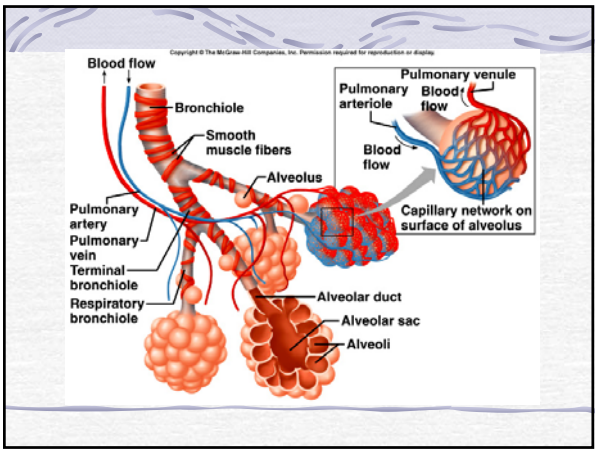
Human Anatomy & Physiology 19

Respiratory System

Unit Five

Karen Webb Smith



Respiratory System URLs

http://yucky.kids.discovery.com/flash/body/pg000138.html

http://www.stemnet.nf.ca/~dpower/resp/exchange.htm#Breathing

http://www.emc.maricopa.edu/faculty/farabee/BIOBK/BioBookRESPSYS.html

Be sure to watch the Video: "The Respiratory System".

All animals need oxygen to live. Land animals need O_2 from the air. Their lungs pump in air. Their lungs also separate out the vital O_2 so it can be put to use inside the cells. Lungs are both pumpers & separators. They provide the breath of life.

Inside your chest is a tree that is called the bronchial tree. Its job is to spread the air from the windpipe over a very wide area inside you as quickly as possible. This is what a tree shape does best.

We say that we breathe in air, but air is NOT really inside of the body until it passes through the lung walls into the blood.

Humans burn O_2 at a furious rate. We need a lot of lung space for moving O_2 into the blood. That's where the tree shape comes in. Air passing in through the windpipe divides into 2 branches, called the bronchial tubes. These divide into little twigs called bronchioles. These twigs open into little bags called alveoli. Once it reaches the alveoli, the air you breathe finally gets under your skin, or more accurately, goes through the lung wall. You have about 600 million of these spongy little bags.

Your lungs are about the size of a pair of footballs & they fill the chest from neck to ribs. The lungs are the pickup place for O_2 & the dumping place for CO_2, the body's exhaust gas. They are continually at work breathing in air & breathing out CO_2.

On the floor of the chest cavity is the diaphragm. It is a large muscle that moves up and down making the room in the chest cavity smaller & larger. When you breathe in, the diaphragm contracts & drops down. At the same time, your ribs expand outward & the room gets larger. Air rushes in to fill the space.

When you breathe out, the diaphragm relaxes into its up position. The ribs settle down. The space shrinks & air is squeezed out of the lungs. The rate of your breathing is controlled automatically in your brain by the respiratory center. It controls your speed of breathing so that it provides just enough O_2 for every activity, like sleeping vs. exercising. You might guess that the respiratory center makes adjustments in breath rate by measuring the blood's O_2 level. The opposite occurs. The amount of CO_2 waste in the blood determines how fast you breathe.

The diaphragm is a voluntary muscle You can will your diaphragm into action. There is also involuntary control which is controlled by the nervous system. If you decided to pant for a while & overdose yourself with O_2, your involuntary control would soon take over. You would faint, & your breathing would slow until normal O_2 levels were restored. So you can't hold your breath until you die!

Lungs are the only organ in the body light enough to float on water.

The total surface area on the lungs is about 25 times that of the body's skin surface.

The lungs secrete a detergent substance called surfactant. This greatly reduces the surface tension of the fluid lining, allowing air in.

I. Introduction

A. The respiratory system consists of a group of passageways that filter incoming air and transport it into the body, into the lungs, & to the many microscopic alveoli (air sacs) where gases are exchanged.

B. The entire process of exchanges of gases between the atmosphere and body cells is called respiration and consists of the following; ventilation, external respiration, transport in the bloodstream, internal respiration, and cellular respiration.

*ventilation – movement of air in & out of the lungs

*external respiration – exchange of gases between the air in the lungs & the blood

*transport in the blood stream – transport of gases between the lungs & body cells

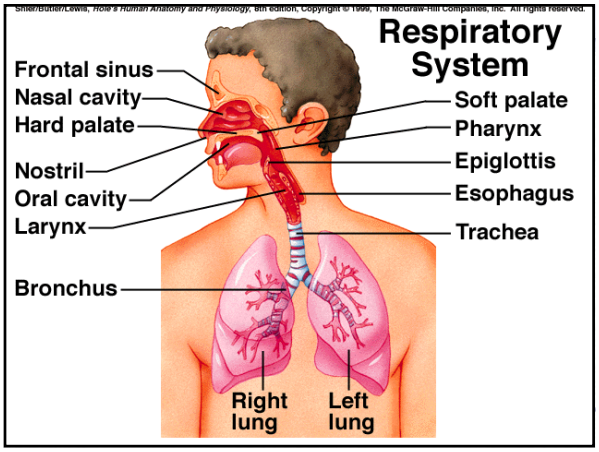
*internal respiration – exchange of gases between the blood & the body cells

*cellular respiration – O_2 utilization & production of CO_2 by the body cells

II. Why We Breathe

A. We, on a macroscopic level, need to breathe because our cells, on a microscopic level, require oxygen as a final electron acceptor in the process of cellular respiration, and must rid themselves of carbon dioxide as a by-product of the same metabolic pathways.

B. Cellular respiration explains why we must obtain O_2 and get rid of CO_2.



III. Organs of the Respiratory System

A. The organs of the respiratory tract can be divided into two groups: the upper respiratory tract (nose, nasal cavity, sinuses, and pharynx), and the lower respiratory tract (larynx, trachea, bronchial tree, and lungs).

Upper Respiratory Tract:

B. Nose

*is supported internally by muscle, bone & cartilage

*2 nostrils (internal nares) provide openings for air to enter & leave the nasal cavity; hair guard the entries & prevent entry of large dust particles & etc.

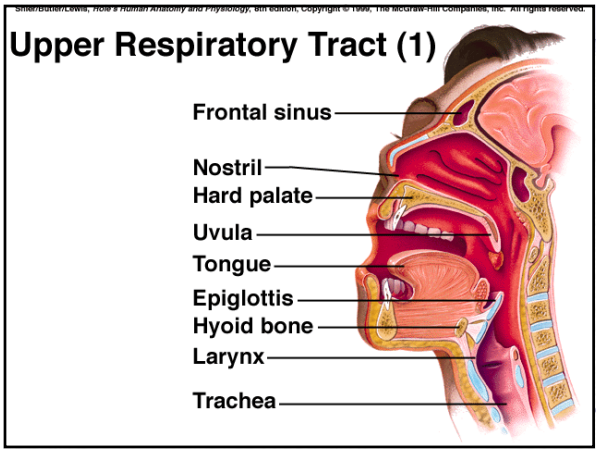
C. Nasal Cavity – a hollow space behind the nose, is divided by into right & left portions = nasal septum

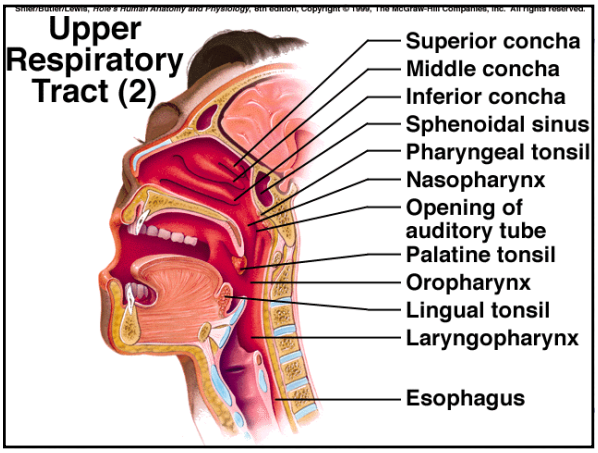
*nasal conchae – divide the cavity into passageways & help increase the surface area of the mucous membrane

*mucous membrane filters, warms, & moistens incoming air

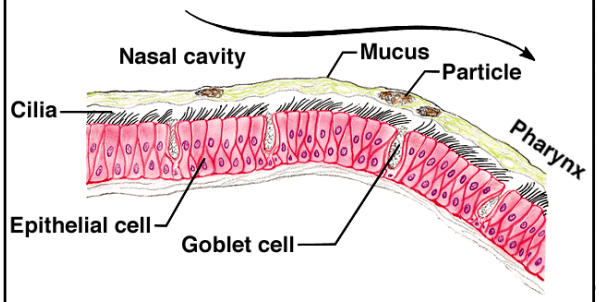
*particles trapped in the mucus are carried to the pharynx by ciliary action & are swallowed

*gastric juice in the stomach destroys microorganisms in the mucus





Cilia



Upper Respiratory Tract (continued):

D. Sinuses – (frontal, sphenoidal, ethmoidal, & maxillary sinuses)

*sinuses are spaces in the bones of the skull that open into the nasal cavity; located within the maxillary, frontal, ethmoid & sphenoid bones

*they are lined with mucous membrane that is continuous with the lining of the nasal cavity; **mucus secretions drain from the sinuses into the nasal cavity; sometimes they become infected

E. Pharynx = the throat; located posterior to the mouth between the nasal cavity & the larynx

*it is a common passageway for food traveling from the oral cavity to the esophagus & for air passing between the nasal cavity`& the larynx

*it aids in producing the sounds of speech.

*subdivisions of the pharynx are:

nasopharynx

oropharynx

laryngopharynx

III. Organs of the Respiratory System

Lower Respiratory Tract:

F. Larynx – an enlargement in the airway at the top of the trachea & below the pharynx; it is a passageway for air & helps prevent foreign objects from entering the trachea

*larynx is composed of a framework of muscles & cartilages bound by elastic tissues;

single cartilages = thyroid, cricoid, & epiglottic cartilages

paired cartilages = arytenoid, corniculate, & cuneiform

*thyroid cartilage – covers lower area of thyroid; is cartilage of Adam's apple

*cricoid cartilage – marks lowest portion of the larynx

*epiglottic cartilage – is elastic cartilage; supports the epiglottis which allows air to enter the larynx

*arytenoid cartilages – located around cricoid cartilage

*corniculate cartilages – attachments for muscles that help regulate tension on the vocal cords during speech & aid in closing the larynx during swallowing

*cuneiform cartilages – in mucous membrane between the epiglottic & arytenoid cartilages (continued)

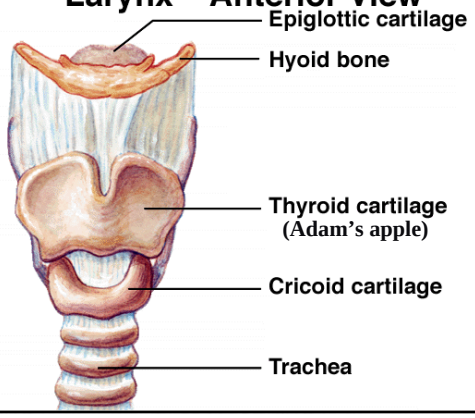
(Larynx continued:)

*contains the vocal cords, which produce sounds by vibrating as air passes over them: 1) the pitch of a sound is related to the tension on the cords 2) the intensity of a sound is related to the force of air passing over the cords

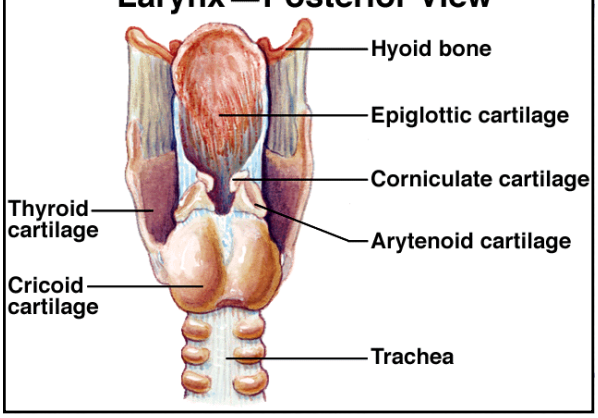
*glottis – the opening (a triangular slit) between the vocal cords

*the glottis & epiglottis help prevent food & liquid from entering the trachea

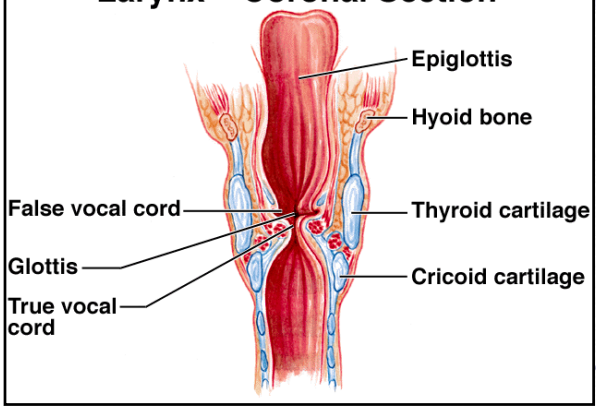
Larynx—Anterior View



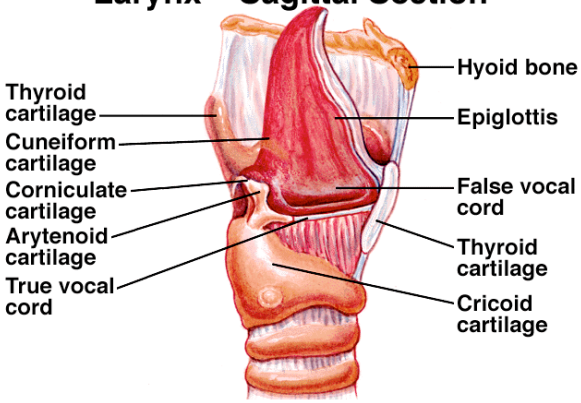
Larynx—Posterior View



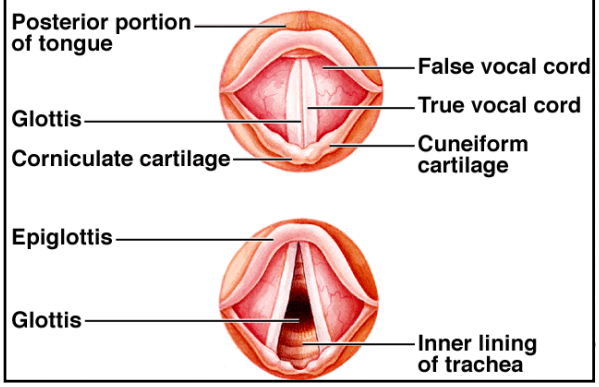
Larynx—Coronal Section



Larynx—Sagittal Section



Vocal Cords



G. Trachea (windpipe)

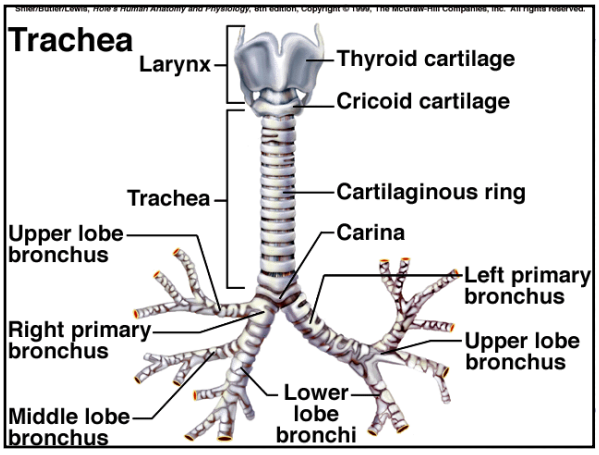
*extends downward anterior to the esophagus & into the thoracic cavity where it splits into right & left bronchi

*inner wall is lined with a ciliated mucous membrane that contains many goblet cells

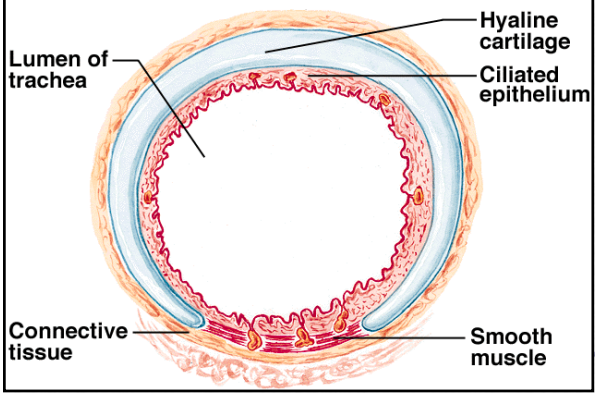
*about 20 C-shaped pieces of hyaline cartilage support the tracheal wall

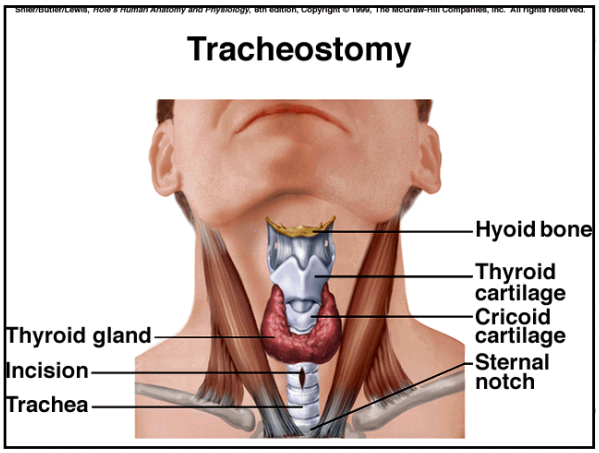
*tracheostomy – surgical procedure which involves making a temporary external opening so that air can bypass an obstruction in the trachea

Trachea



Trachea—Cross Section





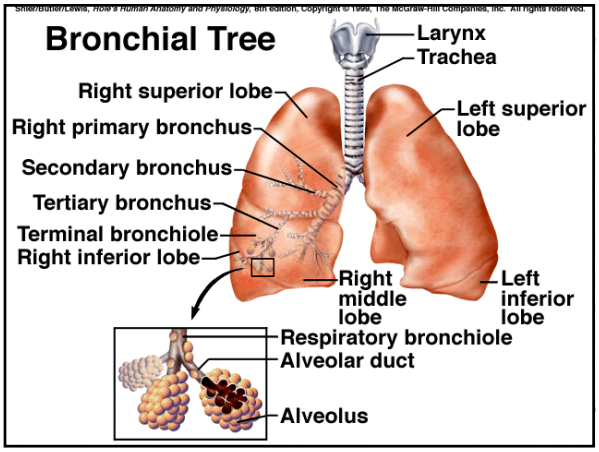
H. Bronchial Tree

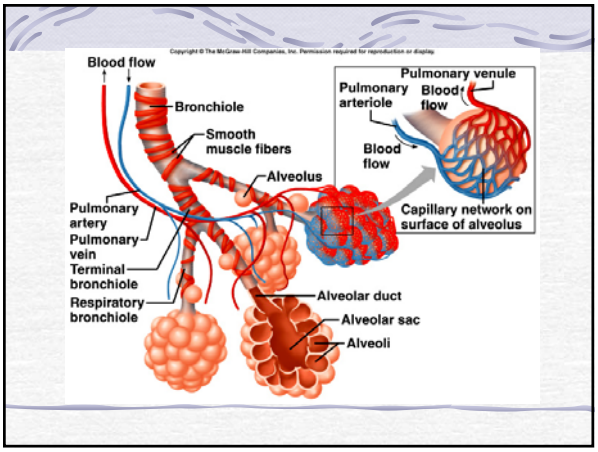
****consists of branched airways leading from the trachea to microscopic air sacs in the lungs

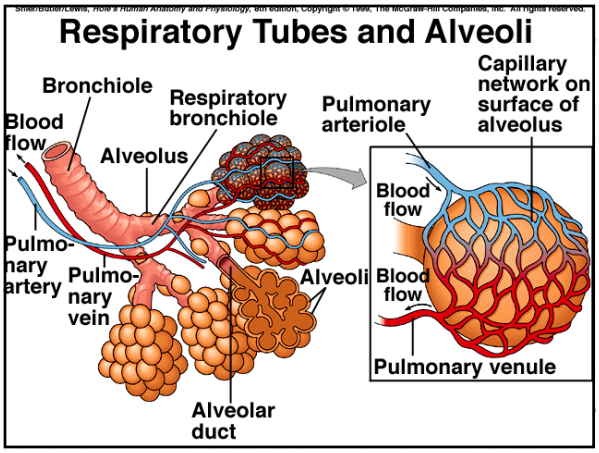
***Branches of the Bronchial Tree:**

1) primary bronchi – right & left; arise from the trachea; accompanied by large blood vessels that enter its respective lung
2) secondary bronchi – 3 branch from each primary bronchus
3) tertiary bronchi – 10 segments in the right lung & 8 in the left lung
4) intralobular bronchioles – small branches that enter the lobules
5) terminal bronchioles – 50 – 80 terminal bronchioles occupy a lobule of the lung
6) respiratory bronchioles – air sacs bud from their sides so they are able to take part in gas exchange
7) alveolar ducts – 2 – 10 extend from each respiratory bronchiole
8) alveolar sacs - closely packed outpouchings of the alveolar ducts
9) alveoli – thin-walled, microscopic air sacs that open into an alveolar sac

***gravity is responsible for depositing pollutants in the respiratory tree**







Structure of the Respiratory Tubes:

***structure of the bronchus is similar to the trachea**

***as tubes branch, the amount of cartilage in the walls decreases, & the muscular layer becomes more prominent**

***elastic fibers in the walls aid breathing**

***epithelial lining changes from pseudostratified & ciliated to cuboidal & simple squamous as the tubes become progressively smaller**

Functions of the Respiratory Tubes & Alveoli:

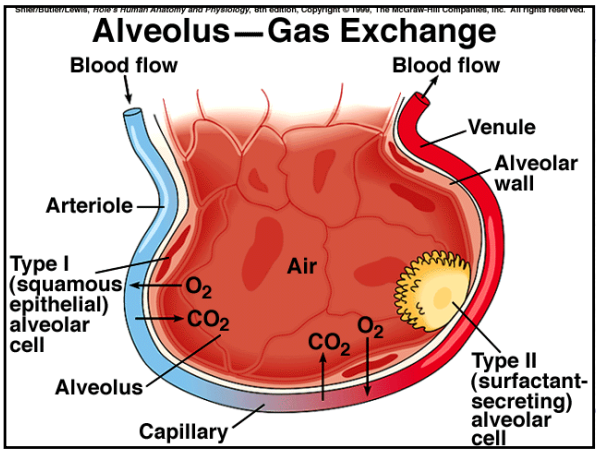
***The branches of the bronchial tree are air passages which continue to filter the incoming air & distribute it to the alveoli in all parts of the lungs.**

***The alveoli provide a large surface area of thin epithelial cells for gas exchange.**

***During gas exchange O_2 diffuses through the alveolar walls & enters the blood in nearby capillaries.**

***CO_2 diffuses from the blood through these walls & enters the alveoli.**

*****distribution of air & exchange of gases between the alveolar air & the blood**



I. Lungs

*soft, spongy, cone-shaped organs that are separated by the mediastinum (right & left lungs) & are enclosed by the diaphragm & the thoracic cage

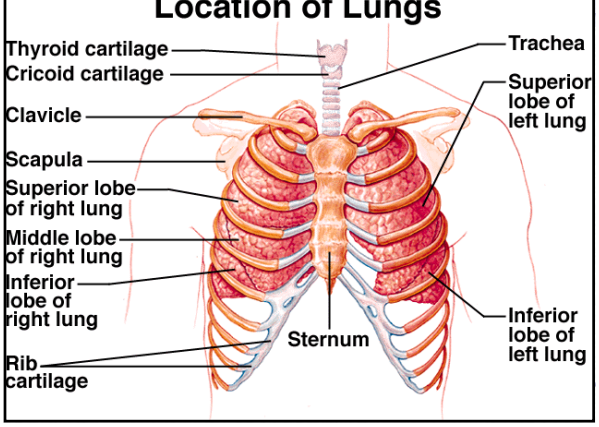
*each lung is suspended by a bronchus & some large blood vessels; they enter the lung through a region called the hilum

*visceral pleura is attached to the surface of the lungs; parietal pleura lines the thoracic cavity

*pleural cavity is very narrow & contains serous fluid

*right lung is larger than the left lung; right lung has 3 lobes & left lung has two lobes

*Each lobe is composed of lobules that contain alveolar ducts, alveolar sacs, alveoli, nerves, blood vessels, lymphatic vessels, & connective tissues.



IV. Breathing Mechanism

A. Ventilation (breathing), the movement of air in and out of the lungs, is composed of inspiration and expiration.

B. Inspiration

*atmospheric pressure, = (760 mm Hg @sea level) due to the weight of the air, is the force that moves air into the lungs

*inspiration occurs when the intra-alveolar pressure (pressure inside the lungs & alveoli) is reduced; this involves the action of muscle fibers within the diaphragm

*the intra-alveolar pressure is reduced when the diaphragm moves downward, & the thoracic cage moves upward & outward

*phrenic nerves stimulate the muscle fibers of the diaphragm to contract

*surface tension holding the pleural membranes together aids lung expansion

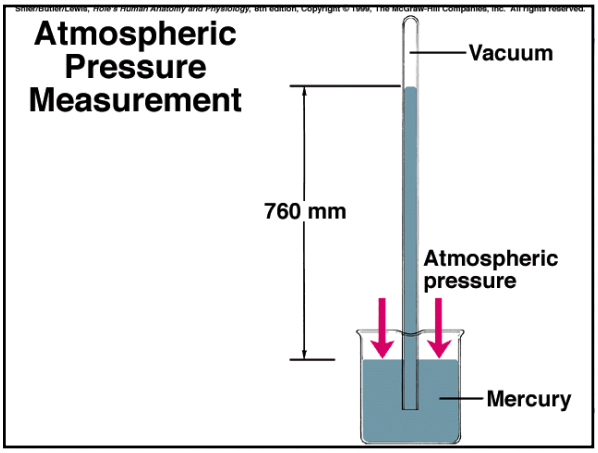
*Certain alveolar cells synthesize a mixture of lipoproteins called surfactant which is continuously secreted into the alveolar air spaces. It reduces surface tension & decreases the tendency of the alveoli to collapse.

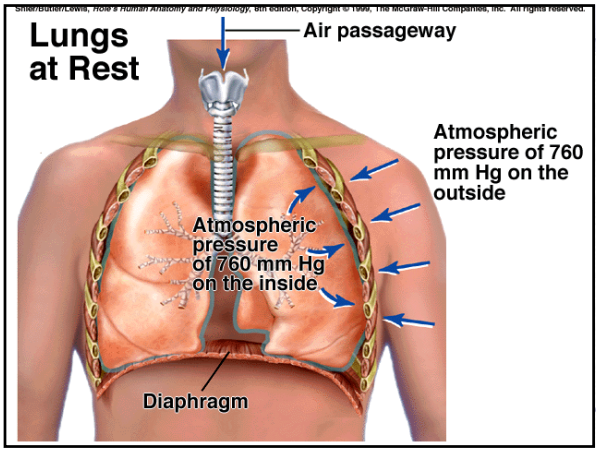
*

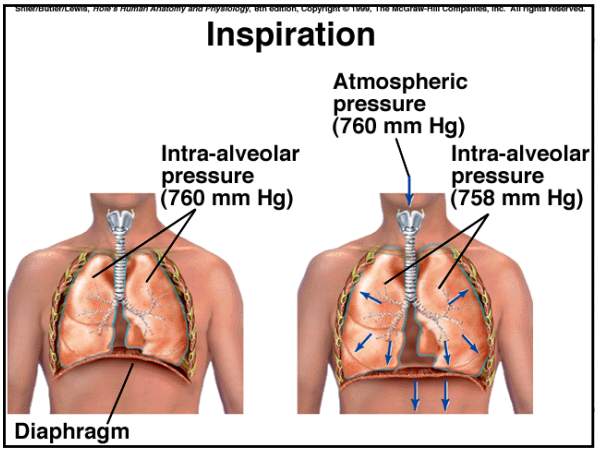
*pectoralis minors & sternocleidomastoids can be used to pull the thoracic cage further upward & outward to decrease alveolar pressure even more if a person needs to take a deeper than normal breath (forceful inhalation)

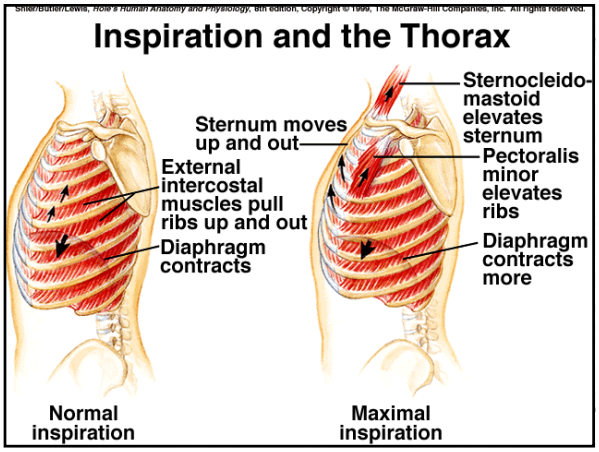
*compliance – the ease with which the lungs can expand as a result of pressure changes occurring during breathing.

Conditions that obstruct air passages, destroy lung tissue, & impede lung expansion decrease compliance.









C. Expiration

*The forces of expiration come from the elastic recoil of tissues & from surface tension within the alveoli.

*Expiration can be aided by thoracic & abdominal wall muscles that pull the thoracic cage downward & inward, & compress the abdominal organs inward & upward

D. Respiratory Volumes and Capacities

*respiratory cycle – one inspiration followed by one expiration

*tidal volume – the amount of air that moves in & out during a respiratory cycle

*inspiratory reserve volume – additional air that can be inhaled

*expiratory reserve volume – additional air that can be exhaled

*residual air remains in the lungs & is mixed with newly inhaled air

*inspiratory capacity – the maximum volume of air a person can inhale following expiration of the tidal volume

*functional residual capacity – the volume of air that remains in the lungs following the expiration of the tidal volume

(continued next slide)

- Moving the plunger of a syringe causes air to move in or out
- Air movements in and out of the lungs occur in much the same way

*vital capacity – maximum amount of air a person can exhale after taking the deepest breath possible

*total lung capacity – equal to the vital capacity plus the residual air volume

*anatomic dead space – air in trachea, bronchi, & bronchioles

*alveolar dead space - air sacs in some regions of the lungs that are nonfunctional due to poor blood flow in the adjacent capillaries

*physiologic dead space – the anatomic & alveolar dead space volumes combined; in a normal lung dead space & physiological dead space are equal

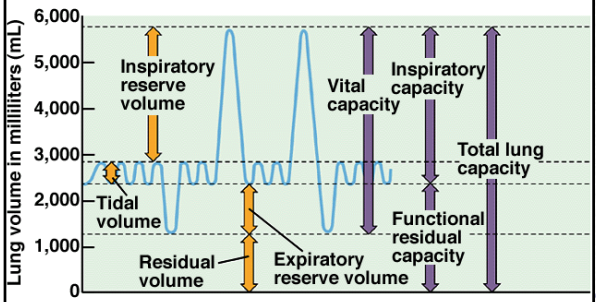
E. Alveolar Ventilation

*alveolar ventilation – a major factor affecting the exchange of gases between the alveolar air & the blood

F. Nonrespiratory Air Movements – air movements other than breathing

*includes coughing, sneezing, laughing, crying, hiccuping, & yawning

Respiratory Volumes and Capacities



V. Control of Breathing

A. Normal breathing is a rhythmic, involuntary act.

B. Respiratory Center – comprised of groups of neurons in the brain stem

*located in the brain stem & includes parts of the medulla oblongata & pons

*medullary rhythmicity area includes 2 groups of neurons:

1) dorsal respiratory group is responsible for the basic rhythm of breathing

2) ventral respiratory group increases inspiratory & expiratory movement during forceful breathing

*pneumotaxic area – regulates the rate of breathing

C. Factors Affecting Breathing

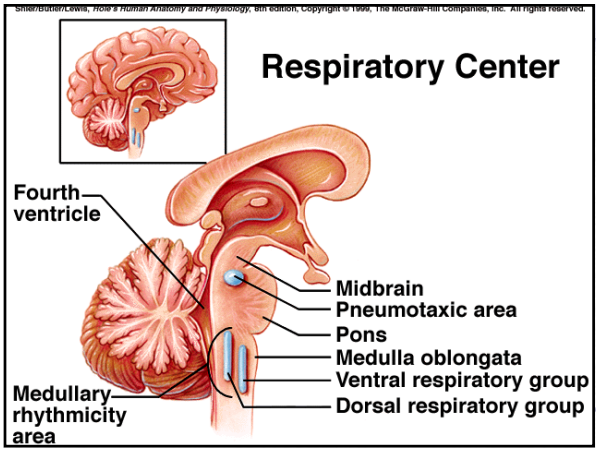
*chemicals, lung tissue, stretching, & emotional state affect breathing

*central chemoreceptors – chemosensitive areas in the brain associated with the respiratory center that are sensitive to changes in the blood concentration of CO_2 & H_2 ions.

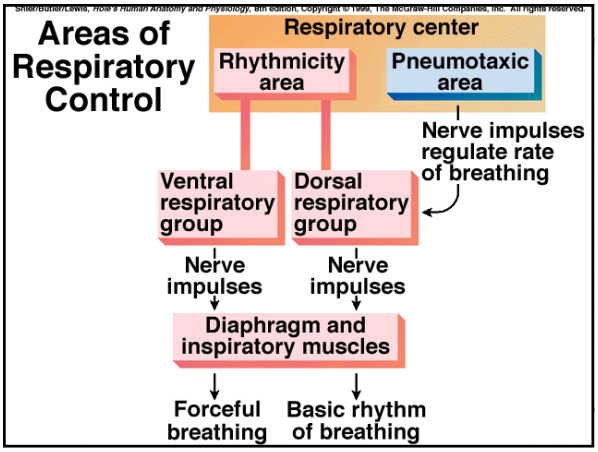
~~(breathing rate increases if ion concentration increases)~~

(continued)

Respiratory Center



Areas of Respiratory Control



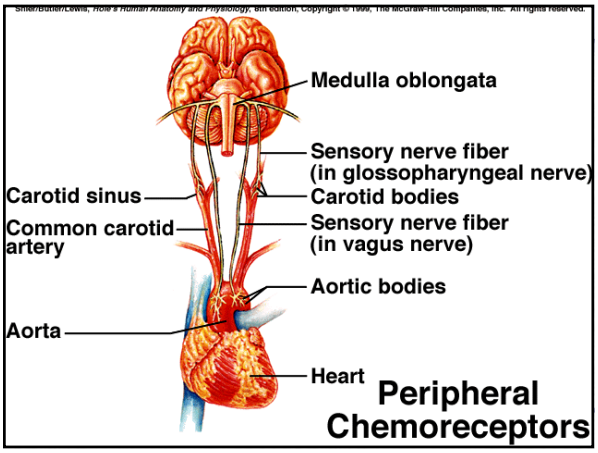
*stimulation of these areas increases alveolar ventilation

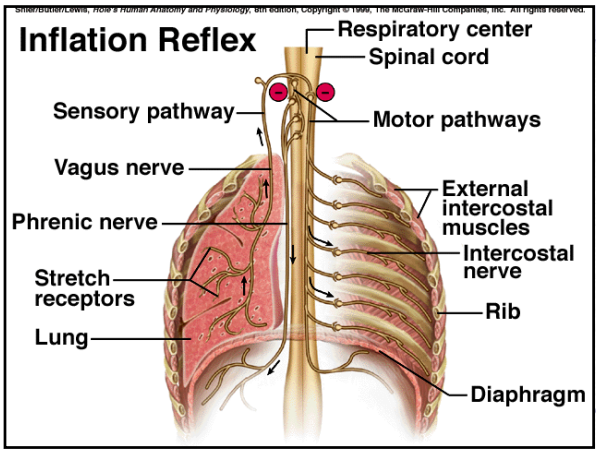
*peripheral chemoreceptors – in the carotid bodies & aortic bodies of certain arteries & are sensitive to blood oxygen concentration

*low O_2 concentration causes alveolar ventilation to increase

*inflation reflex (Hering-Breuer reflex) – occurs when lung tissues are stretched; it helps regulate the depth of breathing; it reduces the duration of inspiratory movements; it prevents over inflation of the lungs during forceful breathing

*hyperventilation – decreases CO2 concentration, but this is very dangerous when associated with breath holding during underwater swimming



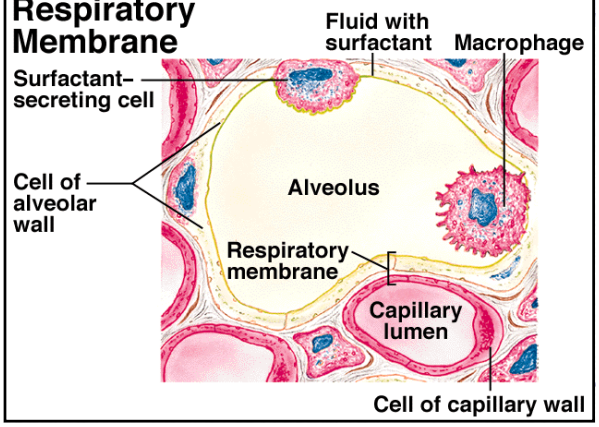


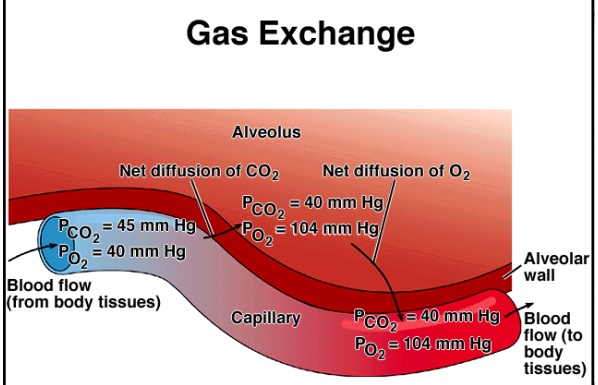
VI. Alveolar Gas Exchanges

A. The alveoli, located at the end of the bronchial tree, are the sites of gas exchange between the atmosphere and the blood.

B. Alveoli
- *tiny sacs clustered at the distal ends of the alveolar ducts
- *alveolar pores – minute openings in the walls of some alveoli that may permit air to pass from one alveolus to another; allows for alternate pathways if some portions of the lung become obstructed
- *alveolar macrophages – phagocytic cells in the alveoli & in the pores that clean the alveoli & keep them free of airborne agents including bacteria

C. Respiratory Membrane
- *consists of alveolar & capillary walls



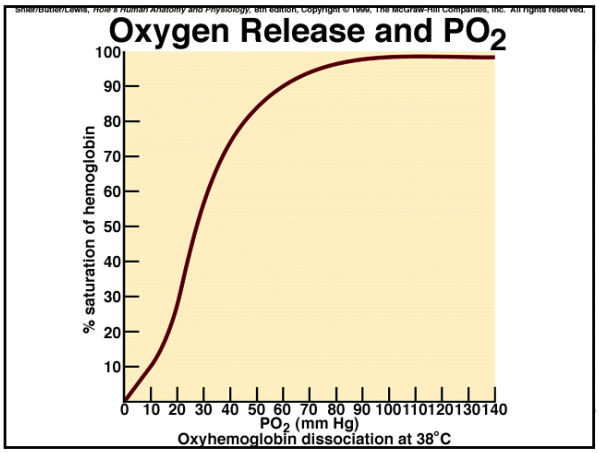


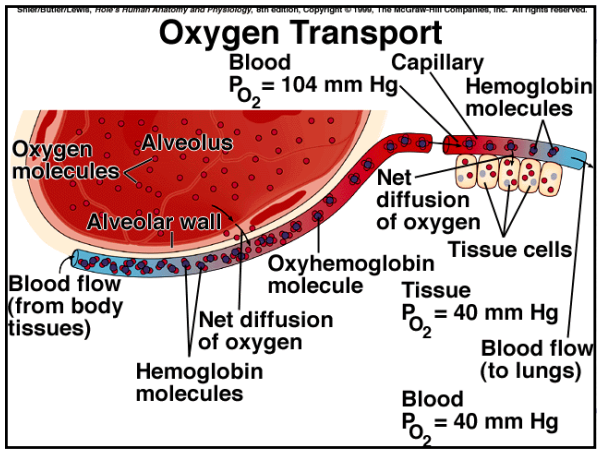
D. Diffusion through the Respiratory Membrane
- *ordinary air is about 78% N, 21% O_2, & .04% CO_2; air has small amounts of other gases that have little or no physiological importance
- *partial pressure – the amount of pressure each gas contributes; the partial pressure of a gas is determined by the concentration of that gas in a mixture of gases or the concentration of gas dissolved in a liquid
- *gases diffuse from regions of higher partial pressure toward regions of lower partial pressure
- *O_2 diffuses from the alveolar air into the blood; CO_2 diffuses from the blood into the alveolar air

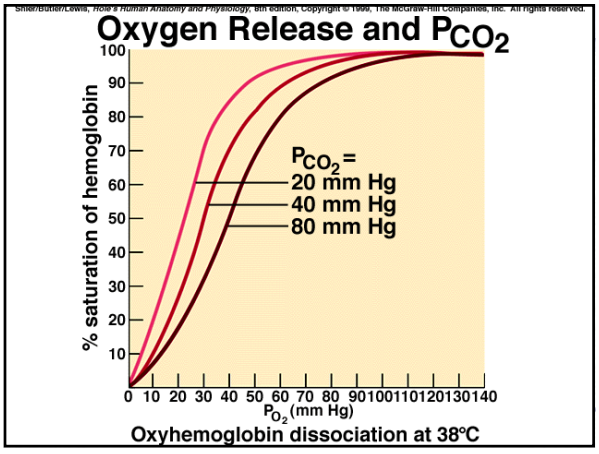
VII. Gas Transport

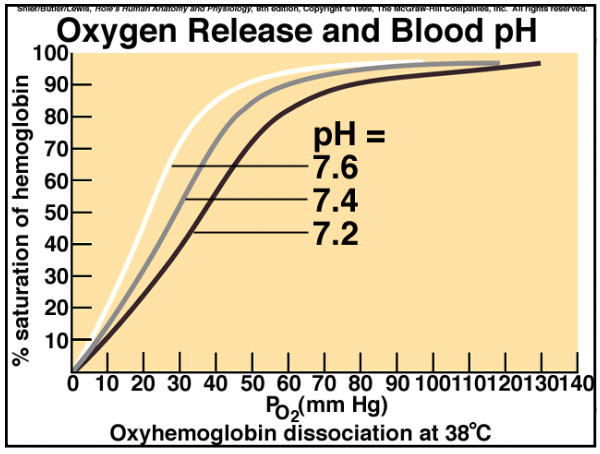
A. Gases are transported in association with molecules in the blood or dissolved in the plasma. Blood transports gases between the lungs & the body cells.

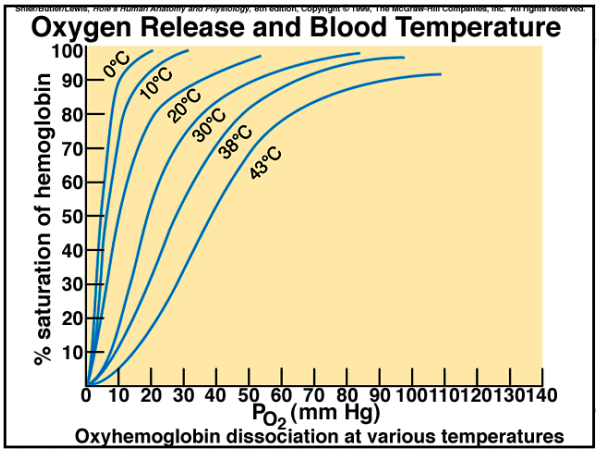
B. Oxygen Transport
- *O_2 is mainly transported in combination with hemoglobin molecules
- *oxyhemoglobin – new compound formed with hemoglobin & O_2; is relatively unstable & releases its O_2 in regions where the PO_2 (partial pressure of O_2) is low
- *more O_2 is released as the blood concentration of CO_2 increases, as the blood becomes more acidic, & as the blood temperature increases











C. Carbon Monoxide

*forms as a result of incomplete combustion of fuels

*it combines with hemoglobin more readily than O_2 & forms a stable compound; CO is toxic because the hemoglobin with which it combines is no longer available for O_2 transport

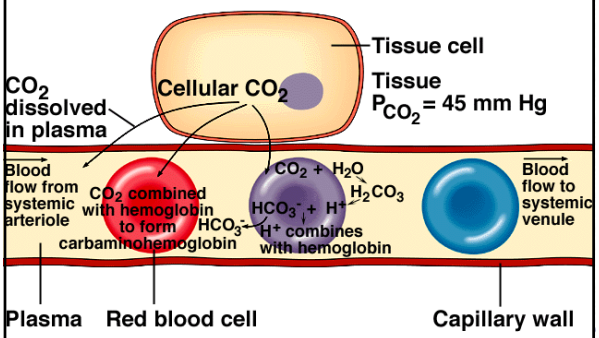
D. Carbon Dioxide Transport

*CO_2 can be carried in solution as dissolved CO_2, CO_2 bound to hemoglobin, or as a bicarbonate ion

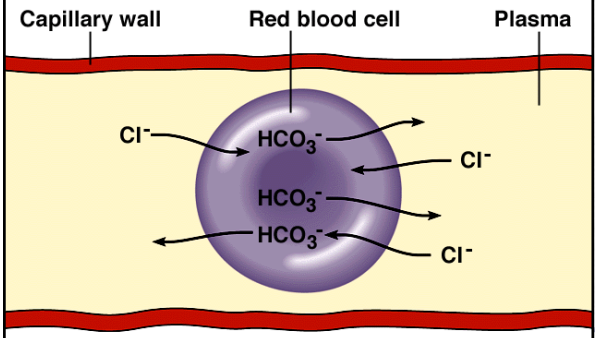
*carbonic anhydrase (enzyme), speeds the reaction between CO_2 & H_2O to form carbonic acid

*carbonic acid dissociates to release H_2 ions & bicarbonate ions

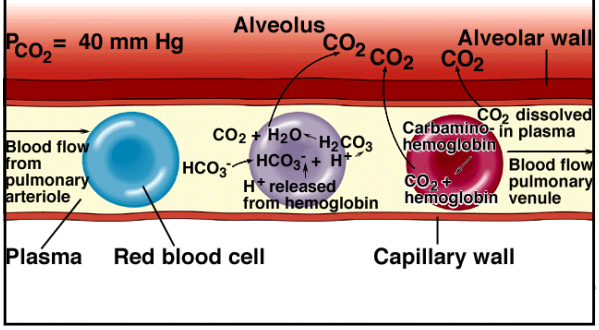
Carbon Dioxide Transport



Chloride Shift

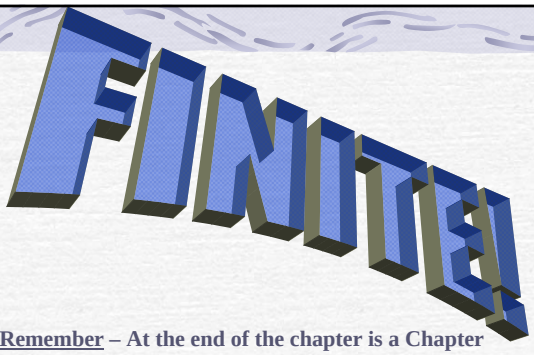


Carbon Dioxide Diffusion — Lungs



Anatomy students observing an inflated pig's lungs at Bowman Gray School of Medicine, Wake Forest University

Pig lung now deflated.



<u>Remember</u> – At the end of the chapter is a Chapter Summary that is your Study Guide for the Chapter 19 test.