hyaline cartilage C-shaped rings
- Anterior to the esophagus
- Splits into right & left primary bronchi
- Tracheostomy – cut opening just above sternal notch; allows air to get to lungs when an obstruction occurs
Bronchial Tree

- The bronchial tree consists of branched airways leading from the trachea to the air sacs in the lungs.

Branches of Bronchial Tree

- Divisions of the branches from the trachea to the alveoli are:
  - Right & left primary bronchi
  - Secondary or lobar bronchi - branches from R. primary & L. primary
  - Tertiary or segmental bronchi - smaller divisions of lobar
  - Intralobular bronchioles - enter lobules of lungs
  - Terminal bronchioles - smaller of intralobular bronchioles; occupy lobe of lung
  - Respiratory bronchioles - 2 or more of terminal bronchioles
  - Alveolar ducts - branches from respiratory bronchioles
  - Alveolar sacs - thin sacs forming from alveolar ducts
  - Alveoli - microscopic sacs that open to alveolar sacs.

SITE OF GAS EXCHANGE
Lungs
- Right & left lungs are soft, spongy, cone-shaped organs in the thoracic cavity
- Separated by heart & enclosed by diaphragm
- Right lung has 3 lobes & the left lung 2 lobes

Breathing Mechanism
- Breathing or ventilation is the movement of air from outside of the body into the bronchial tree & the alveoli
- The actions responsible for these air movements are inspiration, or inhalation, and expiration, or exhalation

Inspiration
- Atmospheric pressure due to the wt. of the air is the force that moves air into the lungs
- Atmospheric pressure is 760 mm Hg
- When diaphragm moves down, air moves into lungs
- EX. Moving the plunger of a syringe down causes air to move in
**Intra-alveolar pressure decreases to about 758 mm Hg as the thoracic cavity enlarges due to diaphragm downward movement caused by impulses carried by the phrenic nerves.**

**Atmospheric pressure then forces air into the airways.**

**Inspiration**

- Phrenic nerve causes diaphragm to contract; ↑ thoracic cavity space
- Sternum and ribs raise; thoracic cavity expands
- Intra-alveolar pressure ↓
- Drop in pressure forces air into respiratory tracts
- Lungs fill with air

**Expiration**

- The forces responsible for normal resting expiration come from elastic recoil of lung tissues
- These factors ↑ the intra-alveolar pressure about 1 mm Hg above atmospheric pressure forcing air out of the lungs
Expiration

- **Steps of Expiration**
  - Diaphragm and chest muscles relax; ↓ space of thoracic cavity
  - Elastic tissues of lungs that were stretched during inspiration, now recoil
  - The intra-alveolar pressure ↑ (greater than outside pressure) and air is squeezed out of the lungs

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**Spirometry**

- A test used to assess how well your lungs work by measuring how much air you inhale, how much you exhale and how quickly you exhale.
- Test is used to diagnose asthma, chronic obstructive pulmonary disease (COPD) and other conditions that affect breathing.
- Respiratory cycle – 1 inspiration and expiration. The volume of air that moves in or out of the lung in 1 cycle is **TIDAL VOLUME** (TV)

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**Table 194**

<table>
<thead>
<tr>
<th>Name</th>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tidal volume (TV)</td>
<td>500 mL</td>
<td>Volume of air that moves in or out of lungs during a respiratory cycle</td>
</tr>
<tr>
<td>Inspiratory reserve volume</td>
<td>300 mL</td>
<td>Maximum volume of air that can be inhaled in addition to normal tidal volume</td>
</tr>
<tr>
<td>Inspiratory reserve volume</td>
<td>150 mL</td>
<td>Maximum volume of air that can be inhaled in addition to normal tidal volume</td>
</tr>
<tr>
<td>Residual volume (RV)</td>
<td>1,200 mL</td>
<td>Volume of air that remains in the lungs at end of normal expiration</td>
</tr>
<tr>
<td>Inspiratory capacity (IC)</td>
<td>2,000 mL</td>
<td>Maximum volume of air that can be inhaled following expiration of normal tidal volume (IC = TV + RV)</td>
</tr>
<tr>
<td>Functional residual capacity  (FRC)</td>
<td>2,000 mL</td>
<td>Volume of air that remains in the lungs following expiration of normal tidal volume (FRC = RV + IC)</td>
</tr>
<tr>
<td>Vital capacity (VC)</td>
<td>4,000 mL</td>
<td>Maximum volume of air that can be expired after taking the deepest breath possible (VC = TV + RV + IC)</td>
</tr>
<tr>
<td>Total lung capacity (TLC)</td>
<td>5,000 mL</td>
<td>Total volume of air that can be expired after taking the deepest breath possible (TLC = VC + RV + IC)</td>
</tr>
</tbody>
</table>
Air Volumes & Capacities

- Inspiratory reserve volume (IRV) – maximum air inhaled
- Expiratory reserve volume (ERV) – maximum air exhaled
- Residual volume (RV) – air that remains in the lungs at all time
- Vital capacity (VC) – maximum volume of air that can to exhaled after taking the deepest breath possible
- Total lung capacity (TLC) – total volume of air that lungs can hold \( \text{TLC} = \text{VC} + \text{RV} \)

Control of Breathing

- Normal breathing is a rhythmic, involuntary act that continues when a person is unconscious
- Respiratory muscles can also be voluntarily
- Respiratory centers of the brain include the medulla oblongata & pons

Alveolar Gas Exchanges

- The alveoli are air sacs are the end of the alveolar ducts
- Sites of gas exchange between air & blood
- Tissues made of simple squamous
- Alveolar pores in walls allow air to pass from 1 alveolus to another; alternate passageway if part of lung is obstructed
Alveolus and Pores

Respiratory Membrane

- Molecules diffuse through simple squamous tissues; from lungs to blood and from blood to lungs
- Always move from High conc. to Low conc.
- Reason breath analysis reveals alcohol & other chemicals

Gas Transport

- Blood transports $O_2$ and $CO_2$ between the lungs and the body cells
- As the gases enter the blood, they dissolve in the plasma or chemically combine with other molecules
- High levels of $CO_2$ regulates respiration rates
Oxygen Transport

- Almost all O$_2$ carried in the blood is bound to Fe in hemoglobin in the form of oxyhemoglobin (red blood)
- Oxyhemoglobin releases O$_2$ into the body cells

Carbon Dioxide Transport

- Blood flowing through capillaries gains CO$_2$ because the tissues have a high P$\text{CO}_2$
- The CO$_2$ is transported to the lungs in 1 of 3 forms:
  - As CO$_2$ dissolved in plasma
  - As part of a compound with hemoglobin
  - As part of a bicarbonate ion which can affect the pH of the blood