Respiratory System

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Functions of Respiratory System

- Provides surface area for gas exchange
- Forms series of passages that conduct air to area where gas exchange will occur
- Protection of respiratory system from dehydration, temperature change, and pathogens
- Production of sound
- Olfaction

Animation

- Animation on respiration
- http://www.youtube.com/watch?v=WXOBJEXxNEo

What is respiration and ventilation?

- Ventilation- refers to movement of air; in and out of lungs
  - Page 327 of the textbook is wrong!
- Respiration refers to the actual exchange of gases

Respiration in three places

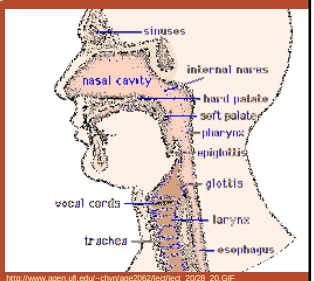
- External respiration
  - Exchange of gases between atmosphere and blood tissue
  - Occurs in alveoli of lung tissue
- Internal respiration
  - Exchange of gases between blood and cells of the body
- Cellular respiration
  - Utilization of oxygen to create ATP through oxidative phosphorylation

Organization of respiratory system

- Two methods of organization in use
  - Organized according to location of structures
  - Organized according to function of structures

Organization of respiratory system

- Structural location
- Upper system-
  - From nose to upper trachea
- Lower system
  - From upper trachea to alveloi



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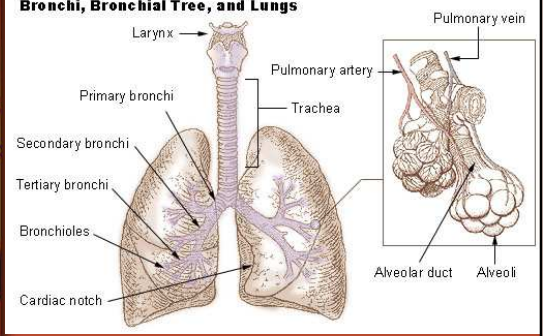
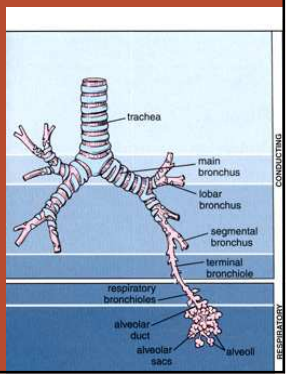
Lower Respiratory System



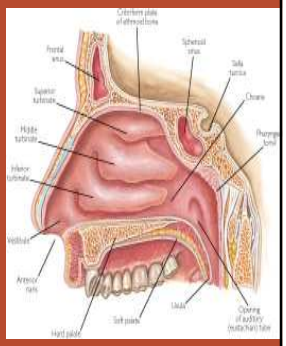
Functional Classification

- Conducting
  - Everything not involved in gas exchange
- Gas exchange
  - Respiratory bronchioles and alveoli



Nasal Cavity

- Nares
  - External opening
- Septum
  - Divides the cavity
- Conchae/ turbinates
  - Create channels for air to move through
  - Causes the air to swirl
  - Increase surface area and increases contact between air and mucosa



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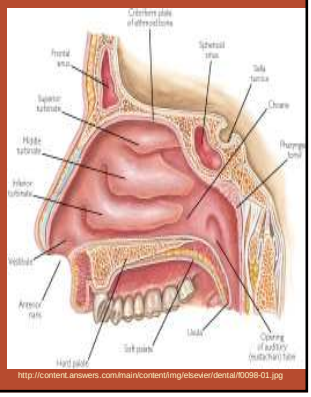
Functions of Nasal Cavity

- Filters air
  - hair in the passages trap particles
- Warms air
- Moisturizes air
- Olfaction



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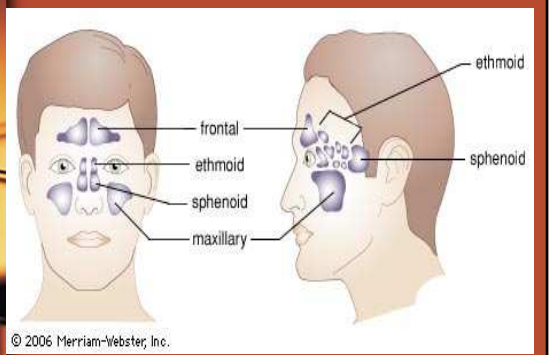
Paranasal Sinuses



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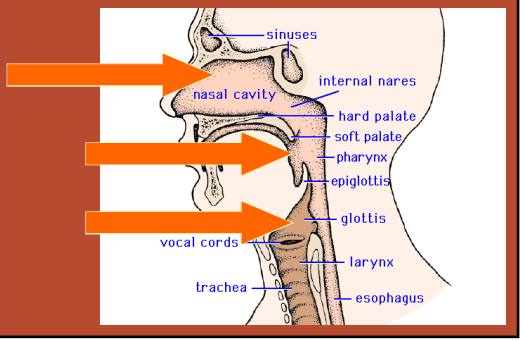
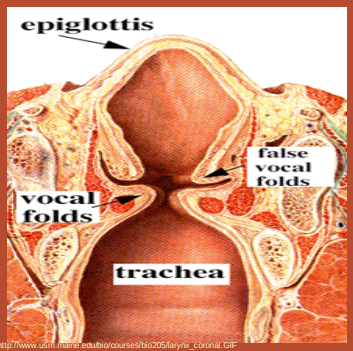
Paranasal Sinuses

- Lighten the skull
- Assist the nasal cavity to warm and moisten air
- Contain cells that create mucus, which drains into nasal cavity

Pharynx



Larynx

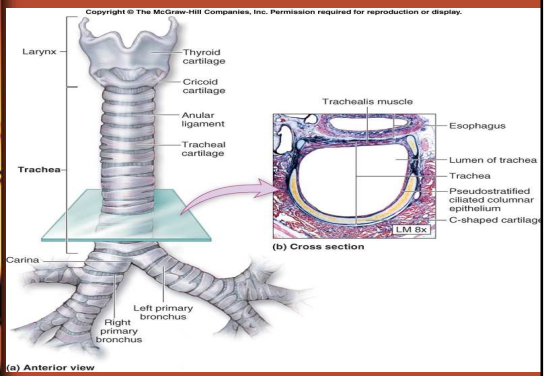


http://www.usm.maine.edu/bio/courses/bio205/larynx_coronal.GIF

Larynx

- Maintains patent airway
- Epiglottis protects trachea from food particles by routing food into esophagus
- Produces sound

Trachea and Bronchi



http://academic.kellogg.cc.mi.us/herbrandsonc/bio201_McKinley/f25-7a-b_trachea_anteri_c.jpg

Trachea

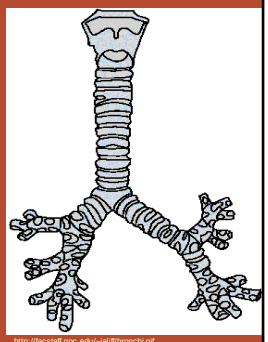
- Extends from larynx into mediastinum
- Carina- ridge that marks bifurcation of primary bronchi
- C-shaped hyaline cartilage keep passage patent
- Posterior of trachea is made of trachealis muscle

Bronchi

- Similar in structure to trachea
- Right bronchus is wider, shorter, and more vertical than left
  - Right main stem intubation more common than left
- Primary bronchi enter lung at hilum

Secondary Bronchi

- One bronchi per lobe of lung
- Three right
- Two left



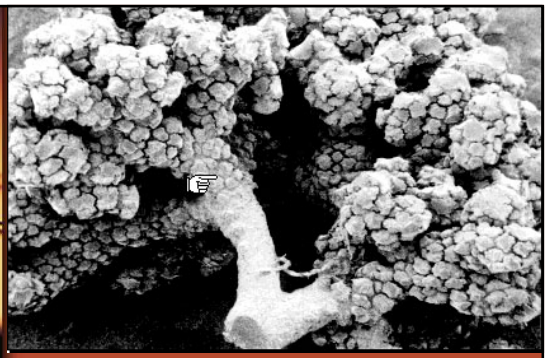
http://facstaff.gpc.edu/~jall/fbronchi.gif

Bronchioles

- Respiratory passages less than 1 mm in diameter
- Branch several times into terminal bronchioles which extend into gas exchange bronchioles
- Alveoli can extend from respiratory bronchioles
- Branch into alveolar ducts

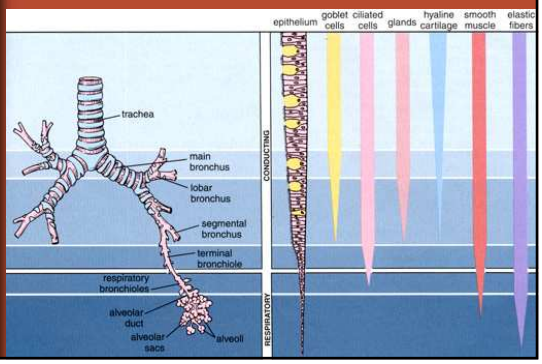
Tertiary Bronchi

- Tertiary bronchi supply bronchopulmonary segments
  - Right lung has 10 segments
  - Left lung has 8-9 segments
- Tertiary bronchus branch several times and eventually form bronchioles



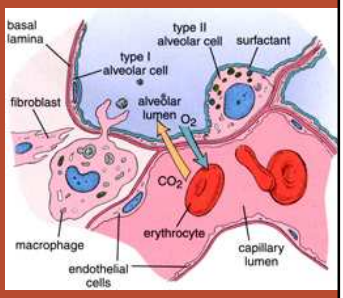
http://trc.ucdavis.edu/mjguinan/apc100/modules/respiratory/lung/images/lung62.jpg

Histology of airway



Alveoli

- Each lung contains 150 million
- Type I pneumocytes = epithelium
- Type II- create surfactant
- Macrophage- Phagocytize debris



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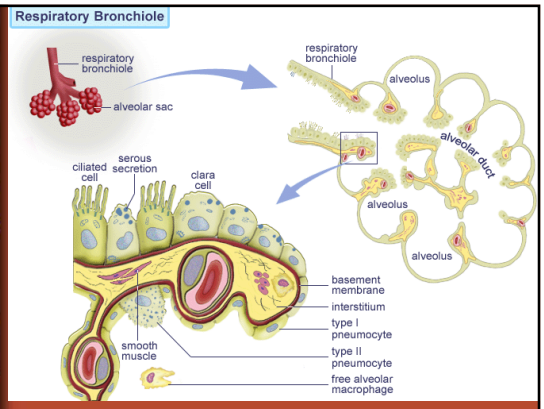
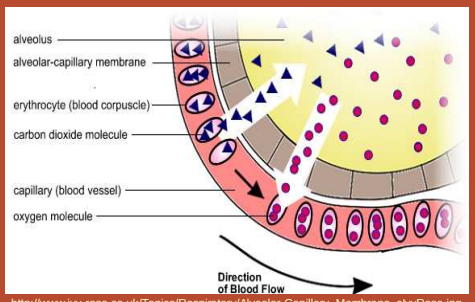


http://www.mmi.mcgill.ca/mmimediasampler2002/images/mckee-26no2.gif

Respiratory Membrane



http://www.ivy-rose.co.uk/Topics/Respiratory/Alveolar-Capillary_Membrane_clvyRose.jpg

Lungs

- Covered by pleurae
  - Thin double layered serous membrane
  - Secretes pleural fluid to lubricate lungs inside chest cavity
  - Visceral covers lung
  - Parietal covers the inside of chest cavity
  - Pleural cavity
    - Potential space between two pleural layers

Blood Supply

- Bronchial arteries- supply blood to lung tissue
  - Enter at hilum
- Pulmonary arteries- Carry blood to lung tissues
  - Enter at hilum and branch profusely and feed into pulmonary capillary network.
- Pulmonary Veins- Drain capillaries and carry back to heart

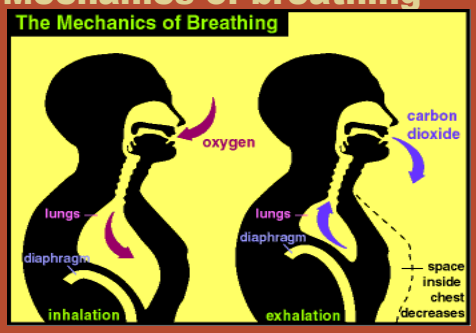
Mechanics of breathing

- Two phases
  - Inspiration = inhalation of atmospheric air
  - Expiration = exhalation of atomospheric air
- Occur because of volume changes in thoracic cavity
  - Boyles Law => P1 x V1 = P2 x V2

Pressure Relationships

- Atmospheric = 760 mmHg
- Intrapulmonary = Variable during phase of breathing
- Intrapleural = Variable during phase
  - Caused by adherence of pleura to each other and suction from lymphatic
  - 4 mm Hg less than intrapulmonary

Mechanics of breathing



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Mechanics of Inspiration

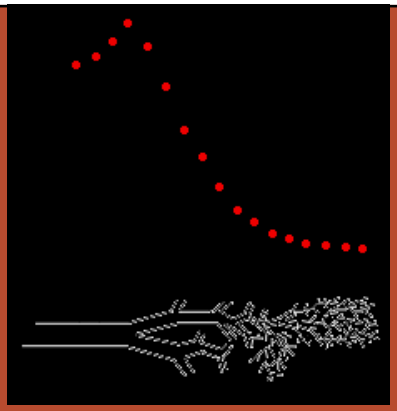
- Diaphragm contracts and increases height of chest cavity
- Intercostal muscles contract and increase AP diameter
- Causes a drop in intrapulmonary pressure to 1-2 mm Hg less than atmospheric pressure
- Air rushes in! and inspiration ends when intrapulmonary pressure equals atmospheric pressure

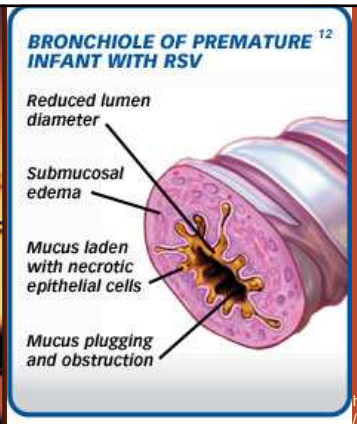
Mechanics of Expiration

- Diaphragm relaxes and is passive process
- Depends upon natural elasticity of lungs
- Intrapulmonary pressure increases to 1-2 mmHg above atmospheric pressure
- If tissue loses elasticity, air trapping occurs
- Forced expiration uses abdomen to increase intrathoracic pressure

Factors influencing ventilation

- Airway resistance- Airway diameter affects resistance
  - Think of breathing through straw
  - Occurs because of friction between air and walls of airways
- Larger airways = little resistance
- Smaller airways = increased resistance
- Greatest resistance in healthy humans is in the trachea!!!!!
  - Think summative effect!





- **Small inflamed airways become point of highest resistance!!**

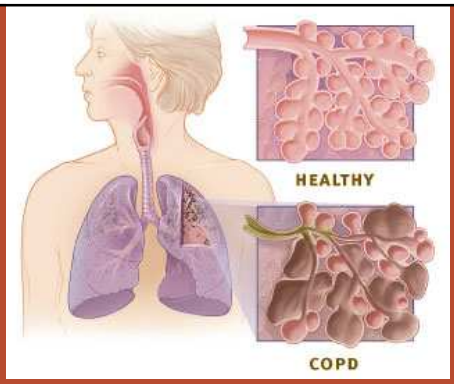
http://www.synagis.com/hcp/images/g.jpg

Compliance

- Refers to how much effort needed to stretch lungs
- High compliance = expands easily
- Low compliance = resists expansion
- Related
  - to lung and chest wall elasticity
  - Surface tension

Lung Elasticity

- Depends upon elastic fibers in alveoli and smaller airways
- COPD loses alveolar wall and loses elasticity
- Increased compliance occurs because of COPD
- Decreased compliance occurs because of pneumonia, fibrosis, kyphosis, or decreased surfactant



http://www.nhlbi.nih.gov/health/public/lung/copd/images/diagram/healthy-vs-copd.jpg

Lung Volumes

- Adult lungs can hold 5 liters of air
- Tidal Volume- Volume of normal breath
  - 70% reaches alveoli
  - 30% used to fill airways (anatomical dead space)
  - Physiological dead space = anatomical + air in alveoli not used for gas exchange

Inspiratory Reserve Volume

- Amount that can be inhaled above normal tidal volume
- Average 3100 ml

Expiratory Reserve Volume

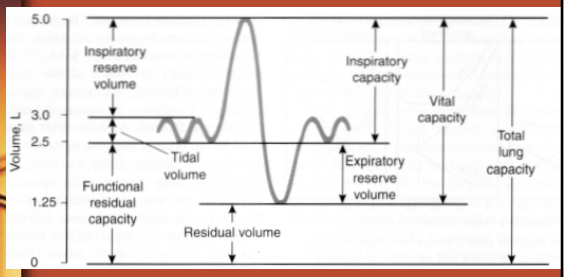
- Amount that can be exhaled above normal tidal volume
- Average 1200 ml

Residual Volume

- Amount left in lungs after expiratory reserve volume is expelled

Calculated Capacities

- Inspiratory Capacity= Sum of tidal volume and inspiratory reserve volume
- Vital capacity = Tidal volume + IRV +ERV



Gas pressures

- Atmospheric pressure = 760 mmHg
- Components of air
  - Nitrogen = 78.6% 597.4 mmHg
  - Oxygen = 20.9% 158.8 mmHg
  - Carbon Dioxide= 0.04% 0.3 mm Hg
  - Other gases = rest
- Each gas in mixture exerts individual pressure
- Gas diffuses from area of higher pressure to lower pressure

Gas Exchange

- Depends upon pressure gradient
- Solubility – how easy a given gas dissolves in fluid

Oxygen Exchange

Location	Partial Pressure
Atmosphere	158 mmHg
Alveoli	104 mmHg
Pulmonary Cap	40 mmHg

Carbon Dioxide Exchange

Location	Partial Pressure
Atmosphere	0.3 mmHg
Alveoli	40 mmHg
Pulmonary Cap	45 or higher mmHg

Oxygen Exchange

Location	Partial Pressure
Arterial Side of Capillary	100 mmHg
Tissue	40 mmHg

Carbon Dioxide Exchange

Location	Partial Pressure
Venous Side of Capillary	40 mmHg
Tissue	45 mmHg

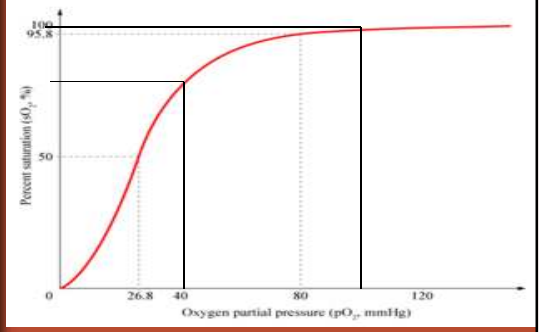
Oxygen Transport

- Oxygen has low solubility
- Requires carrier molecule
  - What is that molecule?
- 99% of oxygen binds to hemoglobin
- At PO2 of 40, Hgb = 75% saturation
- During peak oxygen needs, PO2 of tissues are very low!
  - Causes PO2 of capillaries to decrease

Oxygen Dissociation

- Lower pressure of oxygen across membrane
- Acidity- Acid production
- Carbon dioxide binding to Hgb
- Temperature increase
- BPG- chemical produced during RBC glycoloysis

Oxygen Dissociation Curve



Oxygen Reserve

- Even in tissues with low oxygen concentration, hemoglobin saturation is still 75%
- Reserve can be mobilized if needed!

Importance of curve

- Between 60 mm Hg and above, Hgb is 90% saturated
- Important for ability to travel to higher altitudes
- Allowed man to become hunters and gatherers
- Evolutionarily significant!

Carbon Dioxide Transport

- Three ways to transport CO2
  - Dissolved in plasma
    - 7%
  - Carbaminohemoglobin
    - 23%
  - Bicarbonate ions
    - 70%

Regulation of Respiration

- Respiratory center in medulla oblongata innervates muscles of respiration
- Divided into three functional areas
  - Medullary rhythmic center- controls basic rhythm of respiration
  - Pneumotaxic center- coordinates transition between two phases
    - Prevents over inflation of lungs
  - Apneustic center – Causes prolonged inspiration

Regulation of Respiration

- Cortical influences- Allows for voluntary control
- Chemical regulation senses levels of oxygen and carbon dioxide
  - Can be central or peripherally located

Carbon Dioxide Drive

- Chemoreceptors in medulla sense the Hydrogen ion concentration of CSF
- If H ions increase, stimulus is sent to respiratory center
- Major control of respiration in nearly all indivduals

Hypoxic Drive

- Peripheral chemoreceptors in aorta and carotid arteries
- Detect changes in arterial oxygen partial pressure
- If PO2 decreases, sends signal to respiratory center
- Back up mechanism for CO2 retainers!
- Only 3% of COPD patients rely on mechanism!
- If patient relies on this mechanism, O2 can stop them from breathing