The Respiratory System: It’s a Gas

**Introduction**

- The respiratory system’s primary function is to transport oxygen from the environment and get it into your bloodstream to be utilized by your cells, tissues, and organs in order to sustain life.
- The respiratory system moves 12,000 quarts of air per day into and out of our lungs.
- The respiratory system also removes waste gas – or carbon dioxide – from your body to the environment so it doesn’t build up in your bloodstream.

**Learning Objectives**

- List and state the basic functions of the components of the respiratory system.
- Differentiate between respiration and ventilation.
- Explain how the respiratory system warms and humidifies inhaled air.
- State the purpose and function of the mucociliary escalator.

**Learning Objectives**

- Discuss the process of gas exchange at the alveolar level.
- Describe the various skeletal structures related to the respiratory system.
- Explain the actual process and regulation of ventilation.
- Discuss several common respiratory system diseases.
System Overview

- Cellular respiration depends on a continuous supply of oxygen, found in abundance in the air we breathe.
- Using oxygen produces carbon dioxide, which would become toxic if allowed to build in the blood stream; and it must be removed.
- The respiratory system is closely related to the cardiovascular system and they are sometimes grouped together as the cardiopulmonary system.

Major Components of the Respiratory System

- Two lungs that serve as the vital organs
- Upper and lower airways that conduct, or move, gas through the system
- Terminal air sacs called alveoli surrounded by a network of capillaries that allow gas exchange
- A thoracic cage that houses, protects, and facilitates function for the system
- Muscles of breathing

Figure 14-1: The components of the respiratory system.
Gases in Air

- Air contains many gases, predominantly nitrogen, which is a support gas that keeps the lungs open by adding volume, or filler, to the vitally-needed oxygen.
- The next highest concentration found in air is oxygen, essential to life; carbon dioxide is found in very small concentrations.

Ventilation vs Respiration

- **Ventilation** is the bulk movement of air down to the terminal air sacs, or alveoli, of the lungs.
- **Respiration** is the process of gas exchange, in which oxygen is added to the blood and carbon dioxide is removed.
- Movement of oxygen from the alveoli to the blood is called external respiration.
- Movement of oxygen from the blood to the cells is internal respiration.

Table 14-1: Gases in the Atmosphere

<table>
<thead>
<tr>
<th>GAS</th>
<th>% OF ATMOSPHERE</th>
</tr>
</thead>
<tbody>
<tr>
<td>nitrogen (N₂)</td>
<td>78.08</td>
</tr>
<tr>
<td>oxygen (O₂)</td>
<td>20.95</td>
</tr>
<tr>
<td>carbon dioxide (CO₂)</td>
<td>.03</td>
</tr>
<tr>
<td>argon</td>
<td>.93</td>
</tr>
</tbody>
</table>

Note: The atmosphere also contains trace gases such as neon and krypton.

Click here to view a video on the topic of Gas Exchange in the Lungs.

Figure 14-2: Contrast of ventilation and external and internal respiration.

Figure 14-2 (continued): Contrast of ventilation and external and internal respiration.
Gas Exchange in Plants

- Fortunately for the earth’s ecosystem, the physiology of gas exchange in plants is the exact opposite of humans. Plants take in CO$_2$ and use it for energy, releasing oxygen into the atmosphere as their waste gas.
- The largest source of oxygen released is in the Amazon rain forest, which is, unfortunately, being destroyed at a high rate every day. We truly need a green earth to survive, so thank the next plant you see.

The Airways and Lungs

- We have a reserve of oxygen to last 4-6 minutes, after that we will die if we don’t get more oxygen.
- The respiratory system is a series of branching tubes called bronchi.
- As the branches get smaller they are called bronchioles.

Bronchioles end in alveoli, the terminal end of the respiratory system.
- Each alveolus is surrounded by capillaries. The combination is called the alveolar-capillary membrane and provides an interface between the respiratory and cardiovascular systems.

Upper Airway Functions

- The upper airways begin at the nostrils, or nares, and end at the vocal cords.
- Functions include:
  - Heating or cooling air to body temperature
  - Filtering
  - Humidifying
  - Sense of smell or olfaction
  - Producing sounds or phonations
  - Ventilation, or conducting gas to lower airways

The Nose

- While some people breathe through their mouths, we are meant to breathe through our nose.
- The nose is a semi-rigid structure comprised of cartilage and bone.
- The nasal cavity, behind the nose, is divided into three main regions: the vestibular, olfactory, and respiratory regions.
Vestibular Region

- The vestibular region is located inside the nostrils and contains the coarse nasal hairs that act as the first line of defense for the respiratory system.
- These hairs, called vibrissae, are covered with sebum, a greasy substance secreted by the sebaceous glands of the nose.
- Sebum helps trap particles and keeps the hairs soft and pliable.

Olfactory Region

- The olfactory region is located on the roof of the nasal cavity, allowing air to be held there so it can be sampled.

Respiratory Region

- Air is warmed to body temperature and moistened in the respiratory region inside the nasal cavity, which is lined with mucous membranes and richly supplied with blood.
- There are three scroll-like bones (turbinates or conchae) that split incoming air into three channels, providing more surface area.

Respiratory Region

- The turbinates also serve to make incoming air current more turbulent, bringing more air in contact with the mucous membranes for warming and humidifying – adding 650 to 1,000 mls of water each day to moisten the air to 80% humidity.

Mucociliary Escalator

- Cells in the epithelial lining of the airways of the respiratory system are called pseudostratified ciliated columnar cells.
- This layer consists of a single layer of tall column-like cells that have nuclei at different heights, giving the appearance of two layers when there is only one.
- Each columnar cell has 200 to 250 cilia on its surface. Cilia are hairlike projections that beat at a fantastic rate.
Mucociliary Escalator

- Goblet cells and submucosal glands are interspersed and produce about 100 mls of mucus per day.
- The mucus resides as two layers:
  - A watery layer called the sol layer houses the cilia.
  - The top layer is the gel layer that is more viscous and sticky, trapping small particles.

Mucociliary Escalator

- The cilia act as tiny oars resting in the watery sol layer.
- They beat 1,000-1,500 times per minute and propel the gel layer and its trapped debris upward about 1 inch per minute to be expelled.
- The debris will be propelled toward the oral cavity to be coughed or swallowed.
- This is sometimes called the mucociliary escalator, which is quite descriptive of what it does. Smoking paralyzes this escalator.

The Sinuses

- The skull contains air-filled cavities called sinuses that connect to the nasal cavity via small passageways.
- They are located around the nose and are sometimes referred to as paranasal sinuses.

The Sinuses

- These cavities help prolong and intensify sound produced with our voice, help to lighten the weight of the head, and warm and moisten air.
- We are not born with sinuses. They develop as we do, accounting for the change in facial features as we age.
The Pharynx

- The pharynx, or throat, is a hollow muscular structure starting behind the nasal cavity, that is lined with epithelial tissue.
- The pharynx can be divided into three sections:
  - Nasopharynx
  - Oropharynx
  - Laryngopharynx

The Nasopharynx

- The nasopharynx is the uppermost section, beginning behind the nasal cavity.
- It is lined with respiratory mucosa.
- This section contains:
  - Lymphatic tissue called the adenoids (pharyngeal tonsils)
  - Passageways into the middle ear called the eustachian tubes
- Air from the nasal cavity passes through the nasopharynx.

Oropharynx

- The oropharynx is the center section of the pharynx and is located behind the oral, or buccal, cavity.
- It is lined with stratified squamous epithelium.
- Air, food, and liquid pass through the oropharynx.
- Tonsils are part of the lymph system.
- The palatine tonsils are located in the oropharynx, as are the lingual tonsils located at the back of the tongue.

Laryngopharynx

- The laryngopharynx is the lowermost portion of the pharynx.
- It connects to both the larynx, a part of the respiratory system, and the esophagus, part of the digestive system.
- It is lined with stratified squamous epithelium.
- Water, food, and air pass through the laryngopharynx.

Figure 14-7: The nasopharynx, oropharynx, and laryngopharynx.

Larynx

- The larynx, commonly known as the voice box, is a semi-rigid structure composed of cartilage connected by muscles and ligaments that provide movement of the vocal cords to control our speech.
- The “Adam’s Apple” is the largest of the cartilages found in the larynx: the thyroid cartilage.
Larynx

- The cricoid cartilage lies below it, providing structure and support in an exposed area of the airway to prevent collapse.
- The glottis is the opening that leads into the larynx, and eventually the lungs.

Swallowing

- During swallowing the uvula and soft palate move in a posterior and superior position to protect the nasopharynx from the entry of food or liquid. This can be overcome by forceful laughing.
- Food that is swallowed travels into the esophagus, while air travels into the larynx.

Swallowing

- A leaf-shaped fibro-cartilage, flaplike structure, called the epiglottis, closes when we swallow to prevent food from entering the lungs. This is called glottic or sphincter mechanism, and closes the glottis tightly, forcing food and fluid to enter the esophagus.
- When we breathe, air can enter the larynx or the esophagus, but prefers the larynx because of pressure differences.

From the Streets: Upper Respiratory Infection

- Upper respiratory infections (URIs) are common, but rarely life-threatening.
- The best defense against the spread of URIs is effective hand hygiene.
- Viruses cause the majority of URIs.
- Streptococcus is a causative bacterial organism that causes “strep throat.”
- Signs and symptoms
- Treatment

Upper and Lower Airway

- The vocal cords act as the dividing line between the upper and lower airways.
- The lower airway starts below the vocal cords.
- The upper airway ends at the vocal cords.

Clinical Application: Keeping the Vital Airway Open

- The flow of air must be constant because a disrupted oxygen supply has fatal consequences. An airway can be reestablished, if the natural airway is blocked, through several methods including:
  - A cricoid-thyroidotomy
  - Intubation
  - A tracheostomy tube
The Lower Respiratory Tract

- The lower respiratory tract resembles an upside down tree, called the tracheobronchial tree.

Trachea
- From the vocal cords, air enters the trachea, or windpipe, extending to the sixth thoracic vertebrae.
- C-shaped cartilage are found in the anterior portion of the trachea to provide rigidity and protection for the exposed airway in the neck.

Trachea (cont’d)
- The trachea is the largest pipe and can be thought of as the trunk of the tree.

Bronchi
- The site of bifurcation is called the carina.
- Next, the bronchi must branch into the five lobular bronchi that correspond to the five lobes of the lungs (three in the right; two in the left).
The Lower Respiratory Tract

- Bronchi (cont’d)
  - Each lung lobe is further divided into specific segments and the next branching of bronchi are called the segmental bronchi.
  - The walls of the tracheobronchial tree, from the trachea to the segmental bronchi, have the same anatomy.
    - The inner epithelial layer contains the mucociliary escalator.
    - The middle is the lamina propria layer which contains smooth muscle, lymph, and nerve tracts.
    - The outer layer is the protective and supportive cartilaginous layer.

Clinical Application: The Angle Makes a Difference

- The angle of branching is not the same for both primary bronchi. The right mainstem branches off at a 20–30 degree angle from the midline of the chest. The left mainstem branches off at a more pronounced 40–60 degree angle.
- This is important because the lesser angle of the right main stem branching allows foreign bodies that are accidentally breathed in to more often lodge in the right lung. This is useful to know if a child has aspirated.

The Lower Respiratory Tract

- Smaller Bronchi
  - The branching continues getting more numerous and smaller, deep into the lung segments.
  - As we move towards gas exchange regions the airways simplify to make it easier for gas molecules to pass through. Bronchioles average only 1 mm in diameter and are generation 10–15.

Clinical Application: The Angle Makes a Difference

- An endotracheal, or breathing, tube may be placed too far into the lung, and instead of sitting above the carina so both lungs are ventilated, the tube most likely will pass into and ventilate only the right lung. This is why an x-ray must be done for placement.

The Lower Respiratory Tract

- Smaller Bronchi
  - There is no cartilage layer and the epithelial layer is becoming simple ciliated cuboidal – short, squat cells as opposed to columns.
  - The cilia, goblet cells, and submucosal glands are almost all gone.
  - The bronchioles have smooth muscle in their walls.
  - There is no gas exchange yet.
The Lower Respiratory Tract

- Terminal bronchioles
  - Generation 16 have an average diameter of 0.5 mm.
  - There are no goblet cells, cartilage, cilia, or submucosal glands at this point.
  - The terminal bronchioles mark the border between the conducting and respiratory zones.

The Lower Respiratory Tract

- Respiratory Bronchioles
  - Some gas exchange occurs here.
  - The epithelial lining is simple cuboidal epithelium-interspersed alveoli-type cells called squamous pneumocytes.

The Lower Respiratory Tract

- Alveolar ducts
  - Originate from the respiratory bronchioles
  - The walls of the alveolar ducts are made up of squamous cells arranged in a tubular configuration.

The Lower Respiratory Tract

- Alveoli
  - The air sacs
  - Only simple squamous epithelium, no cartilage, no smooth muscle, no mucous
  - Adults have 300–600 million alveoli, with a total of 80 m² surface area

Figure 14-10 Conduction and gas exchange structures and functions.
**From the Streets:**

**Bronchiolitis and Respiratory Syncytial Virus Infections**

- Bronchiolitis is an infection of the smaller airways and is a common disease in children less than 2 years of age.
- Respiratory syncytial virus (RSV) causes most cases of bronchiolitis.
- Signs and symptoms
- Treatment

**Alveolar Capillary Membrane**

- Alveolar capillary membrane – four distinct components
  - The first layer is the liquid surfactant layer that lines the alveoli.
  - The second component is the tissue layer, or alveolar epithelium, comprised of simple squamous cells of two types.
  - The third component of the alveolar capillary membrane is the interstitial space.
  - The fourth component is the endothelium of pulmonary capillaries surrounding the alveoli.

**Alveolar Capillary Membrane**

- The majority (95%) of alveolar surface is thin, pancake-like cells called squamous pneumocytes, or Type I cells, allowing easy gas molecule movement.
- Type II cells, or plump, granular pneumocytes produce surfactant and aid in cellular repair.

**Alveolar Capillary Membrane**

- Interstitial space
  - This area separates the basement membrane of alveolar epithelium from the basement membrane of the capillary endothelium and contains interstitial fluid.
  - This space is so small that the membranes of the alveoli and capillary appear fused.
  - If too much fluid gets into this space (interstitial edema), it separates, making it harder for gas exchange to occur.

**Alveolar Capillary Membrane**

- Type III cells, or wandering macrophages, ingest foreign particles as they wander through the alveoli.
- Pores of Kohn are small holes between alveoli to allow movement of macrophages from one alveolus to another.

**Applied Science: The Amazing Surfactant**

- Surfactant lowers surface tension and thins with inspiration as the alveoli expand, becoming less effective, increasing surface tension. This prevents over-expansion or rupture of the alveoli.
- Lack of surfactant can cause stiff lungs that resist expansion. Surfactant develops late in fetal development, thus premature babies may have inadequate surfactant levels.
Applied Science: The Amazing Surfactant

- Artificial surfactant replacement therapy can put surfactant into the lungs of these premature babies to prevent collapse or rupture of alveoli.

Clinical Application: What Can Go Wrong with Gas Exchange?

- Any barrier to gas diffusing between the alveoli and capillaries decreases the amount of oxygen that is circulating in the blood.
- Excessive secretions and fluid, such as in pneumonia, would act as a barrier, decreasing oxygen levels in the blood measured via an arterial blood gas (ABG).

Clinical Application: What Can Go Wrong with Gas Exchange?

- Decreases in hemoglobin in the erythrocyte decreases the amount of oxygen carrying capacity of the blood. The body tries to correct low RBC counts by producing more cells in a process called erythropoiesis.
- When the kidneys measure a low level of RBCs, they secrete erythropoietin into the blood which targets the red bone marrow, stimulating RBC production.

Gas Exchange

- Blood from the right heart entering the pulmonary capillaries is high in carbon dioxide and low in oxygen.
- Conversely, the concentration of carbon dioxide is low in the alveoli and there is a large amount of oxygen.
- Gas exchange takes place and the blood in the pulmonary capillaries pick up oxygen before traveling to the left heart to be circulated to the body.

Clinical Application: Therapeutic Oxygen

- Often a distressed respiratory and cardiac system needs supplemental oxygen to assist its function and meet its needs.
- There are many ways to deliver an enriched oxygen supply to the lungs.
- These can include an oxygen mask, nasal cannula, or even specialized devices to deliver both oxygen and extra humidity to the lungs to assist their function.
Clinical Application: Assessing Ventilation and Blood pH

- Carbon dioxide levels are the best indicator of ventilation
  - Due to the rapid diffusion of carbon dioxide to the lungs and its subsequent exhalation
  - In many lung diseases, carbon dioxide levels can rise in the blood and initially form carbonic acid (H$_2$CO$_3$).
  - This acid quickly breaks down into its ionic parts, H$^+$ (hydronium ion) and HCO$_3^-$ (bicarbonate ion).
  - To prevent too much acidity from building up in the blood, H$^+$ will be excreted by the kidneys, and more bicarbonate (base) will be formed to buffer the blood to maintain normal pH.

From the Streets: Pulse Oximetry

- Pulse oximetry is used to measure the hemoglobin oxygen saturation in peripheral tissues such as fingers, toes, and earlobes.

From the Streets: Pulse Oximetry

- Causes of false readings include carbon monoxide poisoning, hemoglobin abnormalities, high-intensity lighting, and possibly some nail polishes.

Housing of the Lungs and Related Structures

- The lungs reside in the thoracic cavity and are separated by a region called the mediastinum, which contains the esophagus, heart, great vessels, and trachea.
- Breathing in and out causes the lungs to move within the thoracic cavity.
- To prevent irritation of the lungs moving against the thorax, each lung is wrapped in a double layered sac, or serous membrane, called the pleura.
Housing of the Lungs and Related Structures

- The visceral pleura covers the lungs while the thoracic cavity and the upper side of the diaphragm are lined by the parietal pleura.
- Between these two pleura layers is a pleural space (intrapleural space) that contains a slippery liquid called pleural fluid, reducing friction as an individual breathes. In a normally functioning lung, the pleural space is only a potential space.

From the Streets: Tension Pneumothorax and Chest Decompression

- Tension pneumothorax occurs when injury to the lung tissue results in the accumulation of air in the pleural space.
- This results in a "collapsed lung".
- Emergency treatment includes chest decompression to allow the air to escape.

From the Streets: Chest Decompression

- A chest decompression is performed by inserting a large gauge needle through the chest wall into the pleural space.
- Insertion is initiated at the third intercostal space midclavicular or the fifth intercostal space midaxillary.
- Analgesic should be considered prior to insertion.
From the Streets: Chest Decompression

- Note: the needle should be inserted along the upper border of the rib to avoid puncturing the intercostal neurovascular bundle.

The Lungs

- The lungs are conical-shaped with rounded peaks (apex) extending 1-2 inches above the clavicle.
- The base of each lung rests on the diaphragm with the right lung base a bit higher to accommodate the liver.
- The medial surface of the lung has a deep concave cavity that holds the heart, called the cardiac impression, which is deeper on the left.

The Lungs

- The hilum is the area where the root attached, contains the main bronchus, pulmonary artery and vein, nerve tracts, and lymph vessels.

The Lungs

- Lobes
  - The right lung has three lobes — upper, middle, and lower lobes — divided by the horizontal and oblique fissures.

The Lungs

- Lobes
  - The left lung has only one fissure, the oblique fissure, and therefore has only two lobes — upper and lower lobes — because the heart is left of center.
    - The lingula is an area of the left lung that corresponds with the right middle lobe.
    - The right lung is larger, with 66% of gas exchange occurring here.

The Lungs

- Segments
  - Segmental bronchi enter each lung segment.
The Protective Bony Thorax

- The bony thorax protects the organs of the chest. It is a bony and cartilaginous frame providing freedom of movement.

The Protective Bony Thorax

- The bony thorax includes the rib cage, sternum, and thoracic vertebrae to which each rib attaches.
  - The sternum, or breastbone, is centrally located. It is comprised of the manubrium, body, and xiphoid process.

The Protective Bony Thorax

- The bony thorax includes the rib cage, sternum, and thoracic vertebrae to which each rib attaches.
  - 12 pairs of ribs. The true ribs (1–7) are vertebrosternal because they connect to the sternum and vertebrae. Pairs 8–10 are false ribs or vertebrocostal because they connect to the costal cartilage of the superior rib and to the vertebrae. Ribs 11–12 are floating ribs, with no anterior attachment.
How We Breathe

- The respiratory control center is in the medulla oblongata.

How We Breathe

- Inspiration is an active process in which the diaphragm is sent a signal via the phrenic nerve, causing it to contract and flatten, increasing thoracic cavity space.
  - The increase in thoracic cavity volume decreases pressure,
  - Creating a lower pressure in the lungs than outside,
  - Allowing air to rush into the lungs.

- The external intercostal muscles also assist by moving the ribs up and outward to increase total volume in the thoracic cavity.
- Exhalation is a passive act
  - Caused by a return of the diaphragm to a resting state
  - Decreasing the space in the thoracic cavity
  - Increasing pressure and pushing air out

Figure 14-16 The thoracic cage.
Respiratory Rate

- While we can consciously influence breathing rate, our breathing rate is ultimately controlled by the level of carbon dioxide in our blood.
- If carbon dioxide levels rise in the blood, it means you are not ventilating, or “blowing off” enough CO₂ and your medulla oblongata will send signals to the respiratory muscles to increase the rate and depth of breathing.
- Increased CO₂ decreases pH which is sensed by the medulla oblongata and receptors in the aorta and carotid arteries.

Accessory Muscles

- During increased activity we need more oxygen.
- Accessory muscles are used to help pull up your rib cage to make an even larger space in the thoracic cavity.
- Accessory muscles include:
  - Scalenus muscles in the neck
  - Sternoceleidomastoid
  - Pectoralis major
  - Pectoralis minor muscles

Accessory Muscles

- While exhalation is usually passive, there are times when exhalation may need to be assisted, such as in certain diseases.
- Accessory muscles of exhalation assist in more forceful and active exhalation by increasing abdominal pressure.
- The main accessory muscles of exhalation are the abdominal muscles that push up the diaphragm and the back muscles that pull down and compress the thoracic cage.

From the Streets: Hypoxic Drive

- As the disease progresses, the chemoreceptors adapt and switch their stimulus to breath to oxygen levels (PO₂) instead.
- Administration of high concentration oxygen can rapidly increase PO₂ levels and inhibit the respiratory drive causing respiratory arrest.

From the Streets: Hypoxic Drive

- The normal respiratory drive is controlled by the amount of carbon dioxide in the blood (PCO₂).
- An increase in PCO₂ increases respirations, while a decrease in PCO₂ decreases respirations.
- In patients with chronic obstructive pulmonary disease, the levels of CO₂ rise creating a chronic state of CO₂ retention.
Pulmonary Function Testing

- Lung function can be measured in terms of volumes and flows using pulmonary function testing (PFTs).
- Volumes can be measured
  - Tidal volume (VT) is the amount of air moved into or out of the lungs at rest during a single breath. The normal tidal volume is 500 mL.
  - Your inspiratory reserve volume is what you can breathe in beyond a normal inspiration.

Volumes can be measured
- Likewise, your expiratory reserve volume is what you can exhale beyond a normal exhalation.
- Residual volume (RV) is the volume left in lungs after maximum exhalation.

We can combine these volumes to get various lung capacities
- Function residual capacity (FRC) – volume of air remaining in the lungs at the end of a normal expiration
- Inspiratory reserve volume (IRV) – volume of air that can be forcefully inhaled after a normal inspiration
- Expiratory reserve volume (ERV) – volume of air that can be forcefully exhaled after a normal expiration

Besides volumes and capacities, we can also measure the flow rates coming out of the lung at various points during a forced (maximum patient effort) vital capacity (FVC).
- Forced expiratory volume in 1 second or (FEV1) and peak expiratory flow rate (PEFR).
Another test that helps to establish whether the airways have become “narrower” than normal (as would be seen in an asthma episode) is peak expiratory flow rate, or PEFR.

– This is the maximum flow rate or speed of air a person can rapidly expel after taking the deepest possible breath.

Several interventions are used to manage respiratory emergencies.

- Mechanical ventilators are used to assist patients that require prolonged ventilation.
Prehospital mechanical ventilators can be simple (as seen here) or complex depending on the needs of the patient.

From the Streets: Prehospital Mechanical Ventilation

- Most prehospital devices are pressure-cycled and powered by compressed oxygen.
- A wide variety of devices exist in the market.
- A special kind of ventilation, positive end-expiratory pressure (PEEP), can be used to increase lung pressure and compliance.

Common Disorders of the Respiratory System

- Atelectasis
  - Atelectasis is a condition in which the air sacs of the lungs are either partially or totally collapsed.
  - The cause may be a patient who can’t, or won’t, take deep breaths to fully expand the lungs and keep the passageways open.
  - This can be due to surgery or thoracic cage injury.

- Pneumonia
  - A lung infection that can be caused by virus, fungi, or bacteria.
  - Pneumonia results in inflammation of the infected area with an accumulation of cell debris and fluid.
  - Some pneumonias actually destroy lung tissue.
  - Severe pneumonia can result in death.
Common Disorders of the Respiratory System

• COPD
  – Chronic obstructive pulmonary disease (COPD) is a general disease resulting in difficulty evacuating air from the lungs, large amount of secretions, and lung damage.
  – COPD refers to one, or a combination, of:
    ▪ Asthma
    ▪ Emphysema
    ▪ Chronic bronchitis

Click [here] to view a video on the topic of COPD.

Common Disorders of the Respiratory System

• Asthma
  – Asthma is a potentially life-threatening lung condition resulting in constriction of the airways, called bronchospasm.
  – It is difficult to get air in, and even more difficult to get air out of the lungs ("gas trapping"), resulting in an inability to get enough fresh, oxygenated air in.
  – The patient breathes the same air over and over.
  – Lower oxygen levels and increased carbon dioxide levels occur.

Click [here] to view a video on the topic of Asthma.

Click [here] to view a video on the topic of COPD.
Emphysema
- Emphysema is an irreversible condition in which the alveolar air sacs are destroyed.
- The damaged alveoli make gas diffusion difficult, if not impossible, in part due to decreased surface area.
- The lung itself becomes fragile and can easily rupture, like a worn tire.
- Escaped air flows through the rupture into the thoracic cavity, further inhibiting gas exchange.
- The most common cause of emphysema is smoking.

Chronic Bronchitis
- Chronic bronchitis is a potentially reversible lung disease.
- The disease process includes inflamed airways and large amounts of sputum production.
- As inflammation progresses, airways swell and the inner diameter gets smaller, making air exchange difficult and increasing the work of breathing.
- This causes increased oxygen use and increased carbon dioxide production.

Pneumothorax
- A pneumothorax is a condition in which there is air outside the lungs, in the thoracic cavity.
- Air can enter the thoracic cavity either through a hole in the lung or a hole in the thorax.
- Causes include stab or gunshot wounds, or disease processes that damage the lungs.
- The air from the external environment fills the space meant for the lungs and prevents lung expansion required for breathing.

Pneumothorax
- This can be a life-threatening condition and must be treated immediately with a chest tube, sucking the air from the thoracic cavity like a vacuum.
Common Disorders of the Respiratory System

- **Pleural effusion**
  - A pleural effusion is the buildup of fluid in the pleural space, between the parietal and visceral pleura.
  - The fluid may be pus (empyema), serum from blood (hydrothorax), or blood (hemothorax).
  - Gravity tends to push fluids to the bases of the pleural space and can have the same effect as a pneumothorax, restricting lung expansion.
  - Pleural effusions can be treated with antibiotics or by inserting a needle into the collection of fluid and aspirating it.

- **Tuberculosis**
  - Tuberculosis, or TB, is an infectious disease, thriving in high oxygen areas such as the lung.
  - TB bacteria can lay dormant for years before multiplying.
  - Unchecked, TB can cause massive lung damage.
  - TB is treated with medications, but there is concern about a new form of TB that is resistant to traditional medications.

There are many symptoms of lung disease
- Dyspnea (difficulty breathing)
- Tachypnea (rapid respiratory rate)
- Cyanosis (a blue coloring to lips and nail beds)
- Retractions (use of accessory muscles of breathing)
- Tachycardia (rapid heart rate)
- Polycythemia (increased RBC count)
Common Disorders of the Respiratory System

- **Smoking**
  - The major, preventable, primary cause of respiratory disease is smoking.
  - The annual number of smoking-related deaths in the United States is equal to a jumbo jet filled with passengers crashing with no survivors every day – 450,000 people per year.

**From the Streets: Tobacco Abuse**

- Tobacco use remains a significant risk factor for respiratory and cardiovascular disease.
- A patient’s cigarette smoking history is reported in pack/years.
- Medical problems related to smoking, such as emphysema, chronic bronchitis and lung cancer usually begin after a patient surpasses a 20 pack/year history.

**From the Streets: Capnography**

- End-tidal carbon dioxide (ETCO₂) monitoring is a non-invasive method of measuring the levels of CO₂ in the exhaled breath.
- When circulation is normal, ETCO₂ levels change with each ventilation.
- Decreased ETCO₂ levels can be found in shock, cardiac arrest, pulmonary embolism, bronchospasm and airway obstruction.

Click [here](#) to view a video on the topic of ARDS.

Click [here](#) to view a video on the topic of Allergic Rhinitis.
Snapshots from the Journey

- Moving approximately 12,000 quarts of air each day, the respiratory system is responsible for providing oxygen for the blood to take to the body’s tissues and removing carbon dioxide, one of the waste products of cellular metabolism.
- Ventilation is the movement of gases into and out of the lungs; during respiration, oxygen is added to the blood, and carbon dioxide is removed.

Snapshots from the Journey

- The lungs contain continually branching airways called bronchi and bronchioles.
- At the end of bronchioles are alveolar sacs.
- Each alveolar sac is surrounded by a capillary network where gas exchange occurs with the blood.
- The purpose of the upper airways is to filter, warm, and moisten inhaled air for its journey to the lungs.

Snapshots from the Journey

- In addition, the upper airways provide for olfaction (sense of smell) and phonation (speech).
- The mucociliary escalator captures foreign particles, and the hairlike cilia constantly move a layer of mucus up to the upper airways to be swallowed or expelled.
- Adenoids and tonsils aid in preventing pathogens from entering the body.
Snapshots from the Journey

- Because activities of breathing and swallowing share a common pathway, the epiglottis protects the airway to the lungs from accidental aspiration of food and liquids.
- Vocal cords are the gateway between the upper and lower airways.

Snapshots from the Journey

- The tracheobronchial tree is like an upside-down tree with ever-branching airways, where the trunk of the tree is represented by the trachea and the leaves by the alveoli.
- The alveolar capillary membrane is where external respiration or gas exchange occurs.
- The bony thorax provides support and protection for the respiratory system.

Snapshots from the Journey

- The main muscle of breathing is the diaphragm, and accessory muscles assist in times of need such as exercise and disease.
- The medulla oblongata in the brain is the control center for breathing and sends impulses via the phrenic nerve to the diaphragm.

Case Study

A patient comes to the emergency department with wheezing and thick secretions. His heart rate, breathing rate, and blood pressure are all increased. He is using accessory muscles of ventilation to breathe and has peripheral cyanosis. He has a history of asthma, and has had a “bad cold” for several days.

Case Study Questions

- What are two possible respiratory conditions he may have?
- Can you think of some recommended treatments for this patient?
- What would be some positive indicators that the treatment is working? For example, after the treatment, you notice less accessory muscle use. Can you think of at least two more?

From the Streets

You are caring for an 22-year-old male victim of an assault complaining of difficulty breathing. His left chest was hit with a baseball bat and reveals a large contusion, deformity, and severe pain upon palpation. His respiratory rate is rapid and shallow with accessory muscle use. You note absent lung sounds on the left and a room air oxygen saturation of 85%.
**From the Streets Questions**

- What is the most likely diagnosis?
- Describe this diagnosis using anatomical terms.
- Why are his lung sounds absent on the left side?
- What is his prognosis?

**End of Chapter Review Questions**

1. The process of gas exchange between the alveolar area and the capillary is:
   - a. External ventilation
   - b. Internal ventilation
   - c. Internal respiration
   - d. External respiration

2. The bulk movement of gas within the lung is called:
   - a. Internal respiration
   - b. Ventilation
   - c. Diffusion
   - d. Gas exchange

3. Which of the following is not a function of the upper airway?
   - a. Humidification
   - b. Gas exchange
   - c. Filtration
   - d. Heating or cooling gases

**End of Chapter Review Questions**

- What is the most likely diagnosis? Tension Pneumothorax
- Describe this diagnosis using anatomical terms. The lung has been damaged allowing air to enter the pleural space. The air in the pleural space has collapsed the left lung, not allowing it to inflate.
- Why are his lung sounds absent on the left side? The lung is collapsed so air exchange does not occur.
- What is his prognosis?
  - This is a life-threatening emergency. Immediate intervention to support oxygenation and ventilation is required. The patient will be transported to a trauma center.
**End of Chapter Review Questions**

4. The largest cartilage in the upper airway is the:
   a. Cricoid
   b. Eustachian
   c. Mega cartilage
   d. Thyroid

5. Which structure controls the opening to the trachea?
   a. Esophagus
   b. Hypoglossus
   c. Epiglottis
   d. Hyperglossus

6. Cells need oxygen to
   a. Make ATP
   b. Get rid of CO₂
   c. Use gasoline
   d. Breathe

**End of Chapter Review Questions**

1. Small bronchi are called ________.
2. The sense of smell is termed ________ and the act of speech is called ________.
3. The hairlike projections called ________ beat within the ________ layer and propel the ________ layer towards the oral cavity to be expectorated.
4. The ________ are thought to lighten the head and provide resonance for the voice.
5. When the diaphragm contracts, lung volume ________ and air flows ________.

**End of Chapter Review Questions**

1. Describe the tissue layers of the bronchi.
2. Explain how gas exchange takes place in the lungs.
3. Discuss the importance of surfactant.
4. Describe the process of normal breathing, beginning with the brain.
5. Explain the changes in the wall of the tracheobronchial tree as you move from the conducting zone to the respiratory zone.