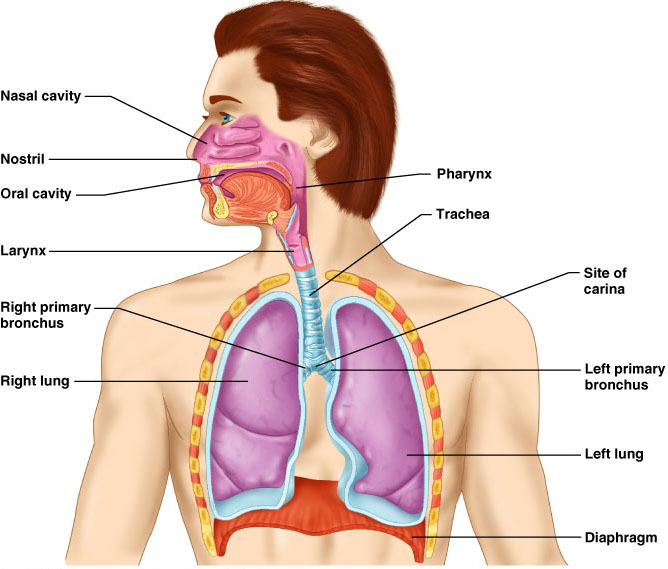
**The Respiratory System**

**Dr. Gary Mumaugh**

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**Major Functions of the Respiratory System**

* To supply the body with oxygen and dispose of CO2
* Respiration – four distinct processes must happen
  + Pulmonary ventilation – moving air into and out of the lungs
  + External respiration – gas exchange between the lungs and the blood
  + Transport – transport of oxygen and carbon dioxide between the lungs and tissues
  + Internal respiration – gas exchange between systemic blood vessels and tissues

**Respiratory System**

* Consists of the respiratory and conducting zones
* Respiratory zone
  + Site of gas exchange
  + Consists of bronchioles, alveolar ducts, and alveoli
* Conducting zone
  + Provides rigid conduits for air to reach the sites of gas exchange
  + Includes all other respiratory structures (e.g., nose, nasal cavity, pharynx, trachea)
* Respiratory muscles – diaphragm and other muscles that promote ventilation

**Function of the Nose**

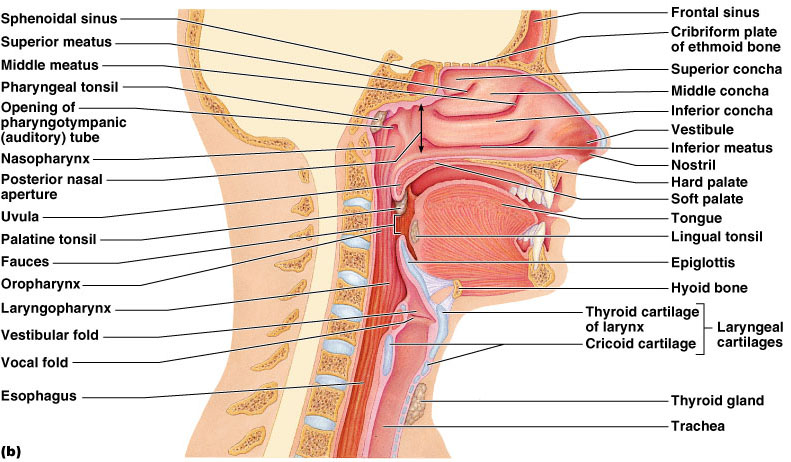
* The only externally visible part of the respiratory system that functions by:
  + Providing an airway for respiration
  + Moistening and warming the entering air
  + Filtering inspired air and cleaning it of foreign matter
  + Serving as a resonating chamber for speech
  + Housing the olfactory receptors

**Structure of the Nose**

* The nose is divided into two regions
  + The external nose
  + The internal nasal cavity

**Nasal Cavity**

* Lies in and posterior to the external nose
* Is divided by a midline nasal septum
* Vestibule – nasal cavity superior to the nares
  + Vibrissae – hairs that filter coarse particles from inspired air
* Olfactory mucosa
  + Lines the superior nasal cavity
  + Contains smell receptors
* Respiratory mucosa
  + Lines the balance of the nasal cavity
  + Glands secrete mucus containing lysozyme and defensins to help destroy bacteria



**Nasal Cavity**

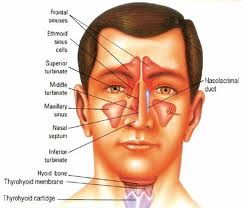
* Inspired air is:
  + Humidified by the high water content in the nasal cavity
  + Warmed by rich plexuses of capillaries
* Ciliated mucosal cells remove contaminated mucus
* Superior, medial, and inferior conchae:
  + Increase mucosal area
  + Enhance air turbulence and help filter air
  + Sensitive mucosa triggers sneezing when stimulated by irritating particles

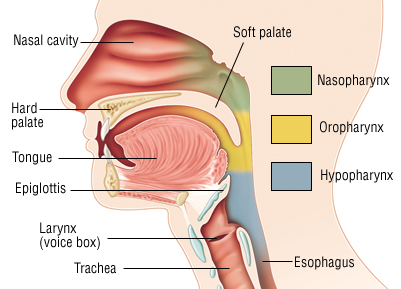
**Functions of the Nasal Mucosa and Conchae**

* During inhalation the conchae and nasal mucosa:
  + Filter, heat, and moisten air
* During exhalation these structures:
  + Reclaim heat and moisture
  + Minimize heat and moisture loss

**Paranasal Sinuses**

* Sinuses in bones that surround the nasal cavity
* Sinuses lighten the skull and help to warm and moisten the air

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**Pharynx**

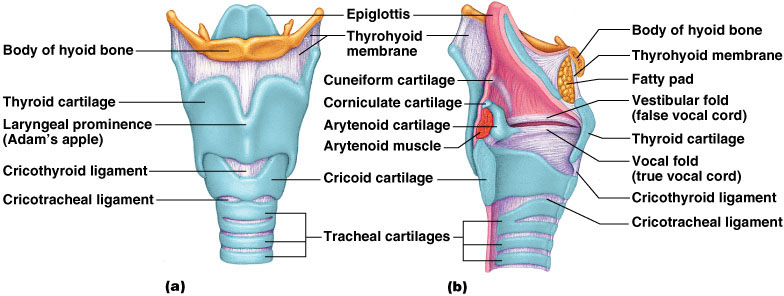
* Funnel-shaped tube of skeletal muscle that connects to the:
  + Nasal cavity and mouth superiorly
  + Larynx and esophagus inferiorly
* Extends from the base of the skull to the level of the sixth cervical vertebra

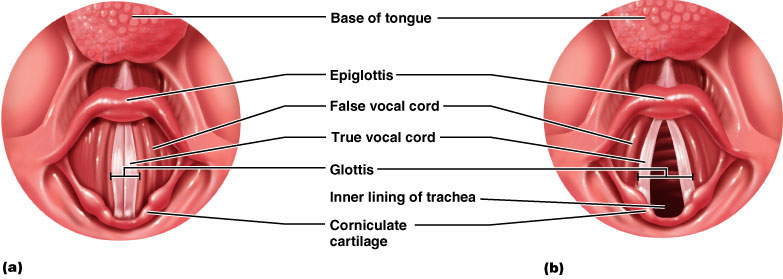
**Pharynx – Divided Into Three Regions**

* Nasopharynx
  + Strictly an air passageway
  + Closes during swallowing to prevent food from entering the nasal cavity
* Oropharynx
  + Opens to the oral cavity via an archway called the fauces
  + Serves as a common passageway for food and air
* Laryngopharynx
  + Serves as a common passageway for food and air
  + Extends to the larynx, where the respiratory and digestive pathways diverge

**Larynx (Voice Box)**

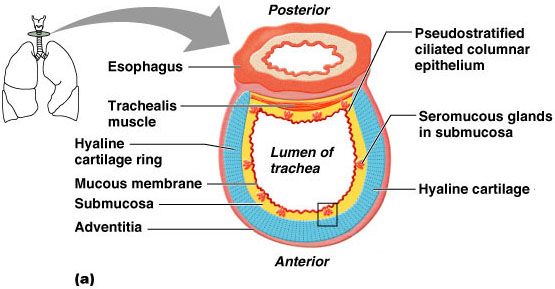
* Superiorly attaches to the hyoid bone. Inferiorly attaches to the trachea
* The three functions of the larynx are:
  + To provide a patent airway
  + To act as a switching mechanism to route air and food into the proper channels
  + To function in voice production
* Epiglottis – elastic cartilage that covers the laryngeal inlet during swallowing



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**Trachea**

* Flexible and mobile tube extending from the larynx into the mediastinum
* Composed of three layers
  + Mucosa – made up of goblet cells and ciliated epithelium
  + Submucosa – connective tissue deep to the mucosa
  + Adventitia – outermost layer made of C-shaped rings of hyaline cartilage

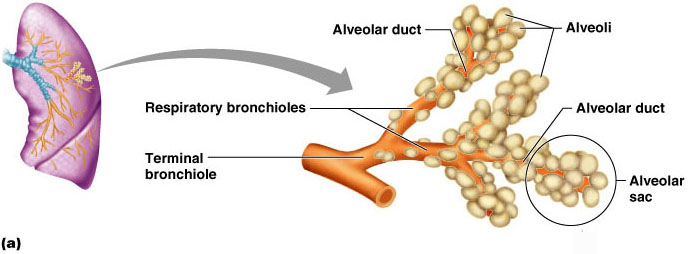
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**Conducting Zone: Bronchi**

* The carina of the last tracheal cartilage marks the end of the trachea and the beginning of the right and left bronchi
* Air reaching the bronchi is:
  + Warm and cleansed of impurities
  + Saturated with water vapor
* Bronchi subdivide into secondary bronchi, each supplying a lobe of the lungs
* Air passages undergo 23 orders of branching in the lungs

**Respiratory Zone**

* Defined by the presence of alveoli; begins as terminal bronchioles feed into respiratory bronchioles
* Respiratory bronchioles lead to alveolar ducts, then to terminal clusters of alveolar sacs composed of alveoli
* Approximately 300 million alveoli:
  + Account for most of the lungs’ volume
  + Provide tremendous surface area for gas exchange





**By Kayla Kern – OT Student**

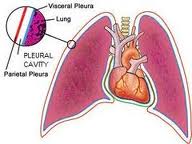
**Gross Anatomy of the Lungs**

* Lungs occupy all of the thoracic cavity except the mediastinum
  + Root – site of vascular and bronchial attachments
  + Costal surface – anterior, lateral, and posterior surfaces in contact with the ribs
  + Apex – narrow superior tip
  + Base – inferior surface that rests on the diaphragm
  + Hilus – indentation that contains pulmonary and systemic blood vessel
  + Cardiac notch (impression) – cavity that accommodates the heart
  + Left lung – separated into upper and lower lobes by the oblique fissure
  + Right lung – separated into three lobes by the oblique and horizontal fissures
  + There are 10 bronchopulmonary segments in each lung

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**Pleurae**

* Thin, double-layered serosa
* Parietal pleura
  + Covers the thoracic wall and superior face of the diaphragm
  + Continues around heart and between lungs
* Visceral, or pulmonary, pleura
  + Covers the external lung surface
  + Divides the thoracic cavity into three chambers
    - The central mediastinum
    - Two lateral compartments, each containing a lung

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**Breathing**

* Breathing, or pulmonary ventilation, consists of two phases
  + Inspiration – air flows into the lungs
  + Expiration – gases exit the lungs

**Pressure Relationships in the Thoracic Cavity**

* Respiratory pressure is always described relative to atmospheric pressure
* Atmospheric pressure
  + Pressure exerted by the air surrounding the body
* Intrapulmonary pressure – pressure within the alveoli
* Intrapleural pressure – pressure within the pleural cavity
* Two forces act to pull the lungs away from the thoracic wall, promoting lung collapse
  + Elasticity of lungs causes them to assume smallest possible size
  + Surface tension of alveolar fluid draws alveoli to their smallest possible size
* Opposing force – elasticity of the chest wall pulls the thorax outward to enlarge the lungs

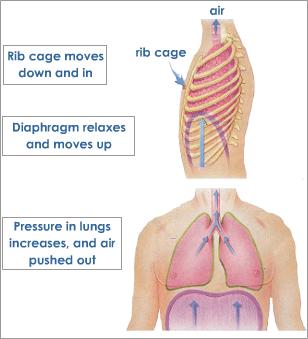
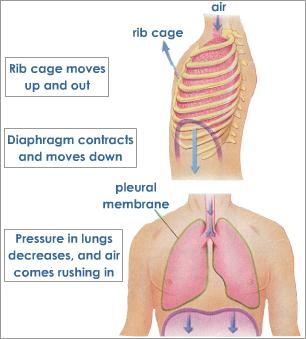
**Inspiration**

* The diaphragm and intercostal muscles (inspiratory muscles) contract and the rib cage rises
* The lungs are stretched and intrapulmonary volume increases
* Air flows into the lungs

**Expiration**

* Intercostal muscles relax and the rib cage descends due to gravity
* Thoracic cavity volume decreases
* Elastic lungs recoil passively and intrapulmonary volume decreases
* Gases flow out of the lungs

**Inspiration Expiration**



**Airway Resistance**

* As airway resistance rises, breathing movements become more strenuous
* Severely constricted or obstructed bronchioles:
  + Can prevent life-sustaining ventilation
  + Can occur during acute asthma attacks which stops ventilation
* Epinephrine release via the sympathetic nervous system dilates bronchioles and reduces air resistance

**Alveolar Surface Tension**

* Surface tension – the attraction of liquid molecules to one another at a liquid-gas interface
* The liquid coating the alveolar surface is always acting to reduce the alveoli to the smallest possible size
* Surfactant, a detergent-like complex, reduces surface tension and helps keep the alveoli from collapsing

**Lung Compliance**

* The ease with which lungs can be expanded
* Determined by two main factors
  + Distensibility of the lung tissue and surrounding thoracic cage
  + Surface tension of the alveoli

**Factors That Diminish Lung Compliance**

* Scar tissue or fibrosis that reduces the natural resilience of the lungs
* Blockage of the smaller respiratory passages with mucus or fluid
* Reduced production of surfactant
* Decreased flexibility of the thoracic cage or its decreased ability to expand
* Examples include:
  + Deformities of thorax
  + Ossification of the costal cartilage
  + Paralysis of intercostal muscles

**Respiratory Volumes**

* *Tidal volume* - Air that moves into and out of the lungs with each breath (approximately 500 ml)
* *Inspiratory reserve volume -* Air that can be inspired forcibly beyond the tidal volume (2100–3200 ml)
* *Expiratory reserve volume -* Air that can be evacuated from the lungs after a tidal expiration (1000–1200 ml)
* *Residual volume -* Air left in the lungs after strenuous expiration (1200 ml)

**Respiratory Capacities**

* *Inspiratory capacity -* Total amount of air that can be inspired after a tidal expiration
* *Functional residual capacity -* Amount of air remaining in the lungs after a tidal expiration
* *Vital capacity -* The total amount of exchangeable air
* *Total lung capacity -* Sum of all lung volumes

**Surface Area and Thickness of the Respiratory Membrane**

* Respiratory membranes:
  + Thicken if lungs become waterlogged and edematous, whereby gas exchange is inadequate and oxygen deprivation results
  + Decrease in surface area with emphysema, when walls of adjacent alveoli break through

**Oxygen Transport**

* Molecular oxygen is carried in the blood:
* Bound to hemoglobin (Hb) within red blood cells
* Dissolved in plasma

**Hypoxia – Low Oxygen to the Tissues**

* Anemic hypoxia
  + Poor oxygen delivery from too few RBCs
* Ischemic or stagnant hypoxia
  + Occurs when blood circulation is impaired or blocked
* Histotoxic hypoxia
  + Occurs when body cells are unable to use oxygen

**Hypoxia – Low Oxygen to the Tissues - continued**

* Hypoxemic hypoxia
  + Seen in reduced oxygen pressure

**Carbon Dioxide Transport**

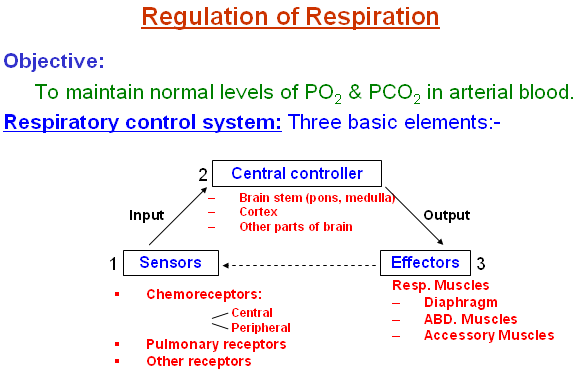
* CO2 is transported in the blood in three forms
  + Dissolved in plasma – 7 to 10%
  + Chemically bound to hemoglobin – 20% is carried in RBCs
  + Bicarbonate ion in plasma – 70% is transported as bicarbonate

**Control of Respiration: Medullary Respiratory Centers**

* The dorsal respiratory group or inspiratory center
  + Appears to be the pacesetting respiratory center
  + Excites the inspiratory muscles and sets breath rates (12-15 breaths/minute)
  + Becomes dormant during expiration
* The ventral respiratory group is involved in forced inspiration and expiration

**Depth and Rate of Breathing: Higher Brain Centers**

* Hypothalamic controls act through the limbic system to modify rate and depth of respiration
  + Example: breath holding that occurs in anger
* A rise in body temperature acts to increase respiratory rate
* Cortical controls are direct signals from the cerebral motor cortex that bypass medullary controls
  + Examples: voluntary breath holding, taking a deep breath

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**Hyperventilation**

* Increase in the rate and depth of breathing that exceeds the bodies need to remove CO2
* Occurs when low CO2 levels in the blood cause cerebral blood vessels to constrict which produces cerebral ischemia

**Hypoventilation**

* Hypoventilation – slow and shallow breathing due to abnormally low PCO2 levels
  + Apnea (breathing cessation) may occur until PCO2 levels rise



**Respiratory Adjustments: Exercise**

* Respiratory adjustments are geared to both the intensity and duration of exercise
* During vigorous exercise:
  + Ventilation can increase 20 fold
  + Breathing becomes deeper and more vigorous, but respiratory rate may not be significantly changed (hyperpnea)
* As exercise begins
  + Ventilation increases abruptly, rises slowly, and reaches a steady state
* When exercise stops
  + Ventilation declines suddenly, then gradually decreases to normal
* Neural factors bring about the above changes, including:
  + Psychic stimuli
  + Cortical motor activation
  + Excitatory impulses from proprioceptors in muscles

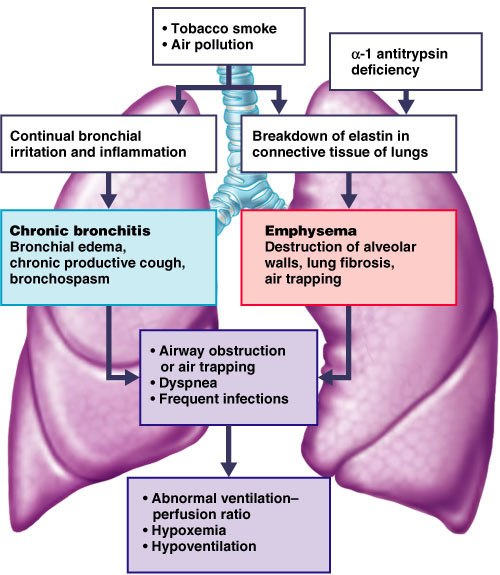
[](http://www.google.com/imgres?hl=en&rlz=1I7GGLD_en&biw=1366&bih=589&tbm=isch&tbnid=hzvNqT_SodvVmM:&imgrefurl=http://www.funnypictures24.com/pictures/funny-exercise-pictures/&docid=RFme65jPFidVWM&imgurl=http://www.funnypictures24.com/fp/funny_excercise_pictures/funny_excercise_picture_1.jpg&w=550&h=412&ei=hlRaT9OdGJGTtwe30a2FDA&zoom=1)[](http://www.google.com/imgres?hl=en&rlz=1I7GGLD_en&biw=1366&bih=589&tbm=isch&tbnid=1QKBgdqRHraRpM:&imgrefurl=http://www.michellemasonfitness.com/2011/10/05/blast-from-the-past-workouts/&docid=tfI8MhyVTVnZDM&imgurl=http://www.michellemasonfitness.com/wp-content/uploads/2011/10/richard-simmons.jpg&w=190&h=250&ei=glVaT76vBYPWtgftkPztCw&zoom=1)

**Respiratory Adjustments: High Altitude**

* The body responds to quick movement to high altitude (above 8000 ft) with symptoms of acute mountain sickness – headache, shortness of breath, nausea, and dizziness
* Acclimatization – respiratory and hematopoietic adjustments to altitude

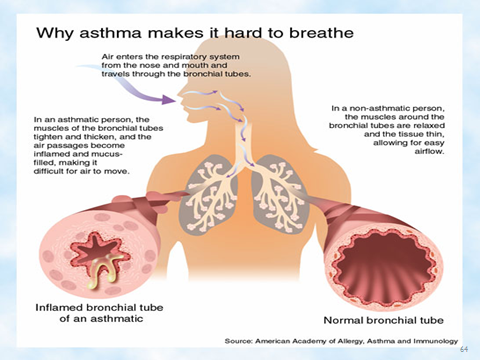
**Chronic Obstructive Pulmonary Disease (COPD)**

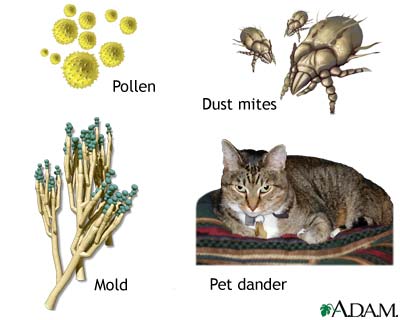
* Exemplified by chronic bronchitis and obstructive emphysema
* Patients have a history of:
  + Smoking
  + Dyspnea, where labored breathing occurs and gets progressively worse
  + Coughing and frequent pulmonary infections
* COPD victims develop respiratory failure accompanied by hypoxemia, carbon dioxide retention, and respiratory acidosis

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**Asthma**

* Characterized by dyspnea, wheezing, and chest tightness
* Active inflammation of the airways precedes bronchospasms
* Airway inflammation is an immune response caused by release of IL-4 and IL-5, which stimulate IgE and recruit inflammatory cells
* Airways thickened with inflammatory exudates magnify the effect of bronchospasms
* Asthma is a process that affects the airways with excessive mucus production, bronchial muscle contraction, and swelling causing obstruction.
* During an asthma attack, spasms in the muscles and bronchi constrict, impeding the outward passage of stale air. Sufferers can get starved for air with coughing, wheezing and chest tightness.
* Recently, asthma has been found to be a chronic inflammatory process with the prior symptoms.
* Most of the research has been aimed at determining what might trigger asthma responses and what to avoid.
* Incidence
  + In the last decade the incidence of asthma has increased by 1/3
  + 20 million people in the US
  + 6 million children and 14 million adults
  + Children under 16 and adults over 65 are more prone

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**Lung Cancer**

* Accounts for 1/3 of all cancer deaths in the U.S.
* 90% of all patients with lung cancer were smokers
* The three most common types are:
  + Squamous cell carcinoma (20-40% of cases) arises in bronchial epithelium
  + Adenocarcinoma (25-35% of cases) originates in peripheral lung area
  + Small cell carcinoma (20-25% of cases) contains lymphocyte-like cells that originate in the primary bronchi and subsequently metastasize

[](http://www.google.com/imgres?hl=en&sa=X&rlz=1I7GGLD_en&biw=1366&bih=589&tbm=isch&tbnid=PgHltpezOih3LM:&imgrefurl=http://lmg.letmeget.net/blog/healthy-lungs-vs-smokers-lungs-photos-quitting-smoking-tips&docid=RkKkFRpDSGGxdM&imgurl=http://2.bp.blogspot.com/_EvZPNndO0AU/S8gu2t3FH5I/AAAAAAAAAOk/5zGZqimmp8Q/s1600/11257767.JPG&w=1000&h=479&ei=D1daT-PIMIKtgweE_emhCw&zoom=1)

**Lifespan Changes**

* By the 28th week, a baby born prematurely can breathe on its own
* During fetal life, the lungs are filled with fluid and blood bypasses the lungs
* Gas exchange takes place via the placenta
* At birth, respiratory centers are activated, alveoli inflate, and lungs begin to function
* Respiratory rate is highest in newborns and slows until adulthood
* Lungs continue to mature and more alveoli are formed until young adulthood
* Respiratory efficiency decreases in old age
* Lifespan changes reflect an accumulation of environmental influences and the effects of aging in other organ systems, and may include:
  + The cilia become less active
  + Mucous thickening
  + Swallowing, gagging, and coughing reflexes slowing
  + Macrophages in the lungs lose efficiency
  + An increased susceptibility to respiratory infections
  + A “barrel chest” may develop
  + Bronchial walls thin and collapse
  + Dead space increasing