INTRODUCTION

The respiratory system is composed of structures involved in ventilation (airflow to and from the lungs) and gas exchange to supply blood with oxygen and remove carbon dioxide from the blood. The respiratory system does this through ventilation, gas exchange between alveoli and capillaries, transportation of oxygen from the lungs to the cells; gas exchange between cells and capillaries and delivery of carbon dioxide from the cells to the lungs. In summary events of respiration includes ventilation, external and internal respiration, and cellular respiration.

Ventilation activities ensure that air moves in and out of the alveoli in sufficient quantities to supply the needs of the cells involved in oxidative cell respiration. Every cell in our body needs energy, and they obtain their energy via cellular respiration (aerobically means need oxygen), thus oxygen should be delivered to each cell continuously. Our cardiovascular system provides a link between the lungs and all the cells throughout the body. Therefore the ultimate function of breathing is to deliver oxygen to cells, where it takes part in the reactions of cellular respiration that liberate energy from nutrient molecules and get rid of carbon dioxide, which maintains the pH of the internal environment.

The passageway that carries air from nose to the alveoli and from alveoli to the nose makes up the respiratory tract. The respiratory tract is divided into upper (nose, nasal cavity, sinuses and pharynx) and lower (larynx, trachea, bronchi, bronchiole, and alveoli) respiratory system. Air enters the upper respiratory system it is filtered, humidified and warmed, before reaching the lungs i.e. upper respiratory system filters, worms and humidifies incoming air to protect the more delicate surface of lower respiratory system. Think of the mucus layer of the respiratory epithelium as a sticky flypaper that traps potentially troubling particles (flies or microbes) from the surrounding airstream.

The lower respiratory system conduct air to the air filled pockets (called alveoli) where gas exchange occurs between air and blood i.e. oxygen of the inhaled air from alveoli diffuses into the capillaries and carbon dioxide diffuses from the capillaries to the alveoli. After the gas exchange the carbon dioxide follows the same path out of the lungs when we exhale.

OVERVIEW

1. The respiratory system consists of passageways that filter incoming air and ultimately transport it into the microscopic air sacs where gases are exchanged.
2. The entire process of exchanging gases between the atmosphere and body cells is called respiration.
3. Respiration includes 5 parts:
   a. Ventilation = breathing
   b. External respiration = air into lungs gas exchange (O₂ load into the capillaries/ CO₂ unload from the capillaries) air out i.e. exchange between atmospheric air (external environment) and capillaries or you could say that external respiration is diffusion of gases between the alveoli and the circulating blood.
   c. Transport of respiratory gases = gases in blood transported from lungs to body cells and back to lungs i.e. delivery of oxygen from the lungs to the cells and delivery of carbon dioxide from the cells back to the lungs
   d. Internal respiration = exchange of gases at body capillaries (O₂ unload from capillaries to the cell/CO₂ load from cells to the capillaries i.e. oxygen dissociates from Hb and diffuses out of RBC and then out of capillaries and enter the cells of peripheral tissue; carbon dioxide diffuses from the cells of peripheral tissue into the capillaries and then into the RBC and some bind to Hb and the rest is converted to bicarbonate ion).
   e. Cellular respiration = use of oxygen by cells to produce energy (production of CO₂).
   f. Only ventilation and external respiration are accomplished by respiratory system organs. Transport of respiratory gases and internal respiration is achieved by cardiovascular system and...
cellular respiration is achieved by cellular metabolism (chemical reactions that take place inside the cell)

WHY WE BREATH?
Respiration is necessary because of cellular respiration, the process by which animal cells use oxygen to release energy from nutrients we eat. The metabolic waste gas, carbon dioxide is produced during cellular respiration, and it must be transported to the lungs to be expelled.

ORGANS OF THE RESPIRATORY SYSTEM
The organs of the respiratory system can be divided into two groups, or tracts. Those in the upper respiratory tract include the nose, nasal cavity, sinuses, and pharynx. Those in the lower respiratory tract include the larynx, trachea, bronchial tree, and lungs.

UPPER RESPIRATORY SYSTEM
1. The upper respiratory organs are lined with mucous membranes. Its function include to: warm incoming air; moisten incoming air; entrap dust, microorganisms, and particles
   a. Epithelium over connective tissue with many goblet cells (mucus).
      i. The mucus functions to trap debris.
      ii. The cilia beat the debris to the pharynx to be swallowed and destroyed by digestive enzymes. Note: A healthy respiratory system is continuously cleansed. The sticky mucus produced by the mucus cells batches the exposed surface of respiratory passageway. As air passes through the passage way sticky mucus traps dirt, microorganisms, debris and pathogens. The continuous beating of cilia sweeps trapped material toward the mouth (pharynx), where they can be swallowed and eliminated by the stomach acid. Smoking greatly impairs this housekeeping by slowing the beating of cilia. In cystic fibrosis the mucus cells produce abnormally thick and sticky mucus, thus beating of cilia cannot sweep the dense mucus. Mucus accumulates and restricts airflow and could block smaller air passageways.
      iii. This tissue also serves to warm and moisten incoming air.
2. Nose (external nares or nostrils)
   a. Nose consists of or includes bone and cartilage with internal hairs (hairs traps large particles i.e. filters air)
3. Nasal cavity (separated by nasal septum)
   a. Bone and cartilage of nasal cavity are lined with mucous membranes
b. Warms and moistens incoming air
c. Olfactory reception
d. Resonating chambers for speech

4. Nasal conchae
   a. Within the nasal cavity there are superior, middle, and inferior bones called conchae
   b. Conchae divide nasal cavity into a series of groove-like passageway
   c. Conchae are lined by mucous membranes
   d. Function of nasal conchae is to increase turbulence of incoming air in order to better warm, moisten, and filter. As air passes through the conchae, it create turbulence in the air so as to trap small particulates in mucus i.e. passing air will bounce up and down and microorganism and small particles will also bounce, and as they bounce up and down small particles and microorganisms will stick to the sticky mucus.

5. Paranasal sinuses
   a. Recall from A&P I that sinuses are air-filled spaces in the frontal, sphenoid, ethmoid, and maxillary bones of the skull. These spaces open into the nasal cavity and are lined with mucous membranes that are continuous with the lining of the nasal cavity, so mucus secretions drain from the sinuses into the nasal cavity
   b. During inflammation (swollen of membrane) of the membrane due to nasal infections or allergic reactions the opening to the nasal cavity could become block and prevent drainage of mucus secretion into nasal cavity. This may increase pressure in a sinus and cause headache.

6. Pharynx (or throat)
   a. It is a passageway for air and food i.e. shared by both respiratory system and digest system.
   b. Pharynx is divided into three parts:
      i. Nasopharynx (uppermost, behind nasal cavity)
      ii. Oropharynx (middle, behind oral cavity) – this is the portion of pharynx that is shared by both digestive and respiratory systems
      iii. Laryngopharynx (lowest)

LOWER RESPIRATORY SYSTEM
Organs of lower respiratory system include:

1. Larynx (or voice box)
   a. Larynx consists of nine pieces of cartilage: 3 large cartilages and 3 pairs of small cartilages. The 3 large cartilages of larynx include:
      i. Thyroid cartilage (Adam's apple)
      ii. Epiglottis closes off the airway during swallowing.
         1. During swallowing the larynx is elevated and the epiglottis folds back over the glottis, preventing food and water particles from entering into respiratory tract i.e. epiglottis is an elastic cartilage that shields the opening to the larynx during
swallowing.

2. **Glottis** = triangular slit opening between two pairs of vocal cords i.e. inhaled air leaves the pharynx and enters the larynx through a narrow opening called glottis. Glottis is the opening to the larynx.

   iii. **Cricoid cartilage** = ring of hyaline cartilage attached to first ring of trachea site of tracheotomy.

b. **Voice production**
   i. Sound production at the larynx is called phonation. Phonation is the first step in speech production. Phonation (sound) produced by vocal fold has to be articulated and modified by tongue, teeth, lips, nasal cavity to produce speech.
   ii. Mucous membranes form two pairs of folds.
      1. Upper ventricular folds (false vocal cords)
      2. Lower vocal folds (true vocal cords)
      3. Triangular space between them = glottis.
   iii. Sound (phonation) originates from vibration of the vocal folds as air passes through the open glottis.

2. **Trachea (windpipe)**
   a. Trachea or windpipe is a tough, flexible tube that receive air from the larynx and pass it to the bronchi
   b. Location = mediastinum anterior to esophagus extends from larynx to T5 (fifth thoracic vertebrae)
   c. Structure: 16-20 incomplete rings of hyaline cartilage = C-rings
      i. C shape cartilages hold them open and prevent its collapse or overexpansion as pressure changes within the respiratory system.
   d. Carina = point where trachea divides into right & left primary bronchi i.e. when trachea branches into left and right, it becomes primary bronchi.
   e. Function = support against collapse, continue to warm, moisten & filter air.

3. **Bronchial Tree**
   a. The bronchial tree consists of branched airways leading from the trachea to the microscopic air sacs in the lungs. Its branches begin with the right and left primary bronchi
   b. The openings of the primary bronchi are separated by a ridge of cartilage called the carina
   c. Each primary bronchus enters its respective lung (left bronchus enters left lung and right bronchus enters right lung)
   d. Primary bronchus branches into secondary or lobar bronchi, which branch to each lobe i.e. at the entrance to the lungs primary bronchi will branch into secondary bronchi and then each secondary bronchus will enter one lobe of the lung (Three branch from the right primary bronchus, and two branch from the left)
   e. Secondary bronchi will branch into tertiary or segmental bronchi
   f. Each tertiary bronchi branches several times giving rise to multiple bronchioles

4. **Bronchioles**
   a. Each bronchiole branches further to form terminal bronchioles
   b. Each terminal bronchiole subdivides into microscopic branches called respiratory bronchioles (lined by simple squamous epithelium), which subdivide into several alveolar ducts, which terminate into numerous alveoli and alveolar sacs.
   c. As bronchi branches: Epithelium changes from ciliated to non-ciliated; Cartilage decreases; Smooth muscle increases
5. ALVEOLI (microscopic air sacs)
   a. Alveoli are thin-walled, microscopic air sacs that open to an alveolar sac. Air can diffuse freely from the alveolar ducts, through the alveolar sacs, and into the alveoli (The lungs contain more than 300 million alveoli)
   b. Wall consists of epithelial cells, septal cells and macrophages
      i. Epithelial cells called Type I Alveolar cells form a continuous simple squamous lining of the alveolar wall.
      ii. Septal cells called Type II Alveolar cells are scattered among the squamous lining. These cells produce (secrete) surfactant
          1. Surfactant lowers surface tension and prevents alveolar collapse i.e. surfactant helps prevent the alveoli from collapsing.
      iii. Alveolar Macrophages remove dust particles and other debris from alveolar spaces.
A diagrammatic view of alveolar structure. A single capillary may be involved in gas exchange with several alveoli simultaneously

iv. Alveolar-Capillary (Respiratory) Membrane
   1. Function = allows for rapid diffusion of gases (from area of high concentration to area of low concentration and/or form area of high pressure to area of low pressure).
   2. This exchange of gas between alveoli and capillaries are called External Respiration

6. Lungs
   a. Location = thoracic cavity
   b. Description: The lungs are soft, spongy, paired, cone-shape organs in the thoracic cavity; covered by pleural (serous) membranes. A layer of serous membrane, the visceral pleura, is firmly attached to the surface of each lung, and this membrane folds back at the hilus to become the parietal pleura
      i. visceral pleura – covers the outer surfaces of the lungs
      ii. Parietal pleura – covers the inner surface of the thoracic wall and extends over the diaphragm.
      iii. Pleural cavity filled with serous fluid.
c. **Each lung is divided into lobes** by fissures:
   i. Right lung has 3 lobes: superior, middle, and inferior.
   ii. Left lung has 2 lobes: superior and inferior
   iii. Each lobe: receives a secondary bronchus
   iv. Each lobe is divided into lobules (bronchopulmonary segment)

**BREATHING MECHANISM/VENTILATION**

**Introduction:** Recall that the function of the respiratory system is to supply cells with oxygen and remove carbon dioxide. The breathing mechanism is called ventilation. Movement of the diaphragm and rib cage causes change in the volume of the thoracic cavity. When the shape of thoracic cavity changes, the lungs will either expands or compresses, and consequently expansion and compression changes the air pressure within the lungs. Air will flow from area of higher pressure to area of lower pressure. The direction of air flow is determined by the difference between atmospheric pressure and intrapulmonary pressure (pressure inside the lungs or pressure inside the respiratory tract).

1. **Gas Law**
   a. **Boyle’s Law:** states that pressure and volume are inversely (indirectly) proportional i.e. volume and pressure have indirect relationship. When volume is decreased pressure increases, and when volume is increase, pressure decreases.
   b. **Dalton’s law:** in a mixture of gases like air, the total pressure is the sum of the individual partial pressures of the gases in the mixture. The pressure of gas determines the rate at which it will diffuse from region to region. Gas will diffuse from are of high pressure to area of low pressure.
   c. **Henry’s law:** The amount of gas in solution is directly proportional to their partial pressure i.e. more pressure means more gasses in solution. For example unopened can of soda will have high pressure inside and high pressure means more gas will be in the solution, but when a can of soda is opened, pressure decreases and gas escapes from the solution.

2. **Ventilation** involves two actions, inspiration and expiration.
   a. **Inspiration** (inhalation) = breathing air in.
      i. Elevation of rib cage and contraction of the diaphragm enlarges the thoracic cavity. Increase in the size of thoracic cavity mean the pressure inside the lungs becomes lower than the atmospheric pressure, air flows into the lung i.e. when atmospheric pressure is higher than lung pressure air moves into the lung
      ii. During inspiration: The diaphragm muscle pushes downward i.e. The size of thoracic cavity increases; The pressure in the thoracic cavity decreases (Boyles' Law); The air pressure inside the thoracic cavity (lungs) is less than the atmospheric pressure and therefore air rushes into lungs to equalize the pressure gradient.
   b. **Expiration** = breathing out depends on two factors: the **elastic recoil of tissues** that were stretched during inspiration (i.e. tissues bouncing back to shape); the inward pull of surface
tension due to the alveolar fluid. The first event in expiration is the diaphragm and external intercostal respiratory muscles relax.

i. When the rib cage returns to its original position and the diaphragm relaxes the volume of the thoracic cavity decreases. Pressure rises, and air moves out of the lungs.

3. **Respiratory Distress Syndrome (RDS)** in premature newborns (collapsed lungs) occurs due to the lack of surfactant in the alveoli.

4. **Respiratory Volumes and Capacities**
   a. Are measured by a spirometer
   b. Include the following 4 volumes from which 4 capacities may be calculated.

   i. One inspiration plus the following expiration is called a respiratory cycle. **Tidal Volume** = amount (volume) of air that enters the lungs during normal inspiration and leaves the lungs during normal expiration; approximately 500 ml. In other word it is the volume of air that enters or leaves the lungs during a normal respiratory cycle.

   ii. **Inspiratory Reserve Volume (IRV)** = the amount of air that can be forcibly inhaled after a normal tidal inspiration; approximately 3000 ml.

   iii. **Expiratory Reserve Volume (ERV)** = the amount of air that can be forcibly exhaled after a normal tidal expiration; approximately 1100 ml.

   iv. **Residual Volume (RV)** = amount of air that always remains in lungs; approximately 1200 ml.

   v. **Vital Capacity (VC)** = the maximum amount of air that can be exhaled after a maximum inhalation.

   vi. **Inspiratory Capacity** = total amount of air that can be inspired after a tidal expiration.

   vii. **Functional Residual Capacity** = amount of air left in the lungs after a tidal expiration

   viii. **Total Lung Capacity** = VC + RV; approximately 6 L.
5. **Alveolar Ventilation**  
a. **Minute Ventilation** = Amount of air that enters and exits respiratory system in one minute (tidal volume multiplied by the number of breathing per minute)  
b. **Anatomic dead space (ADS)** = air space in respiratory passageways not involved in gas exchange;  

**CONTROL OF BREATHING**  
1. Normal breathing = rhythmic and involuntary.  
2. Respiratory Center = Nervous Control  
   a. Located in pons & medulla of brain stem  
   b. Medullary Rhythmicity area composed of dorsal respiratory group which controls the basic rhythm of breathing and ventral respiratory group which controls forceful breathing.  
3. **Factors Affecting Breathing**  
   a. **Chemoreceptors** in carotid and aortic bodies of some arteries are sensitive to:  
      i. Low levels of oxygen  
      ii. High levels of CO₂  
         1. Increase in CO₂ level affects chemosensitive areas (central chemoreceptors) of respiratory center and breathing rate and depth increases  
         iii. Hyperventilation is rapid, shallow breathing that increases O₂ level and decrease in blood CO₂ concentration and a rise in pH. NOTE CO₂ concentration and pH have inverse (indirect) relationship. The higher the CO₂, the lower the pH, the lower the CO₂, the higher the pH i.e. high CO₂ = acidic pH; and low CO₂ = base or alkaline pH  
      iv. Low pH increases breathing rate. High concentration of CO₂ decreases pH (make pH acidic)  

**ALVEOLAR GAS EXCHANGES**  
1. **External Respiration** = the exchange of oxygen and carbon dioxide between the alveoli and capillaries at the lungs.  
   a. The **pressure** of gas determines the rate at which it will diffuse from region to region (Dalton's Law).  
   b. In a mixture of gases, the amount of pressure that each gas creates = **partial pressure**.  
   c. In air that reaches the alveoli:  
      i. P₀₂ = 104 mm Hg (the partial pressure of oxygen in the alveoli is about 104)  
      ii. Partial pressure of deoxygenated blood at the pulmonary capillaries = 40  
      iii. Oxygen will diffuse from are of high pressure (alveoli) to are of low pressure (pulmonary capillaries)  
      iv. P₀₂ = 40 mm Hg (the partial pressure of carbon dioxide in the alveoli is about 40)  
      v. Partial pressure of carbon dioxide in the pulmonary capillaries are 45  
      vi. Carbon dioxide will diffuse from are of high pressure (pulmonary capillaries) to are of low pressure (alveoli)  
   d. The partial pressure of a gas is **directly** related to the concentration of that gas in a mixture.(Dalton’s Law of Partial Pressure)  
   e. **Diffusion** of gases through the respiratory membrane proceeds from where a gas is at high partial pressure → low partial pressure.  
   f. The **rate of diffusion of gases** also depends on a number of factors, including the following:  
      1. gas exchange surface area  
      2. diffusion distance  
      3. Breathing rate and depth.  
2. **Internal Respiration** = the exchange of oxygen and carbon dioxide between tissue capillaries and tissue cells i.e. internal respiration is the process by which dissolved gases are exchanged between the blood
and interstitial fluids.

a. In tissue cell: \[ pCO_2 = 45 \quad pO_2 = 40 \]
b. In tissue capillaries: \[ pCO_2 = 40 \quad pO_2 = 95. \]
c. Therefore, oxygen diffuses from the capillaries into the interstitial fluid and from interstitial fluid into the cell and carbon dioxide diffuses from cell into the interstitial fluid and from interstitial fluid into capillaries.

**GAS TRANSPORT (in Blood)**

1. **Oxygen Transport**
   a. When oxygen diffuses into the capillaries from the alveoli, it binds with hemoglobin (Hb) in red blood cells to form **oxyhemoglobin**. Recall that each hemoglobin could bind to 4 oxygen molecules.

   b. A weak bond is formed so oxygen can be delivered to the cells and then released when needed.

   c. The release of oxygen from hemoglobin depends on many factors:
i. High blood $[CO_2]$ means need for oxygen

ii. Low blood pH (acidity) means high concentration of $CO_2$, and high concentration of $CO_2$ means acidic pH (low pH)

iii. High blood temperature, means increased physical activity thus it means need for more oxygen. Recall from your A&P that heat is produced by skeletal muscle and distributed by blood. High muscle activity means more heat.

d. **Carbon Monoxide (CO)** binds to hemoglobin more efficiently than oxygen i.e. hemoglobin has more affinity to bind to carbon monoxide than to oxygen

   i. If the hemoglobin (that is supposed to bind with oxygen) is bound to CO, much less Hb is available to bind and transport oxygen to the tissues Hypoxia (oxygen deficiency) results and cells die.

2. **Carbon Dioxide Transport (CO$_2$)**

   a. CO$_2$ is transported in 3 forms:

      i. Dissolved CO$_2$ = 7%

      ii. Carbaminohemoglobin = 23%

      iii. Bicarbonate ions = 70%

   b. In tissues, CO$_2$ is produced by cellular respiration i.e. cells continuously use oxygen and organic molecules (e.g. glucose) to generate ATP (energy to maintain homeostasis) and CO$_2$ as a waste product of cellular respiration). CO$_2$ from the cell diffuses into the interstitial fluid and then from the interstitial fluid it diffuses into the capillaries.

   c. Once inside the capillaries, 7% of the CO$_2$ will be dissolved in the plasma and transported to the lungs as dissolved in the plasma

   d. 93% of the CO$_2$ will enter the RBC (red blood cells).

   e. Inside the RBC 23% of the CO$_2$ will bind to hemoglobin and will be transported to the lungs as bound to the hemoglobin

   f. 70% of CO$_2$ inside the RBC will combine with $H_2O$ to form $H_2CO_3$ (Carbonic acid). Carbonic acid dissociates to $H^+$ and bicarbonate ion ($HCO_3^-$). Enzyme **carbonic anhydrase** facilitate this reaction

\[
CO_2 + H_2O \rightarrow H_2CO_3 \rightarrow H^+ + HCO_3^-
\]
1) In the capillaries 93% of CO2 will enter RBC. Inside RBC 70% of CO2 will combine with H2O and form carbonic acid; 23% will bind to hemoglobin (Hb) and form carboxyhemoglobin.

2) Carbonic acid is a weak acid therefore it will quickly dissociate into bicarbonate and hydrogen ions with the help of an enzyme called carbonic anhydrase.

3) Hydrogen ions will bind to hemoglobin and bicarbonate will move out of the RBC via chloride shift in exchange for Cl⁻ (chloride shift).

4) Carbon dioxide will be delivered to the lungs (mainly in the form of bicarbonate ions, but 23% bound to Hb and 7% dissolved in the plasma). At the lungs the reaction is reversed: Bicarbonate enters RBC and chlorine moves out of the RBC; Hydrogen ion that was bound to Hb will be dissociated; Hydrogen ion and bicarbonate will combine and form carbonic acid; carbonic acid will dissociate into carbon dioxide and water; carbon dioxide will diffuse from RBC to the plasma and from plasma to alveoli; also carbon dioxide that was bound to Hb will dissociate from it and diffuse out of RBC and then diffuse to the alveoli.

**LIFE SPAN CHANGES**

1. The lungs, respiratory passageways, and alveoli undergo aging-related changes exacerbated by exposure to pollutants, smoke, etc., increasing the risk of developing respiratory illnesses.
2. Loss of cilia, thickening of mucus, and impaired macrophages increases the risk of infection as one ages.
3. Breathing becomes more difficult as one ages due to:
   a. calcified cartilage
   b. skeletal changes
c. altered posture
d. Replacement of bronchiole smooth muscle by fibrous connective tissue.

   a. The lungs contain a greater proportion of “stale” air.
   b. Alveoli coalesce and become shallower, slowing gas exchange.

**Summary of Organs of Respiratory System and their Function**

<table>
<thead>
<tr>
<th>Part</th>
<th>Description</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nose</td>
<td>Part of face centered above the mouth and inferior to the space between the eyes</td>
<td>Nostrils provide entrance to nasal cavity; internal hairs begin to filter incoming air</td>
</tr>
<tr>
<td>Nasal cavity</td>
<td>Hollow space behind nose</td>
<td>Conducts air to pharynx; mucous lining filters, warms, and moistens incoming air</td>
</tr>
<tr>
<td>Sinuses</td>
<td>Hollow spaces in various bones of the skull</td>
<td>Reduce weight of the skull; serve as resonant chambers</td>
</tr>
<tr>
<td>Pharynx</td>
<td>Chamber posterior to the nasal cavity, oral cavity, and larynx</td>
<td>Passageway for air moving from nasal cavity to larynx and for food moving from oral cavity to esophagus</td>
</tr>
<tr>
<td>Larynx</td>
<td>Enlargement at the top of the trachea</td>
<td>Passageway for air; prevents foreign objects from entering trachea; houses vocal cords</td>
</tr>
<tr>
<td>Trachea</td>
<td>Flexible tube that connects larynx with bronchial tree</td>
<td>Passageway for air; mucous lining continues to filter incoming air</td>
</tr>
<tr>
<td>Bronchial tree</td>
<td>Branched tubes that lead from the trachea to the alveoli</td>
<td>Conducts air to the alveoli; mucous lining continues to filter incoming air</td>
</tr>
<tr>
<td>Lungs</td>
<td>Soft, cone-shaped organs that occupy a large portion of the thoracic cavity</td>
<td>Contain the air passages, alveoli, blood vessels, connective tissues, lymphatic vessels, and nerves of the lower respiratory tract</td>
</tr>
</tbody>
</table>

**Summary of divisions of Respiratory System**

<table>
<thead>
<tr>
<th>Divisions</th>
<th>Organs</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Upper respiratory System</td>
<td>Nasal cavity, sinuses, pharynx</td>
<td>filtered, warmed, and humidified incoming air</td>
</tr>
<tr>
<td>Lower respiratory system</td>
<td>Larynx, trachea, bronchi, bronchiole, alveoli</td>
<td>Continue filtering air, alveoli allows for gas exchange</td>
</tr>
</tbody>
</table>