

Chapter 13

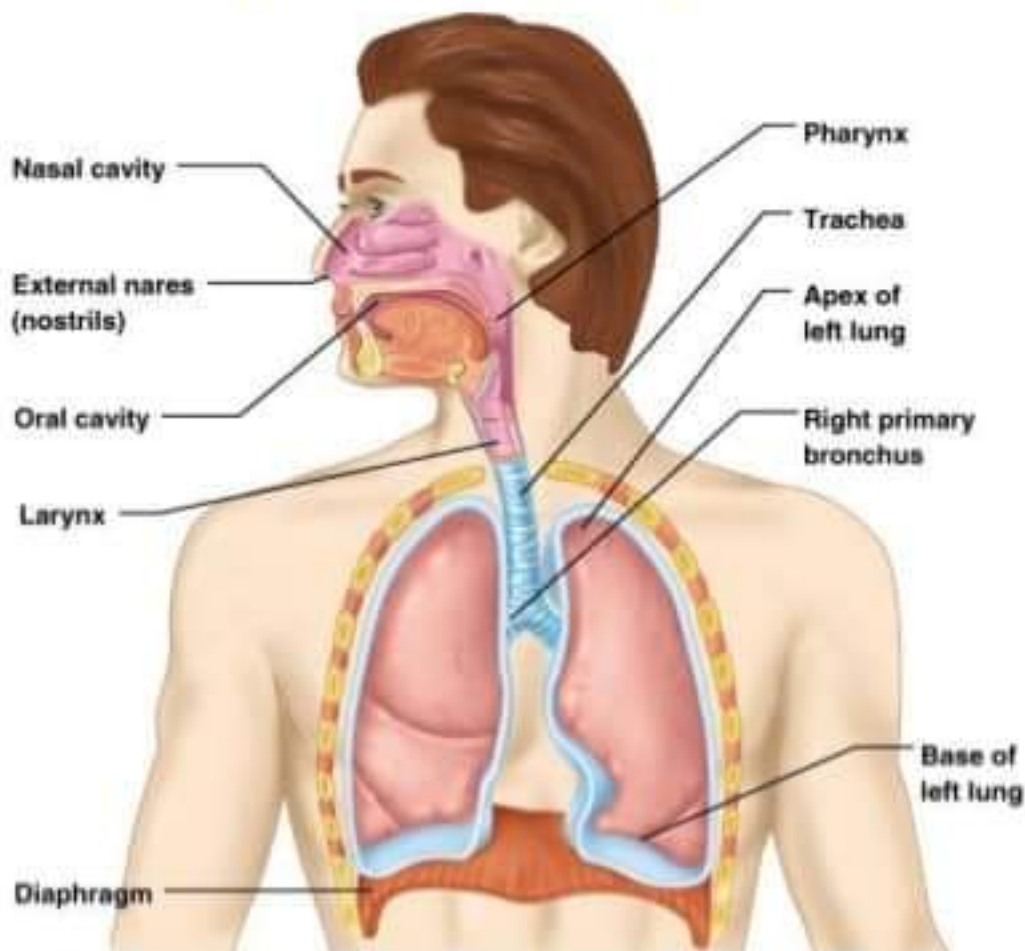
The Respiratory System

Function of the Respiratory System

- Oversees gas exchanges (oxygen and carbon dioxide) between the blood and external environment
- Exchange of gasses takes place within the lungs in the alveoli(only site of gas exchange, other structures passageways
- Passageways to the lungs purify, warm, and humidify the incoming air
- Shares responsibility with cardiovascular system

Organs of the Respiratory system

- Nose
- Pharynx
- Larynx
- Trachea
- Bronchi
- Lungs – alveoli



Upper Respiratory Tract

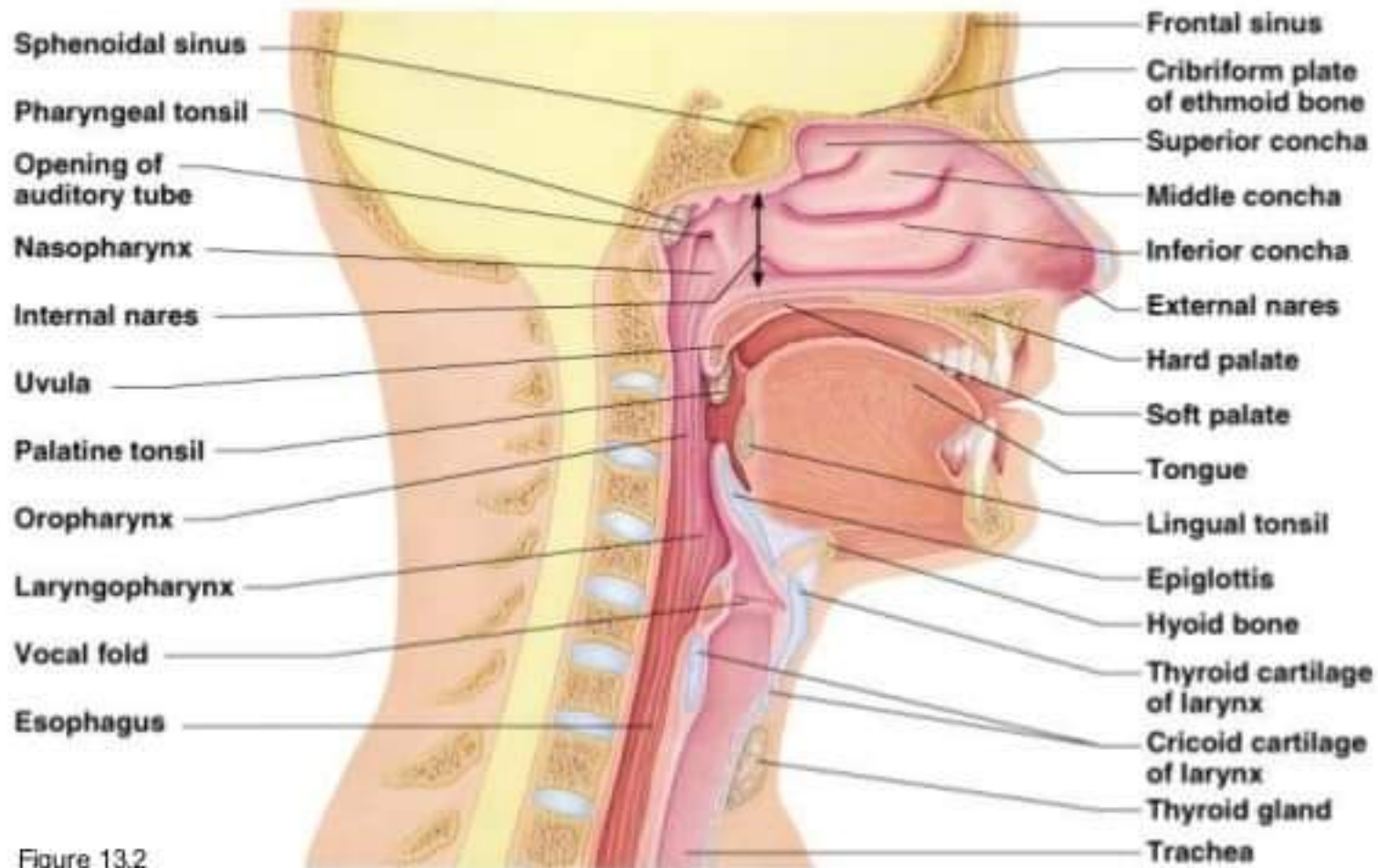


Figure 13.2

Anatomy of the Nasal Cavity

- Olfactory receptors are located in the mucosa on the superior surface
- The rest of the cavity is lined with respiratory mucosa
 - Moistens air
 - Traps incoming foreign particles

Anatomy of the Nasal Cavity

- Lateral walls have projections called conchae
 - Increases surface area
 - Increases air turbulence within the nasal cavity
- The nasal cavity is separated from the oral cavity by the palate
 - Anterior hard palate (bone)
 - Posterior soft palate (muscle)

Paranasal Sinuses

- Cavities within bones surrounding the nasal cavity
 - Frontal bone
 - Sphenoid bone
 - Ethmoid bone
 - Maxillary bone

Paranasal Sinuses

- Function of the sinuses
 - Lighten the skull
 - Act as resonance chambers for speech
 - Produce mucus that drains into the nasal cavity

Pharynx (Throat)

- Muscular passage from nasal cavity to larynx
- Three regions of the pharynx
 - Nasopharynx – superior region behind nasal cavity
 - Oropharynx – middle region behind mouth
 - Laryngopharynx – inferior region attached to larynx
- The oropharynx and laryngopharynx are common passageways for air and food

Upper Respiratory Tract

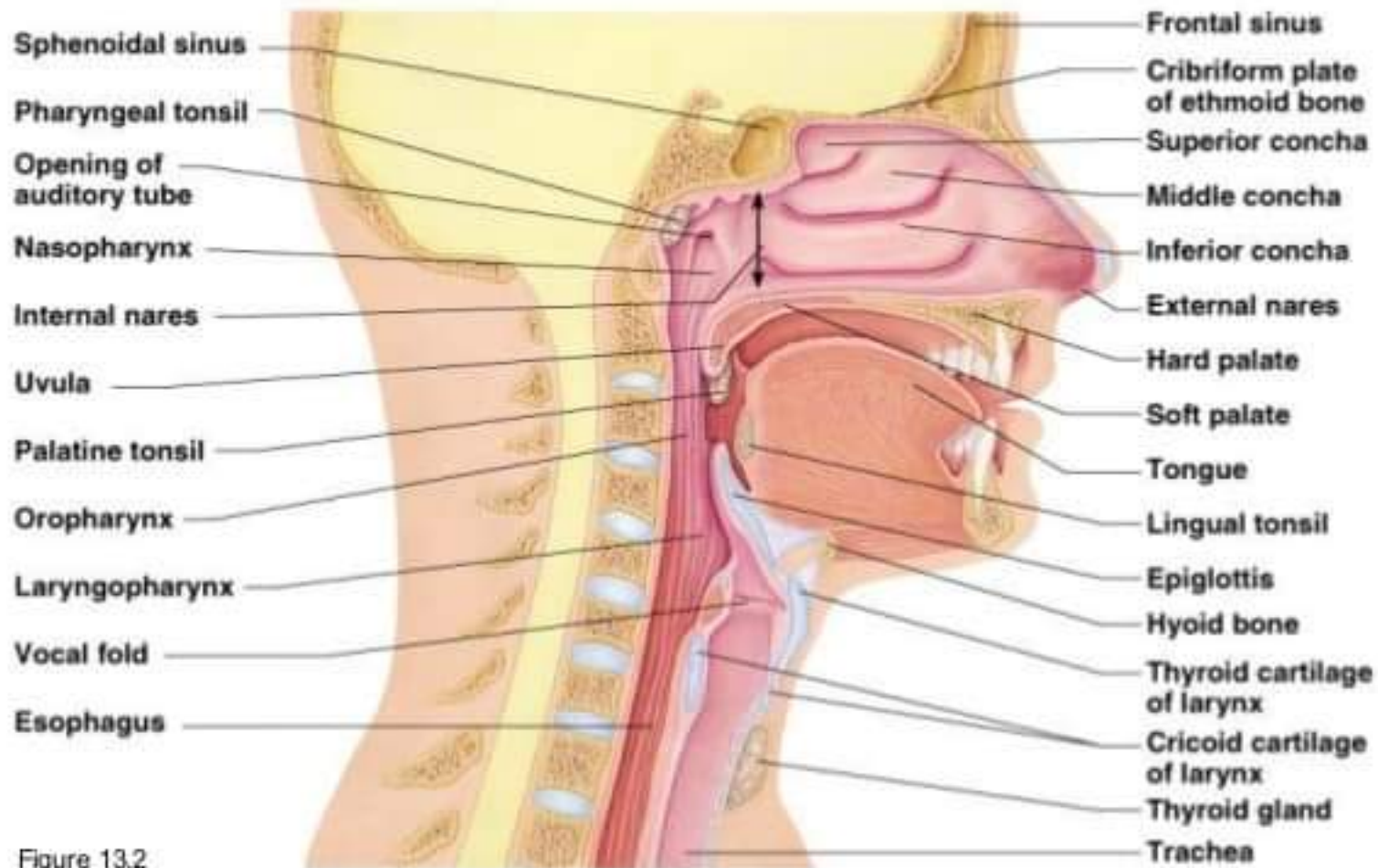


Figure 13.2

Structures of the Pharynx

- Auditory tubes enter the nasopharynx
- Tonsils of the pharynx
 - Pharyngeal tonsil (adenoids) in the nasopharynx
 - Palatine tonsils in the oropharynx
 - Lingual tonsils at the base of the tongue

Larynx (Voice Box)

- Routes air and food into proper channels
- Plays a role in speech
- Made of eight rigid hyaline cartilages and a spoon-shaped flap of elastic cartilage (epiglottis)

Structures of the Larynx

- Vocal cords (vocal folds)
 - Vibrate with expelled air to create sound (speech)
- Glottis – opening between vocal cords

Trachea (Windpipe)

- Connects larynx with bronchi
- Lined with ciliated mucosa
 - Beat continuously in the opposite direction of incoming air
 - Expel mucus loaded with dust and other debris away from lungs
- Walls are reinforced with C-shaped hyaline cartilage

Primary Bronchi

- Formed by division of the trachea
- Enters the lung at the hilus (medial depression)
- Right bronchus is wider, shorter, and straighter than left
- Bronchi subdivide into smaller and smaller branches

Lungs

- Occupy most of the thoracic cavity
 - Apex is near the clavicle (superior portion)
 - Base rests on the diaphragm (inferior portion)
 - Each lung is divided into lobes by fissures
 - Left lung – two lobes
 - Right lung – three lobes

Lungs

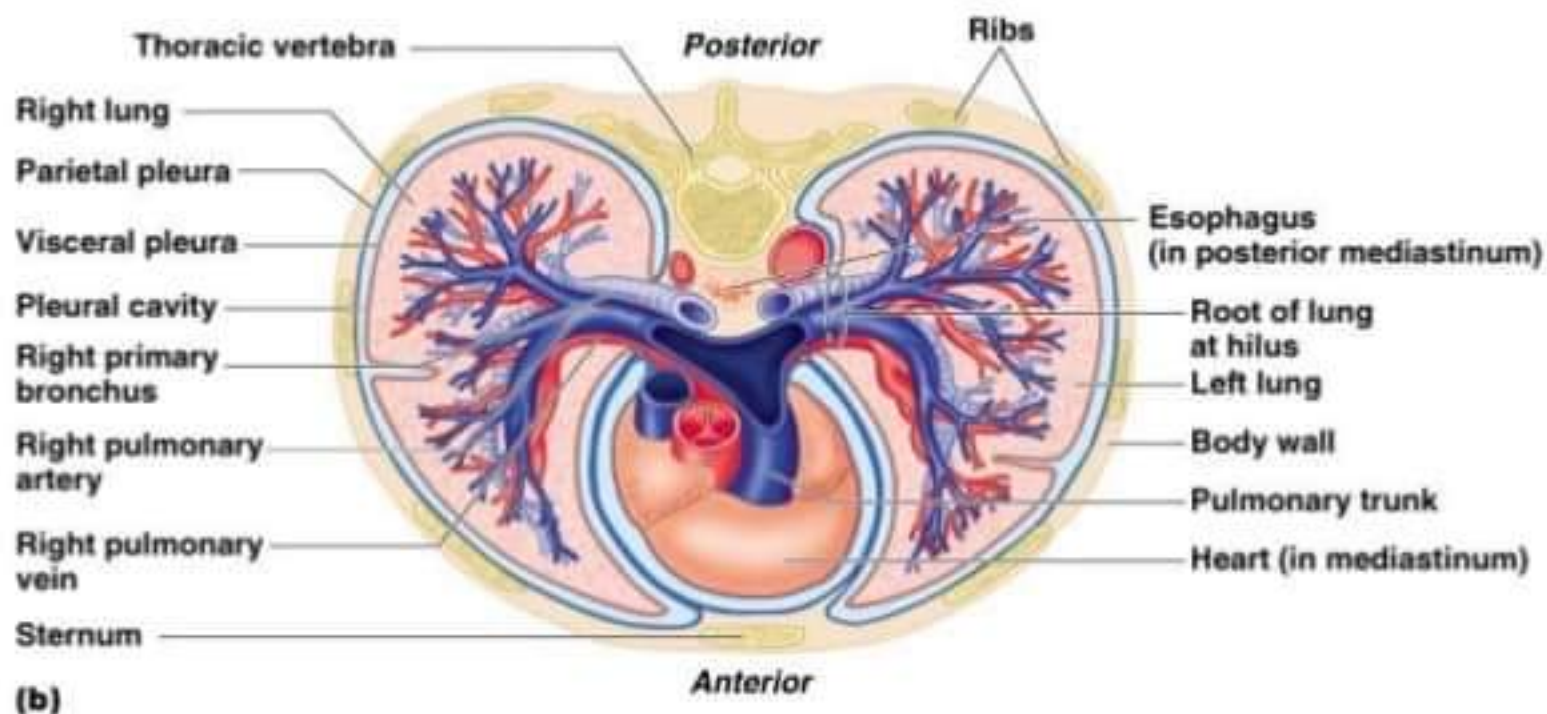


Figure 13.4b

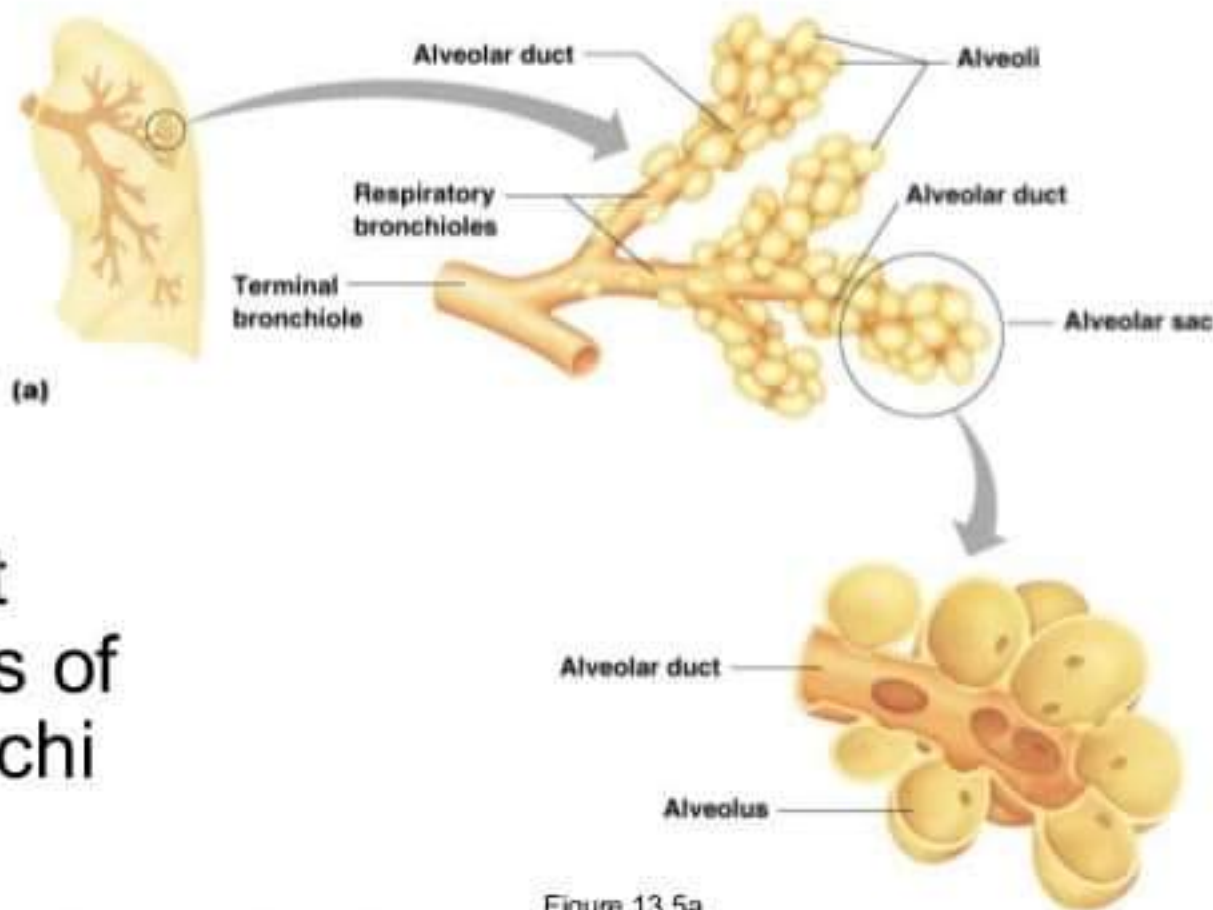
Coverings of the Lungs

- Pulmonary (visceral) pleura covers the lung surface
- Parietal pleura lines the walls of the thoracic cavity
- Pleural fluid fills the area between layers of pleura to allow gliding

Respiratory Tree Divisions

- Primary bronchi
- Secondary bronchi
- Tertiary bronchi
- Bronchioli
- Terminal bronchioli

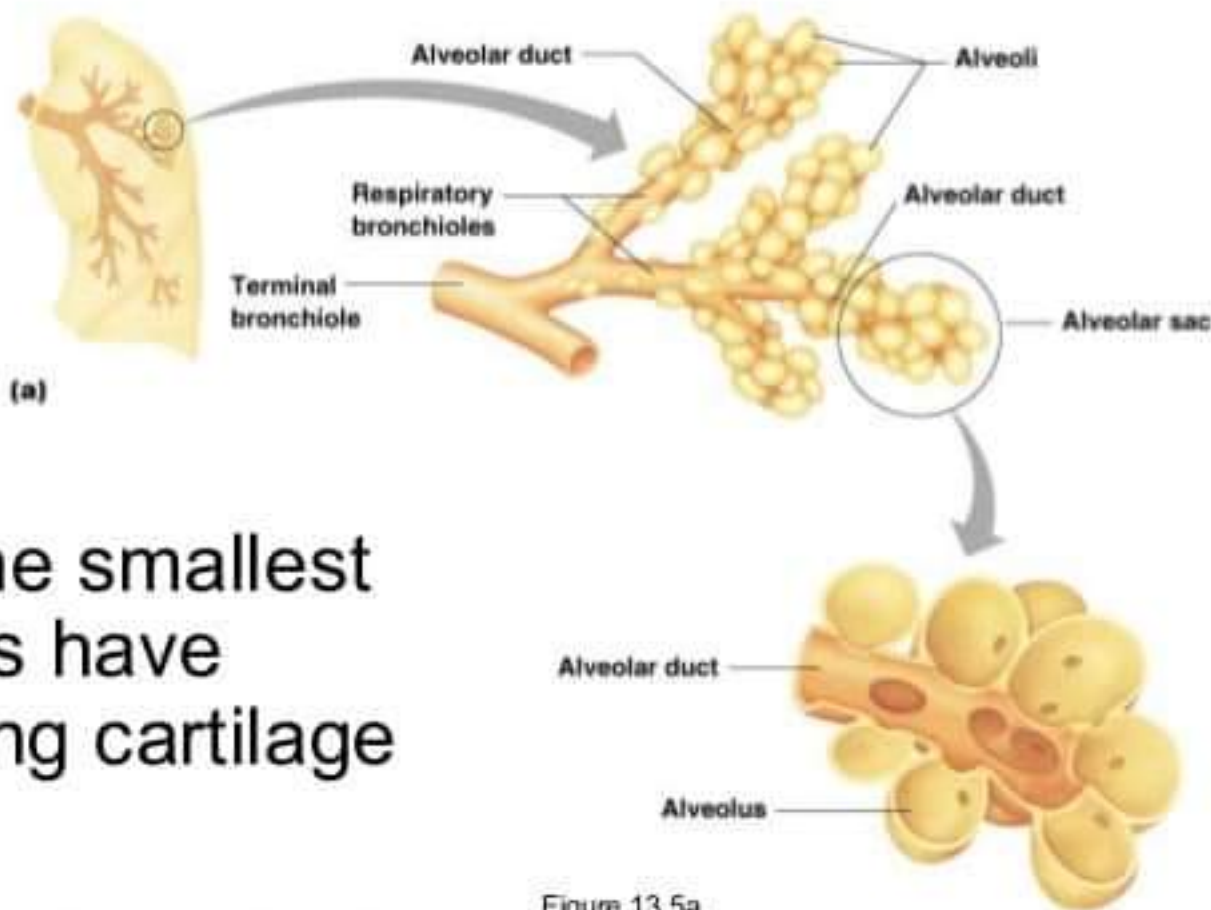
Bronchioles



- Smallest branches of the bronchi

Figure 13.5a

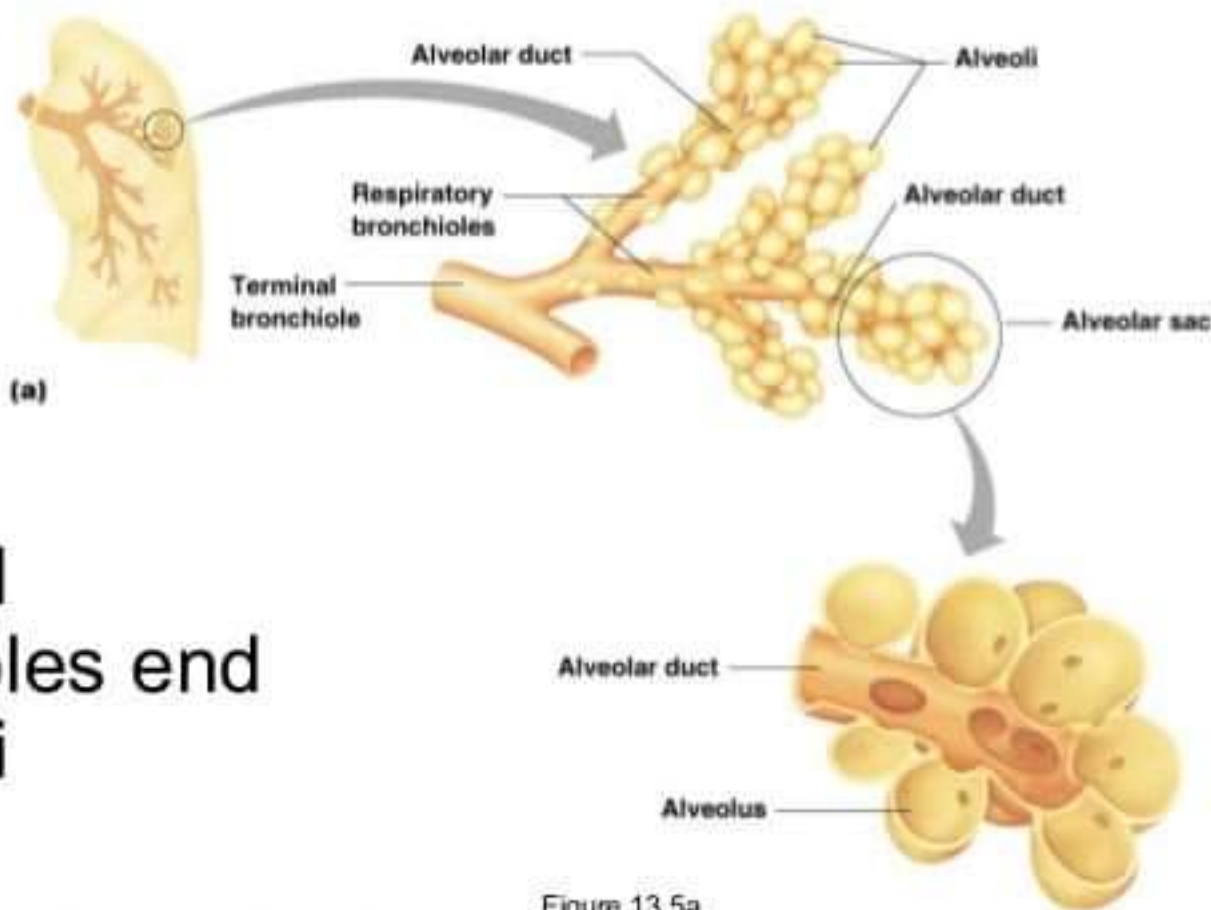
Bronchioles



- All but the smallest branches have reinforcing cartilage

Figure 13.5a

Bronchioles



- Terminal bronchioles end in alveoli

Figure 13.5a

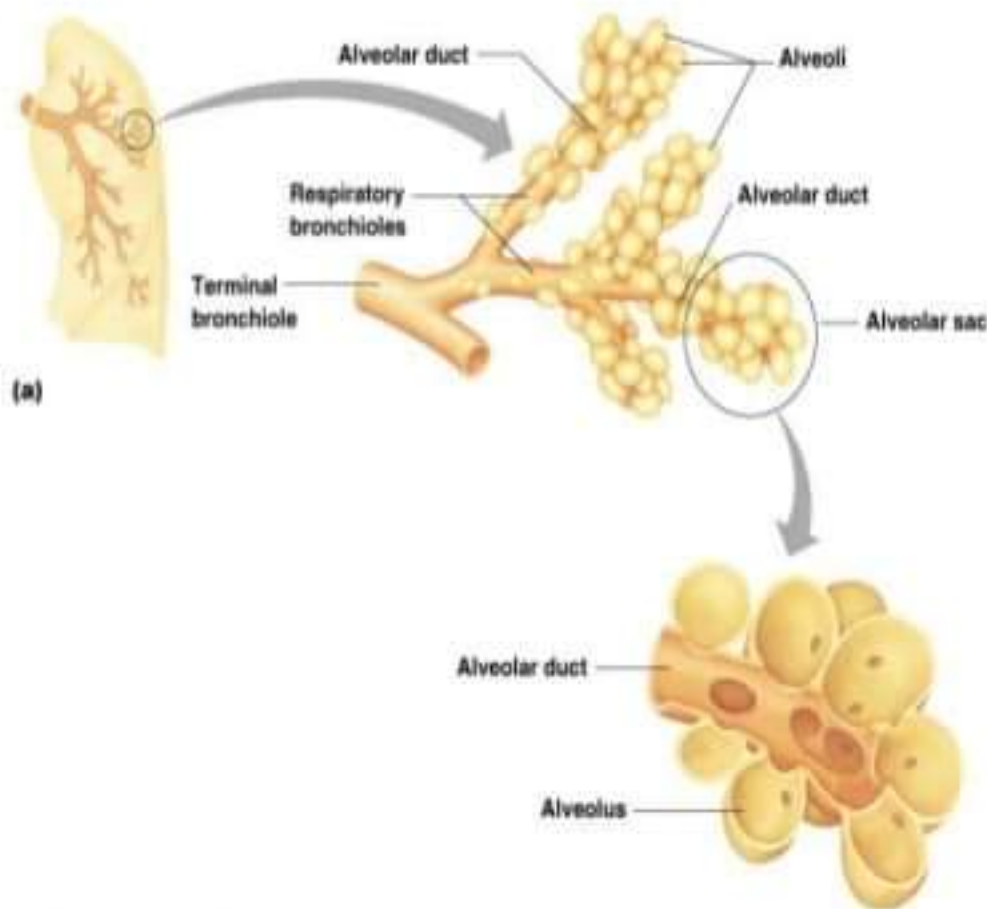
Respiratory Zone

- Structures
 - Respiratory bronchioli
 - Alveolar duct
 - Alveoli
- Site of gas exchange

Alveoli

Structure of alveoli

- Alveolar duct
- Alveolar sac
- Alveolus
- Gas exchange



Respiratory Membrane (Air-Blood Barrier)

- Thin squamous epithelial layer lining alveolar walls
- Pulmonary capillaries cover external surfaces of alveoli

Respiratory Membrane (Air-Blood Barrier)

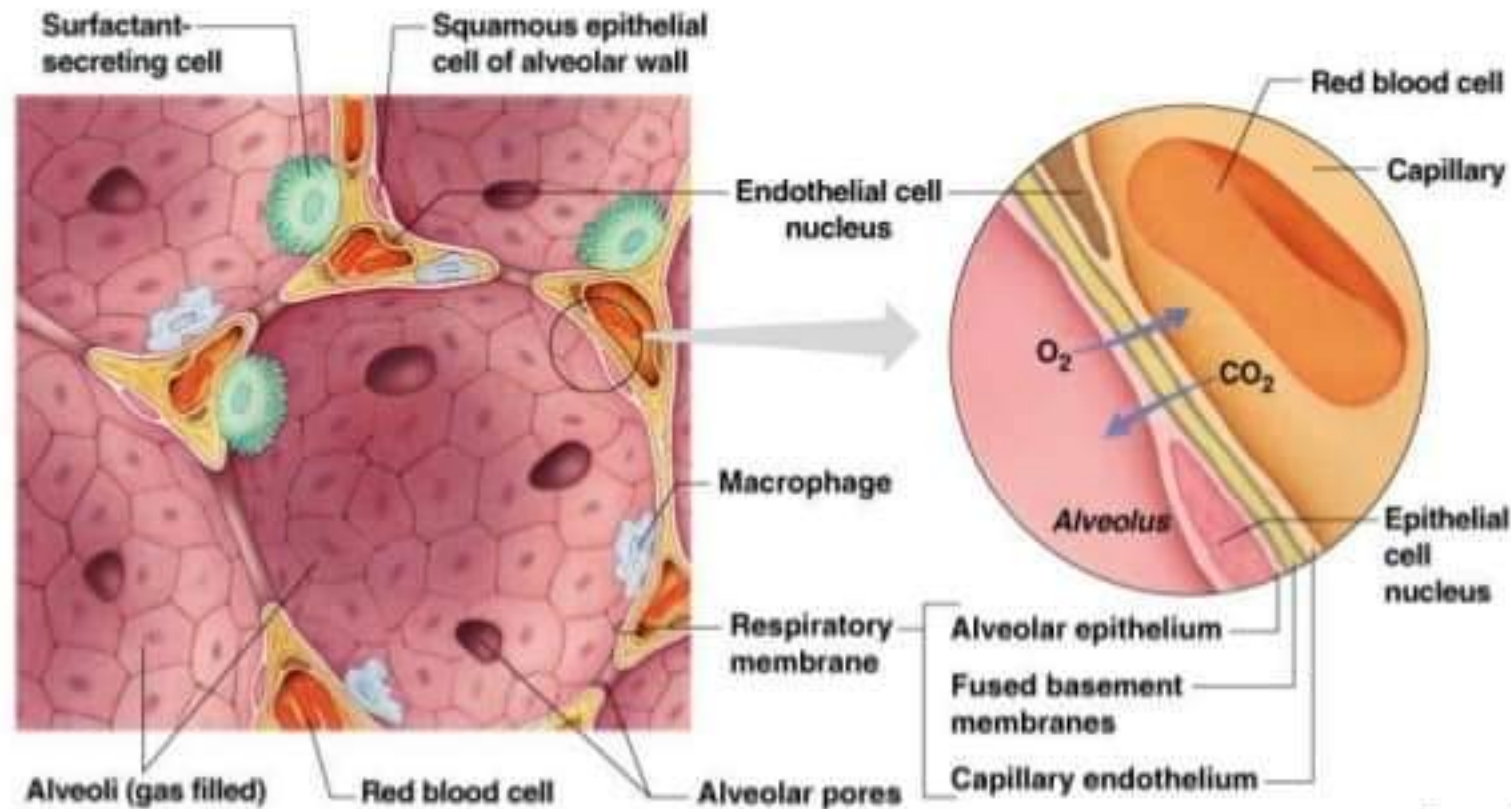


Figure 13.6

Gas Exchange

- Gas crosses the respiratory membrane by diffusion
 - Oxygen enters the blood
 - Carbon dioxide enters the alveoli
- Macrophages add protection
- Surfactant coats gas-exposed alveolar surfaces

Events of Respiration

- Pulmonary ventilation – moving air in and out of the lungs
- External respiration – gas exchange between pulmonary blood and alveoli

Events of Respiration

- Respiratory gas transport – transport of oxygen and carbon dioxide via the bloodstream
- Internal respiration – gas exchange between blood and tissue cells in systemic capillaries

Mechanics of Breathing (Pulmonary Ventilation)

- Completely mechanical process
- Depends on volume changes in the thoracic cavity
- Volume changes lead to pressure changes, which lead to the flow of gases to equalize pressure

Mechanics of Breathing (Pulmonary Ventilation)

- Two phases
 - Inspiration – flow of air into lung
 - Expiration – air leaving lung

Inspiration

- Diaphragm and intercostal muscles contract
- The size of the thoracic cavity increases
- External air is pulled into the lungs due to an increase in intrapulmonary volume

Inspiration

Changes in anterior-posterior and superior-inferior dimensions



Changes in lateral dimensions

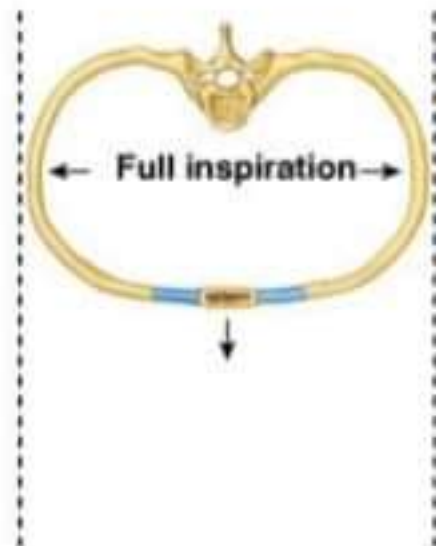


Figure 13.7a

Exhalation

- Largely a passive process which depends on natural lung elasticity
- As muscles relax, air is pushed out of the lungs
- Forced expiration can occur mostly by contracting internal intercostal muscles to depress the rib cage

Exhalation



Figure 13.7b



Nonrespiratory Air Movements

- Can be caused by reflexes or voluntary actions
- Examples
 - Cough and sneeze – clears lungs of debris
 - Laughing
 - Crying
 - Yawn
 - Hiccup

Respiratory Volumes and Capacities

- Normal breathing moves about 500 ml of air with each breath (tidal volume [TV])
- Many factors that affect respiratory capacity
 - A person's size
 - Sex
 - Age
 - Physical condition
- Residual volume of air – after exhalation, about 1200 ml of air remains in the lungs

Respiratory Volumes and Capacities

- Inspiratory reserve volume (IRV)
 - Amount of air that can be taken in forcibly over the tidal volume
 - Usually between 2100 and 3200 ml
- Expiratory reserve volume (ERV)
 - Amount of air that can be forcibly exhaled
 - Approximately 1200 ml

Respiratory Volumes and Capacities

- Residual volume
 - Air remaining in lung after expiration
 - About 1200 ml

Respiratory Volumes and Capacities

- Vital capacity
 - The total amount of exchangeable air
 - $\text{Vital capacity} = \text{TV} + \text{IRV} + \text{ERV}$
- Dead space volume
 - Air that remains in conducting zone and never reaches alveoli
 - About 150 ml

Respiratory Volumes and Capacities

- Functional volume
 - Air that actually reaches the respiratory zone
 - Usually about 350 ml
- Respiratory capacities are measured with a spirometer

Respiratory Capacities

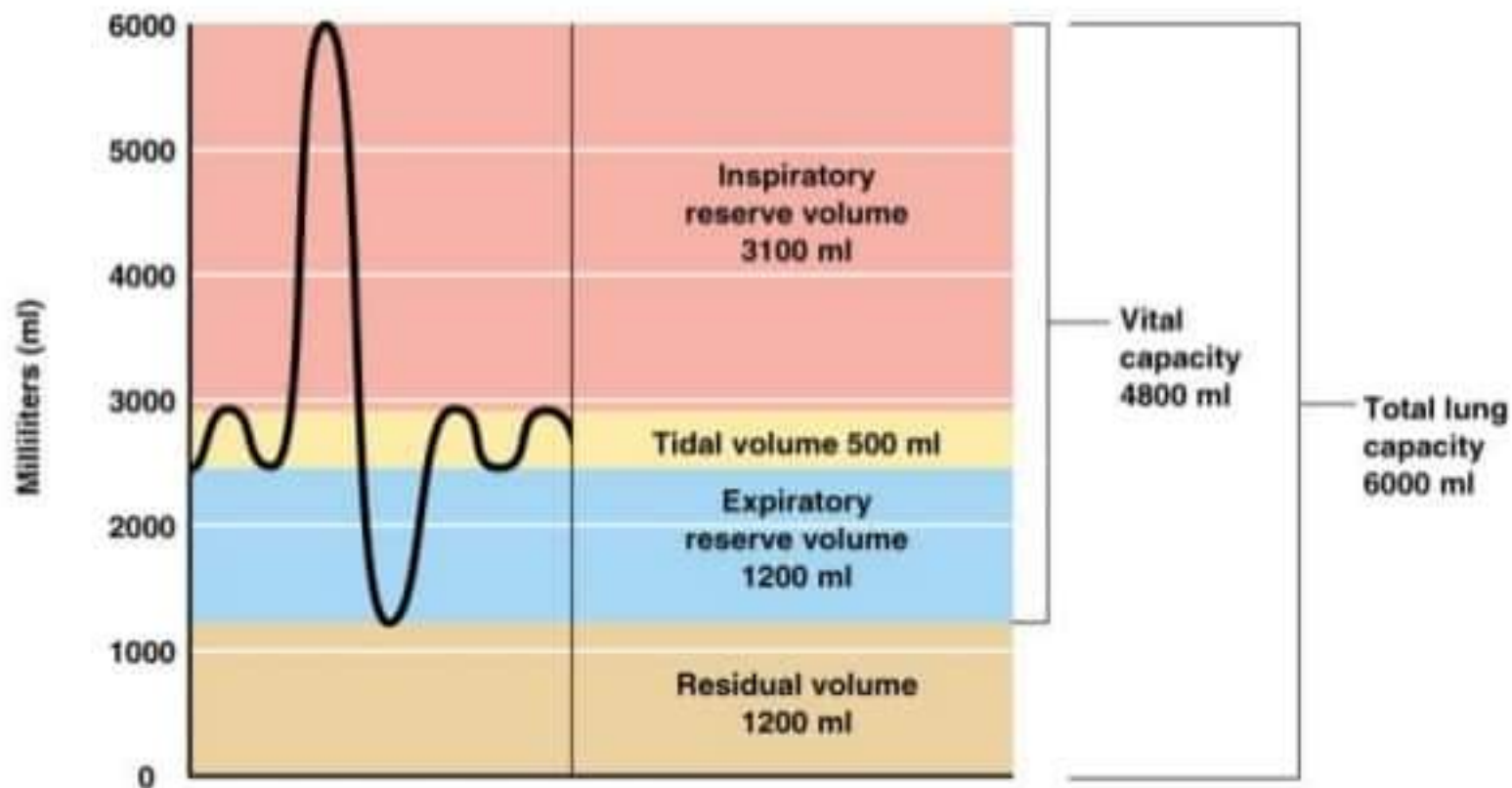


Figure 13.9

Respiratory Sounds

- Sounds are monitored with a stethoscope
- Bronchial sounds – produced by air rushing through trachea and bronchi
- Vesicular breathing sounds – soft sounds of air filling alveoli

External Respiration

- Oxygen movement into the blood
 - The alveoli always has more oxygen than the blood
 - Oxygen moves by diffusion towards the area of lower concentration
 - Pulmonary capillary blood gains oxygen

External Respiration

- Carbon dioxide movement out of the blood
 - Blood returning from tissues has higher concentrations of carbon dioxide than air in the alveoli
 - Pulmonary capillary blood gives up carbon dioxide
- Blood leaving the lungs is oxygen-rich and carbon dioxide-poor

Gas Transport in the Blood

- Oxygen transport in the blood
 - Inside red blood cells attached to hemoglobin (oxyhemoglobin [HbO_2])
 - A small amount is carried dissolved in the plasma

Gas Transport in the Blood

- Carbon dioxide transport in the blood
 - Most is transported in the plasma as bicarbonate ion (HCO_3^-)
 - A small amount is carried inside red blood cells on hemoglobin, but at different binding sites than those of oxygen

Internal Respiration

- Exchange of gases between blood and body cells
- An opposite reaction to what occurs in the lungs
 - Carbon dioxide diffuses out of tissue to blood
 - Oxygen diffuses from blood into tissue

External Respiration, Gas Transport, and Internal Respiration Summary

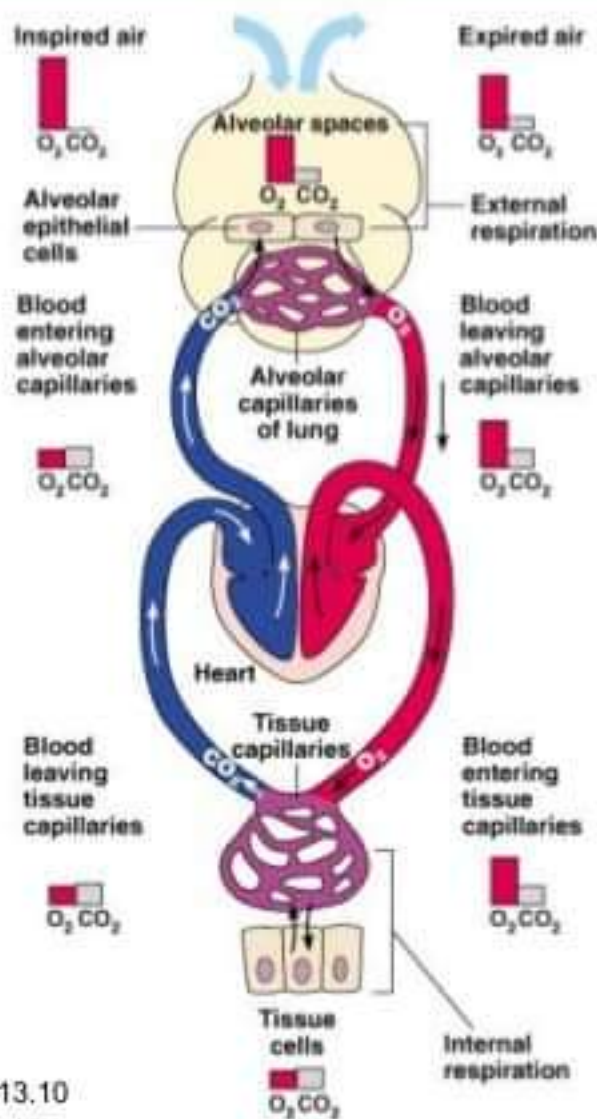


Figure 13.10

Neural Regulation of Respiration

- Activity of respiratory muscles is transmitted to the brain by the phrenic and intercostal nerves
- Neural centers that control rate and depth are located in the medulla
- The pons appears to smooth out respiratory rate
- Normal respiratory rate (eupnea) is 12–15 respirations per minute
- Hyperpnea is increased respiratory rate often due to extra oxygen needs

Neural Regulation of Respiration

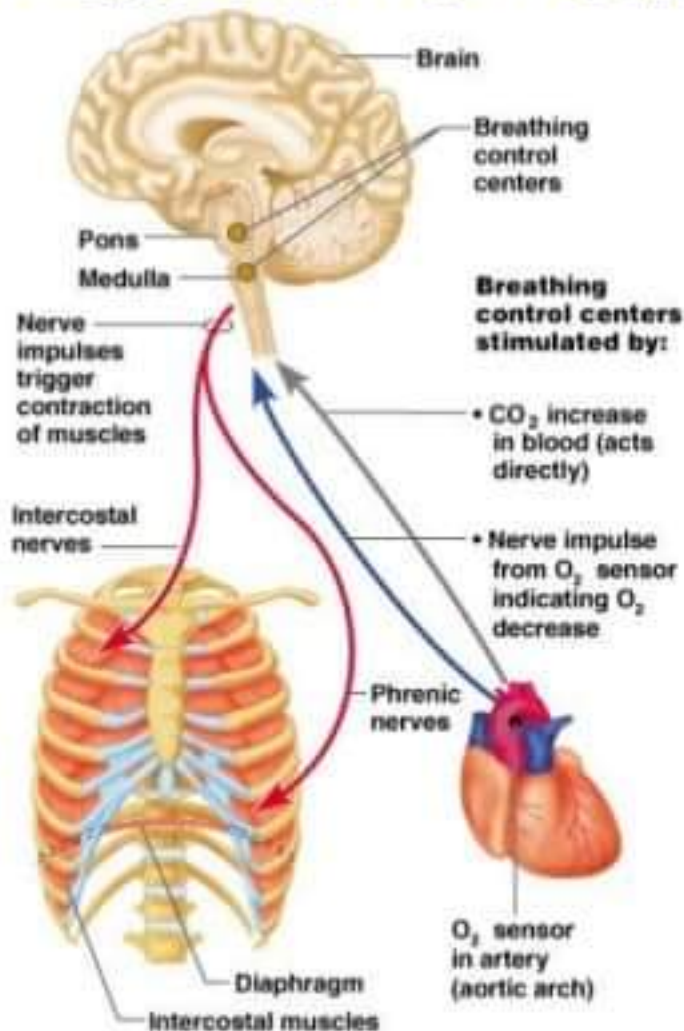


Figure 13.12

Factors Influencing Respiratory Rate and Depth

- Physical factors
 - Increased body temperature
 - Exercise
 - Talking
 - Coughing
- Volition (conscious control)
- Emotional factors

Factors Influencing Respiratory Rate and Depth

- Chemical factors
 - Carbon dioxide levels
 - Level of carbon dioxide in the blood is the main regulatory chemical for respiration
 - Increased carbon dioxide increases respiration
 - Changes in carbon dioxide act directly on the medulla oblongata

Factors Influencing Respiratory Rate and Depth

- Chemical factors (continued)
 - Oxygen levels
 - Changes in oxygen concentration in the blood are detected by chemoreceptors in the aorta and carotid artery
 - Information is sent to the medulla oblongata

Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)

- Exemplified by chronic bronchitis and emphysema
- Major causes of death and disability in the United States

Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)

- Features of these diseases
 - Patients almost always have a history of smoking
 - Labored breathing (dyspnea) becomes progressively more severe
 - Coughing and frequent pulmonary infections are common

Respiratory Disorders: Chronic Obstructive Pulmonary Disease (COPD)

- Features of these diseases (continued)
 - Most victims retain carbon dioxide, are hypoxic and have respiratory acidosis
 - Those infected will ultimately develop respiratory failure

Emphysema

- Alveoli enlarge as adjacent chambers break through
- Chronic inflammation promotes lung fibrosis
- Airways collapse during expiration
- Patients use a large amount of energy to exhale
- Overinflation of the lungs leads to a permanently expanded barrel chest
- Cyanosis appears late in the disease

Chronic Bronchitis

- Mucosa of the lower respiratory passages becomes severely inflamed
- Mucus production increases
- Pooled mucus impairs ventilation and gas exchange
- Risk of lung infection increases
- Pneumonia is common
- Hypoxia and cyanosis occur early

Chronic Obstructive Pulmonary Disease (COPD)

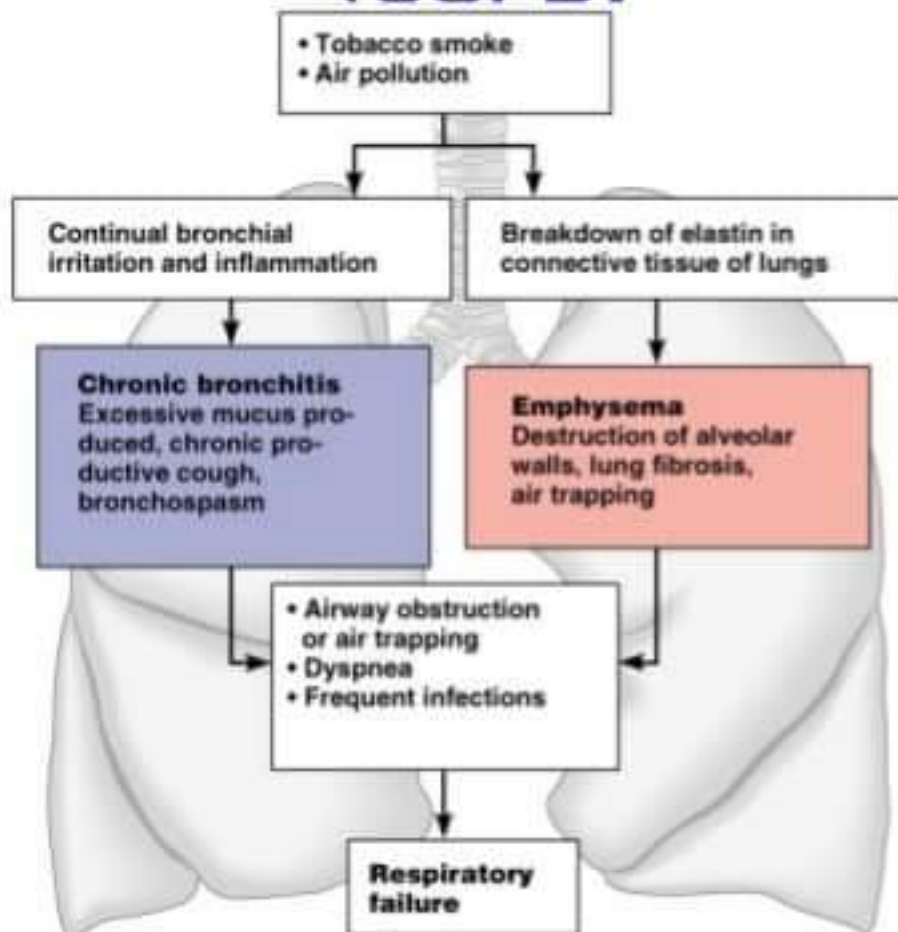


Figure 13.13

Lung Cancer

- Accounts for 1/3 of all cancer deaths in the United States
- Increased incidence associated with smoking
- Three common types
 - Squamous cell carcinoma
 - Adenocarcinoma
 - Small cell carcinoma

Sudden Infant Death syndrome (SIDS)

- Apparently healthy infant stops breathing and dies during sleep
- Some cases are thought to be a problem of the neural respiratory control center
- One third of cases appear to be due to heart rhythm abnormalities

Asthma

- Chronic inflamed hypersensitive bronchiole passages
- Response to irritants with dyspnea, coughing, and wheezing

Developmental Aspects of the Respiratory System

- Lungs are filled with fluid in the fetus
- Lungs are not fully inflated with air until two weeks after birth
- Surfactant that lowers alveolar surface tension is not present until late in fetal development and may not be present in premature babies

Developmental Aspects of the Respiratory System

- Important birth defects
 - Cystic fibrosis – oversecretion of thick mucus clogs the respiratory system
 - Cleft palate

Aging Effects

- Elasticity of lungs decreases
- Vital capacity decreases
- Blood oxygen levels decrease
- Stimulating effects of carbon dioxide decreases
- More risks of respiratory tract infection

Respiratory Rate Changes Throughout Life

- Newborns – 40 to 80 respirations per minute
- Infants – 30 respirations per minute
- Age 5 – 25 respirations per minute
- Adults – 12 to 18 respirations per minute
- Rate often increases somewhat with old age