Chapter 23: Respiratory System

I. Functions of the Respiratory System
   A. List and describe the five major functions of the respiratory system:
      1. ______________________________________________________________
         ______________________________________________________________
         ______________________________________________________________
         ______________________________________________________________
         ______________________________________________________________
      2. ______________________________________________________________
         ______________________________________________________________
      3. ______________________________________________________________
         ______________________________________________________________
      4. ______________________________________________________________
         ______________________________________________________________
      5. ______________________________________________________________
         ______________________________________________________________
      ______________________________________________________________

II. Anatomy and Histology of the Respiratory System
   A. Nose
      1. Consists of ____________________ and the ____________________
      2. External Nose
         a. The largest part is composed of ______________________________
         b. What bones make the bridge of the nose? _____________________ &
            extensions of the ____________________ and ____________________
      4. Nasal Cavity
         a. Extends from the ____________________ to the ___________________
            1. What are the nares? ______________________________
            2. What are the choanae? _____________________________
            b. What is the vestibule? _____________________________
c. What forms the floor of the nasal cavity and separates it from the oral cavity? ____________________ 

d. The nasal septum is composed of:
   1. Anterior part is ____________________
   2. Posterior part consists of:
      a. ____________________ bone
      b. Perpendicular ______________________________

e. What are the conchae? ________________________________
   1. Where are they located in the nasal cavity? __________________

f. What is a meatus? ________________________________

g. The paranasal sinuses open into ________________________________

h. The nasolacrimal duct opens into ________________________________

i. Functionally the nasal cavity:
   1. Passageway ________________________________
   2. Cleans ________________________________
   3. Humidifies and ________________________________
   4. Sensory organ for ________________________________ located __________________
   5. Resonating ________________________________

B. Pharynx
   1. Common opening for both ____________________ & __________________
   2. Inferiorly connected to:
      a. Respiratory system at the ________________________________
      b. Digestive system at the ________________________________

3. Nasopharynx
   a. Superior part of the pharynx and extends from ____________________ to ____________________
   b. What is the uvula attached to? ________________________________
   c. Functionally the soft palate prevents ________________________________
   d. Mucus containing trapped particles from the nasal cavity moves through the nasopharynx and is ____________________
e. The auditory tubes from _________________ open into the nasopharynx
   a. They function to ___________________________________________

f. Where is the pharyngeal tonsil or adenoid located? ________________

4. Oropharynx
   a. Extends from ____________________ to the ____________________
   b. The opening to the oral cavity is called the ____________________
   c. What two sets of tonsils are located near the opening to the oral cavity?
      1. ______________________________
      2. ______________________________

5. Laryngopharynx
   a. Extends from the ____________________ to the ___________________
   b. Passes posterior to the ______________________________

C. Larynx
   1. Consists of an outer casing of _________________ that are connected to
      one another by ____________________ & ____________________
   2. What is the largest unpaired cartilage? __________________________
   3. What cartilage forms the base of the larynx? _______________________
   4. Which cartilage projects as a free flap toward the tongue? ____________
      a. This cartilage is composed of ______________________________
      b. During swallowing it covers _______________________________
   5. The paired cartilages:
      a. Where are the arytenoid cartilages? __________________________
      b. Where are the corniculate cartilages? __________________________
      c. Where are the cuneiform cartilages? ____________________________

6. Two pairs of ligaments extend from ________________________________ to
   ____________________________________________________________________
   a. The superior pair is called ______________________________
      1. Functionally when they come together _________________________
      _________________________
   b. The inferior pair is called ________________________________
c. What is the glottis? 

d. What is laryngitis?

7. Functionally the larynx:
   a. Maintain an open
   b. Prevent
   c. Primary source of
      1. Higher pitched tones are produced when
      2. Progressively lower tones
      3. Why do males have lower-pitched voices?
      4. Movement of the cartilages is controlled by
      5. Movement of arytenoid cartilages:
         a. Lateral rotation
         b. Medial rotation
         c. Anterior/posterior movement

D. Trachea
   1. Describe the structure of the trachea:
   2. Functionally the C-shaped cartilage the trachea and for air
   3. The posterior wall of the trachea is but contains:
      a. Elastic
      b. Bundles of called
   4. What does the smooth muscle do during coughing?
   5. Describe the structure of the mucous membrane:
      a. What functional role do the cilia play?
   6. At the level of the fifth thoracic vertebrae the trachea divides into
   7. What is the carina?

E. Tracheobronchial Tree
   1. What does the term tracheobronchial tree refer to?
2. Conducting Zone
   a. Extends from the ____________________ to ____________________
   b. How many generations of branching are present? ________________
   c. Functionally the conducting zone is a ___________________________ & contains epithelial tissue that helps ______________________________
   d. The trachea divides into the __________ & ________________________
      1. Compared to the left primary bronchus, the right primary bronchus is:
         a. ______________________________
         b. ______________________________
         c. ______________________________
   e. The primary bronchi divide into __________________________________ 
      1. How many in the left lung? ________________
         2. How many in the right lung? ________________
   f. The secondary bronchi divide into _______________________________
   g. The bronchi continue to branch giving rise to _______________________
   h. Several more subdivisions finally become __________________________
   i. As the tubes divide the amount of cartilage and smooth muscle changes:
      1. Primary bronchi have ________________________________
      2. Secondary bronchi have ________________________________
      3. Terminal bronchioles have ________________________________
   j. Diameter of the air passageways is changed by ____________________
   k. What happens to the air passageways in an asthma attack? ___________

3. Respiratory Zone
   a. Extends from the ____________________ to ____________________
      called _______________ which are sites of _________________________
   b. How many generations of branching are present? ________________
   c. The terminal bronchioles divide to form __________________________
      1. Have a few attached alveoli so have a limited ability ______________
d. As respiratory bronchioles divide into smaller branches the number of attached alveoli ____________________
e. The respiratory bronchioles finally form ____________________ ducts
   1. The alveolar duct wall is little more than ______________________
   2. The alveolar duct ends as _________________________________

f. The tissue surrounding the alveoli contains ______________________
   1. This allows the alveoli to:
      a. Expand ______________________________
      b. Recoil ______________________________

la. Structurally the walls of respiratory bronchioles consists of:
   a. ____________________ and ____________________________ with
   b. Bundles of ______________________________
   c. Epithelium is a ________________________________

h. Structurally the alveolar ducts and alveoli consist of __________________
   __________________________________________

i. Debris in the respiratory zone is removed by ______________________
   1. Where does the debris end up? ____________________________ or
   __________________________________________________________________

j. Alveolar walls are composed of two cell types:
   1. Type I pneumocytes are _____________________________ that form
      __________________________________________
   2. Type II pneumocytes are ________________________________ that
      produce ____________________ which ______________________
   3. Most gas exchange occurs through which cells? _______________

k. What is the respiratory membrane? ______________________________

l. Why does the respiratory membrane need to be thin? ______________________________

m. List the elements of the respiratory membrane:
   1. _____________________________________________________
   2. _____________________________________________________
   3. _____________________________________________________
4. ______________________________________________________
5. ______________________________________________________
6. ______________________________________________________

F. Lungs

1. What is the shape of a lung? ______________________________________
2. What is the hilum? ______________________________________________
3. What is the root of the lung? _______________________________________
4. How many lobes does each lung have?
   a. Right lung has ____________________
   b. Left lung has ____________________
5. What separates the lobes of the lung? _______________________________
6. Internally each lobe is supplied by a ____________________ bronchus
7. The lobes are subdivided into ________________________________ which are
   supplied by ______________________________
8. Bronchopulmonary segments are subdivided into ____________________
   that are supplied by ______________________________

G. Thoracic Wall and Muscles of Respiration

1. The thoracic wall consists of the:
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
   e. ______________________________
2. How is the thoracic cavity defined? _________________________________
   ________________________________________________________________
3. The associated muscles are responsible for __________________________
4. The muscles of inspiration include:
   a. ______________________________
   b. ______________________________
   c. ______________________________
   d. ______________________________
5. Which muscle is responsible for two-thirds of the thoracic cavity volume increase? ______________________________

6. Which muscles elevate the ribs to increase thoracic cavity volume? ______________________________

7. The muscles of expiration that compress the ribs and sternum include:
   a. ______________________________
   b. ______________________________

8. How is inward collapse of the thoracic cage prevented during inspiration? ______________________________

9. Describe the shape of the diaphragm: ______________________________
   a. The base is attached to ______________________________
   b. What is the central tendon? ______________________________

10. What happens to the diaphragm during normal quiet breathing? ________________

11. When breathing deeper what happens to the diaphragm? ________________

12. When the ribs are elevated the costal cartilage allows ___________________

13. During quiet breathing expiration occurs when ___________________ & __________________ relax and the __________________ cause a ___________________
   a. Contraction of the abdominal muscles ____________________________

H. Pleura

1. Each lung is contained inside a ______________________________

2. What is the mediastinum? ______________________________

3. What does the parietal pleura cover? ______________________________

   ___________________________________________________________________________

4. What does the visceral pleura cover? ______________________________

5. The pleural cavity is filled with ______________________________

6. Functionally the pleural fluid:
   a. Acts as a ______________________________
b. Helps hold __________________________________________________

I. Blood Supply

1. What is oxygenated blood? _______________________________________
2. What is deoxygenated blood? _____________________________________
3. The major blood flow route:
   a. Brings deoxygenated blood from the heart through ________________
   b. Flows through pulmonary capillaries where it is _________________
   c. Then flows back to the heart through _____________________________
4. The smaller blood flow route:
   a. Brings oxygenated blood from the ______________________________
   b. Passes through ____________________ to ____________________
      where oxygen is released
   c. The now deoxygenated blood from the proximal part of the bronchi returns
      to the heart through _______ veins and the ___________________________
   d. The now deoxygenated blood from the distal part of the bronchi returns to
      the heart through the __________________________ containing __________

J. Lymphatic Supply

1. Where are the superficial lymphatic vessels located? ________________
   a. Functionally they drain lymph from ______________________________

2. Where are the deep lymphatic vessels located? ______________________
   a. Functionally they drain lymph from ______________________________

3. The lymphatic vessels exit the lungs at the _________________________

III. Ventilation

A. Pressure Differences and Airflow

1. What is ventilation? _____________________________________________
2. Airflow into the lungs requires _________________________________
3. Airflow out of the lungs requires _______________________________
B. Pressure and Volume
1. The general gas law reveals that air pressure is _______________________
   ______________________ to ______________________________
   a. As volume increases ______________________________
   b. As volume decreases ______________________________
C. Airflow into and out of Alveoli
1. Barometric air pressure is defined to be equal to ______________________
2. What is alveolar pressure? ________________________________________
   a. This pressure is usually expressed in terms of ______________________
3. During the process of ventilation:
   a. At the End of Expiration:
      1. No air is moving because ______________________________
   b. During Inspiration
      1. Contraction of ______________________________
      2. ____________________ thoracic volume
      3. Results in ____________________ of the lungs and an
         ______________________________
      4. Causes a ____________________ in alveolar pressure
      5. Air flows ____________________ because ____________________
         is ______________________________
   c. End of Inspiration
      1. Thorax and alveoli ______________________________
      2. Alveolar pressure becomes ______________________________
      3. No further movement of air because ______________________________
   d. During Expiration
      1. Diaphragm ______________________________
      2. ____________________ thoracic volume
      3. Thorax and lungs ______________________________
      4. Decreased thoracic volume results in _______________ alveolar
         volume and _______________ alveolar pressure
5. Air flows ____________________ because _____________________
   is __________________________________________________

6. As expiration ends:
   a. ____________________ in thoracic volume stops
   b. Alveoli ______________________________

D. Changing Alveolar Volume
   1. Lung Recoil
      a. What does lung recoil cause? ______________________________
      b. Lung recoil is the result of:
         1. Elastic __________________________________________________
         2. Surface _________________________________________________
      c. Surfactant composed of _______________________________________
      d. How does surfactant reduce the tendency of the lungs to collapse?
         ___________________________________________________________

   2. Pleural Pressure
      a. Pleural pressure is the pressure in the __________________________
      b. Normally the alveoli are expanded because_______________________
      c. When pleural pressure is lower than alveolar pressure _____________
      d. This expansion is opposed by the tendency of the lungs to __________
      e. What happens if the pleural pressure is sufficiently low? __________
      f. What happens if the pleural pressure is not low enough to overcome lung
         recoil? ______________________________

   3. Pressure Changes During Inspiration and Expiration
      a. At the end of a normal expiration:
         1. Pleural pressure is ______________________________
         2. Alveolar pressure is ______________________________
      b. During normal quiet inspiration:
         1. Pleural pressure ____________________ to ____________________
         2. Alveolar volume ______________________
3. Alveolar pressure ________________________________
4. Air flows ____________________________
5. As air flows into the lungs, alveolar pressure ____________________
   and ____________________________ at the end of inspiration
6. The tendency for the lungs to recoil increases as ____________________
   ________________________________ similar to ____________________________

c. During expiration:
   1. Thoracic volume _____________________________
   2. Pleural pressure ______________________________
   3. Alveolar volume ______________________________
   4. Alveolar pressure ______________________________
   5. Air flows ____________________________
   6. As air flows out of the lungs, alveolar pressure ____________________
   and ____________________________ at the end of expiration

IV. Measuring Lung Function

A. Compliance of the Lungs and the Thorax
   1. What is compliance a measure of? ________________________________
      ______________________________________________________________
   2. Compliance of the lungs and thorax is the ____________ by which they
      ____________ for each unit of ____________ in ____________
   3. The greater the compliance ________________________________
      ______________________________________________________________
   4. A higher than normal compliance means the lungs will expand ____________
   5. A lower than normal compliance means that __________________________

B. Pulmonary Volumes and Capacities
   1. What is spirometry? ________________________________
   2. What is a spirometer? ________________________________
   3. List and describe the pulmonary volumes:
      a. ______________________________________________________________
      ______________________________________________________________
4. List and describe the pulmonary capacities:
   a. ___________________________________________________________
      ___________________________________________________________
   b. ___________________________________________________________
      ___________________________________________________________
   c. ___________________________________________________________
      ___________________________________________________________
   d. ___________________________________________________________
      ___________________________________________________________

5. List factors that cause variations in pulmonary volumes and capacities:
   ________________________________________________________________

6. Do males or females have a larger vital capacity? ______________________

7. The vital capacity is usually highest at what age? ______________________

8. What is the forced expiratory vital capacity? __________________________
   ________________________________________________________________

C. Minute Ventilation and Alveolar Ventilation

1. Define minute ventilation: __________________________________________
   ________________________________________________________________

2. Minute ventilation is equal to ______________________________________

3. The anatomic dead space is the part of the respiratory system where gas exchange ______________________________

4. What structures make up the anatomic dead space? ________________,
   __________, __________, __________, __________, & __________

5. What is physiologic dead space? ___________________________________
6. Alveolar ventilation is the volume of air ______________________________
   per ______________________________

V. Physical Principles of Gas Exchange
A. Partial Pressure
   1. What is atmospheric pressure at sea level? ___________________________
   2. What does Dalton's law say about pressures in a mixture of gases?
      ________________________________________________________________
      ________________________________________________________________
   3. What is a partial pressure? ______________________________
   4. How do you calculate a partial pressure? _____________________________
      ________________________________________________________________
   5. What is water vapor pressure? ______________________________

B. Diffusion of Gases Through Liquids
   1. The amount of gas that will dissolve in a liquid is determined by:
      a. Partial ______________________________
      b. Solubility ______________________________
         1. This is described by ______________________________
   2. What is the solubility coefficient? ______________________________
   3. The calculated partial pressure of a gas in a liquid is a measure of
      ______________________________

C. Diffusion of Gases Through the Respiratory Membrane
   1. Respiratory Membrane Thickness
      a. Increasing the thickness of the respiratory membrane __________________
         __________________________________________
      b. How thick is the respiratory membrane normally? __________________
      c. What happens if the thickness increases two or three times? _________
         _____________________________________________________________
      d. What is the most common cause of an increase in the thickness of the
         respiratory membrane? ______________________________
e. List a few examples of conditions that can cause such fluid accumulation:
___________________________________________________________

2. Diffusion Coefficient
   a. What is the diffusion coefficient? _______________________________
      1. This takes into account:
         a. Solubility ________________________________________
         b. Size ________________________________________
      b. Does oxygen or carbon dioxide diffuse more easily? _________________
      c. Damage to the respiratory membrane interferes with the diffusion of
         ____________________ more than the diffusion of ___________________
      d. Extensive oxygen therapy can result in large blood increases of ________

3. Surface Area
   a. What is the normal surface area of the respiratory membrane of a healthy
      adult? ______________________________
   b. What diseases might decrease surface area? ______________________
   c. Small decreases in surface area affect the ability to exchange gases
datauring ______________________________
   d. The ability to exchange gases becomes a problem even under resting
      conditions when the surface area is decreased by ___________________
   e. List examples of how surface area for gas exchange can be reduced:
      _____________________________________________________________

4. Partial Pressure Difference
   a. Define partial pressure difference: _______________________________
      _____________________________________________________________
      _____________________________________________________________
   b. Net diffusion occurs from the _________________ partial pressure to
      _________________ partial pressure
   c. Normally the partial pressure of oxygen (\(P_{O_2}\)) is higher in ____________
      than the _________________
   d. Normally the partial pressure of carbon dioxide (\(P_{CO_2}\)) is higher in
      _________________ than the _________________
e. How can the partial pressure difference for oxygen and carbon dioxide be raised? __________________________________________________
f. A lower than normal partial pressure difference is caused by: ___________________________________________________________

D. Relationship Between Ventilation and Pulmonary Capillary Blood Flow

1. Regular ventilation of the alveoli and normal blood flow through pulmonary capillaries allows effective _________________ between air and blood

2. During exercise effective gas exchange is maintained because:
   a. Ventilation _________________
   b. Cardiac output _________________

3. The normal relationship can be disrupted in two ways:
   a. Cardiac output is _________________ and therefore not enough blood flows to the lungs to pick up the available oxygen
   b. Ventilation is _________________ to provide enough oxygen for the blood flowing through the pulmonary capillaries

4. What is shunted blood? __________________________________________

5. What is the anatomic shunt? ______________________________________

6. What is the physiologic shunt? _____________________________________

7. When a person is standing blood flow and ventilation in the lungs is effected by _________________

8. When a person is standing most gas exchange occurs at _______________

9. There is decreased pressure at the _________________ of the lungs

10. During exercise, cardiac output and ventilation _________________
    a. This _________________ pulmonary blood pressure throughout the lung
    b. Blood flow _________________ most at the _________________
    c. Effectiveness of gas exchange increases _________________
        because of _________________

11. If there is a low P\textsubscript{O\textsubscript{2}} in one portion of the lung:
    a. Causes arterioles to _________________ blood flow
    b. This reroutes blood _________________
        ___________________________________________
c. This reduces the effect on gas exchange by rerouting the blood to

VI. Oxygen and Carbon Dioxide Transport in the Blood

A. Oxygen Diffusion Gradients
1. The PO_2 within the alveoli averages approximately 
2. The PO_2 of the blood as it flows into pulmonary capillaries is 
   a. Therefore, oxygen diffuses from into 
3. Does the blood PO_2 ever reach equilibrium with the alveoli PO_2? 
4. Blood leaving the pulmonary capillaries has a PO_2 of 
   but blood leaving the lungs in the pulmonary veins has a PO_2 of 
   a. What causes this decrease in PO_2? 
5. The PO_2 of blood entering tissue capillaries is approximately 
6. The PO_2 of the interstitial spaces is close to 
7. The PO_2 inside the cells is probably near 
   a. Therefore, oxygen diffuses from into & from the into 
   b. A constant diffusion gradient exists because 

B. Carbon Dioxide Diffusion Gradients
1. Carbon dioxide is continually produced as a by-product of 
   a. This establishes a diffusion gradient for carbon dioxide from the 
      to the 
      1. The intracellular PCO_2 is approximately 
      2. The interstitial fluid PCO_2 is approximately 
      3. The blood entering the tissue capillaries has a PCO_2 of 
         a. Therefore, carbon dioxide diffuses from to 
      c. As the blood leaves the tissue capillaries it has a PCO_2 of 
2. At the lungs:
   a. The PCO_2 of blood entering the pulmonary capillaries is 
b. The PCO2 of the alveoli is approximately ____________________
   1. Therefore, carbon dioxide diffuses from ____________________ into ____________________
   c. The PCO2 of blood leaving the pulmonary capillaries has decreased to ____________________

C. Hemoglobin and Oxygen Transport
   1. How much of the oxygen transported in blood is in combination with hemoglobin? ____________________
   2. The combination of oxygen with hemoglobin is ____________________
      a. In the pulmonary capillaries ____________________
      b. In the tissue capillaries ____________________
   3. Effect of PO2
      a. What is the oxygen-hemoglobin dissociation curve? ____________________
      b. When is hemoglobin saturated with oxygen? ____________________
      c. At any PO2 above 80 mm Hg the hemoglobin is about ________ saturated
      d. At the PO2 of 104 mm Hg the hemoglobin is ____________ saturated
      e. In the skeletal muscle of a resting person:
         1. The blood leaving the muscle has a PO2 of ____________________
            a. At this PO2 the hemoglobin is approximately ________ saturated
               1. Therefore the hemoglobin released __________ of the oxygen
         f. During vigorous exercise the blood PO2 can decline to __________
            1. At this level approximately __________ of the hemoglobin is saturated and _______________ of the bound oxygen is released
         g. When the oxygen needs of the tissue ______________, blood PO2 ______________ and __________________
   4. Effect of pH, PCO2, and Temperature
      a. pH
         1. As the pH of the blood declines ____________________
2. This occurs because decreased pH is caused by _________________
3. Hydrogen ions combine with _________________________________
   & change _________________________________
   a. This results in a decrease in the ability ______________________
4. As the pH of the blood increases ______________________________
   __________________________________________________________
5. The effect of pH on the oxygen-hemoglobin dissociation curve is called
   ________________________________
   b. P<sub>CO</sub><sub>2</sub>
   1. An increase in P<sub>CO</sub><sub>2</sub> ____________________ the ability of hemoglobin
      to bind oxygen because carbon dioxide effects __________
   2. What is carbonic anhydrase? ________________________________
   3. What is the chemical reaction carbonic anhydrase is involved in?
      _________________________________________________________
   4. When carbon dioxide levels increase more _________________
   5. When carbon dioxide levels decline there is a decrease in ________
      _________________________________ and an increase in ________
6. As blood passes through tissue capillaries:
   a. Carbon dioxide _________________________________
   b. Blood carbon dioxide levels ______________________________
   c. Hemoglobin has _________________________________
   d. Greater amount of _________________________________
    _______________________________________________________
7. As blood passes through the lungs:
   a. Carbon dioxide _____________________ & _____________________
   b. Carbon dioxide levels in the pulmonary capillaries _____________
   c. Affinity _________________________________
   C. Temperature
   1. What effect does an increase in temperature have on the tendency of
      hemoglobin to bind to oxygen? __________________________
   2. Tissues with increased metabolism have higher temperature and
therefore ________________ oxygen is released from hemoglobin

3. Less active tissues have a lower temperature and ________________
   oxygen is released

d. During exercise what happens to the following in the tissues:

1. Carbon dioxide levels ________________
2. Acidic substances ________________ so the pH _______
3. Temperature ________________
   a. These conditions cause how much of the oxygen to be released
      from the hemoglobin? ________________
      1. This is due to the oxygen-hemoglobin curve shifting ______

e. In the lungs the hemoglobin becomes easily saturated because:

1. Carbon dioxide levels ________________
2. Temperature ________________
3. Lactic acid levels ________________

5. Effect of BPG (2,3-biphosphoglycerate)

   a. BPG is formed as red blood cells ________________
   b. What does BPG do when it binds to hemoglobin? ________________
   c. When BPG levels increase ________________
   d. When BPG levels decrease ________________
   e. What happens to BPG levels at high altitudes? ________________
   f. What happens to BPG levels in stored blood? ________________
      1. Why does stored blood become unsuitable for transfusion? ______

6. Fetal Hemoglobin

   a. Fetal blood is very efficient at picking up oxygen because:

      1. Concentration of fetal hemoglobin is ________________
      ________________

      2. Fetal hemoglobin has an oxygen-hemoglobin dissociation curve that is
to the _________ of the maternal curve. This means that fetal
hemoglobin can ________________

      3. BPG has ________________ on fetal hemoglobin.
4. Of the double Bohr effect. Describe what happens in the double Bohr effect: ___________________________________________________ 
________________________________________________________ 
________________________________________________________

D. Transport of Carbon Dioxide

1. Carbon dioxide is transported in the blood in three major ways:
   a. 7% ________________________________________
   b. 23% ________________________________________
   c. 70% ________________________________________

2. Carbon dioxide binds in a reversible fashion to the ____________________
of the ______________________________

3. What is the Haldane effect? _______________________________________
   ________________________________________________________________
   a. In the tissues ________________________________________________
   b. In the lungs _________________________________________________

4. Chloride Shift
   a. At the tissues:
      1. Carbon dioxide diffuses into ______________________________
      2. Some of the carbon dioxide binds to ________________________
      3. Most of the carbon dioxide reacts with ____________________ to 
         form ______________________________
         a. This reaction is catalyzed by the enzyme ____________________
      4. The carbonic acid then dissociates into:
         a. ______________________________
         b. ______________________________
   5. In the chloride shift carrier molecules move:
      a. Bicarbonate ions ______________________________
      b. Chloride ions ______________________________
         1. This exchange maintains ______________________________
   6. Hemoglobin binds to ______________________________
      a. In this fashion hemoglobin functions as a ____________________
b. At the lungs:
   1. Carbon dioxide ______________________________
   2. Carbonic acid is converted to ______________________________
   3. Bicarbonate ions join _________________ to form _______________
   4. Bicarbonate ions _______ the red blood cell in exchange for ________
   5. Hemoglobin releases __________________________

5. Carbon Dioxide and Blood pH
   a. Blood pH refers to ____________________ not ____________________
   b. Carbonic anhydrase is found on _______________________________
   c. So in plasma carbon dioxide joins with _________________ to form _________________ which dissociates to form _________________ and _________________
   d. As carbon dioxide increases, hydrogen ions ________ & pH ________
   e. The respiratory system regulates blood pH by ______________________

VII. Rhythmic Ventilation

A. Respiratory Areas in the Brainstem
   1. The medullary respiratory center consists of:
      a. Two ________________________________________________
      b. Two ________________________________________________
   1. Communication exists between ______________________________
   2. Communication also exists between __________________________
   2. The dorsal respiratory groups are primarily responsible for ______________
      ______________
      a. The input they receive allows ______________________________
   3. The ventral respiratory group is a collection of neurons that are active during ______________ & ______________
      a. The neurons of the ventral respiratory group primarily stimulate:
         1. ______________________________
         2. ______________________________
         3. ______________________________
4. Functionally the pontine respiratory group has:
   a. Some of the neurons ____________________________
   b. Some of the neurons ____________________________
   c. Some of the neurons ____________________________
      1. Appears to play a role in ______________________

B. Generation of Rhythmic Ventilation

1. Starting inspiration:
   a. Neurons that promote inspiration are ____________________________
   b. The medullary respiratory center constantly receives input related to:
      1. Blood __________________
      2. Blood __________________
      3. Movements of ____________________ & ____________________
   c. The medullary respiratory center can also receive input from:
      1. Parts of brain concerned with ______________________________ &
          __________________
   d. Inspiration starts when the combined input from all sources causes the
      production of ____________________________

2. Increasing inspiration:
   a. What happens once inspiration begins? ____________________________
      ____________________________
   b. What does this do to the stimulation of respiratory muscles? _________
      ____________________________ lasts for ________________

3. Stopping inspiration:
   a. Neurons in the medullary respiratory center that are responsible for
      stopping inspiration:
      1. Are ____________________________ that stimulate the inspiratory muscles
      2. Also receive input from:
         a. Pontine ____________________________
         b. Stretch ____________________________ & probably other sources
   b. When these inhibitory neurons are activated, they inhibit ________________
      ____________________________
c. Relaxation of respiratory muscles results in ________________ that lasts ________________________________

VIII. Modification of Ventilation

A. Cerebral and Limbic System Control

1. A person can consciously increase or decrease the rate and depth of respiratory movements through the _________________

2. Apnea is ____________________________________________

3. When a person holds their breath they eventually develop an urge to breathe:
   a. This is associated with ________________________________
   b. Finally $P_{CO_2}$ is high enough that __________________________

4. If a person is able to hold their breath until they pass out due to lack of oxygen then _________________________________

5. What causes the feeling of dizziness when a person hyperventilates?
   ______________________________________________________________________________________
   ______________________________________________________________________________________
   ______________________________________________________________________________________

6. Emotions affect the respiratory system through the ________________ system

7. What kind of affects can strong emotions have on respiratory movements?
   ______________________________________________________________________________________

B. Chemical Control of Ventilation

1. Chemoreceptors
   a. What are chemoreceptors? ________________________________
   b. The chemoreceptors involved in respiration respond to changes in:
      1. ________________________________ OR
      2. ________________________________ or both
   c. Where are the central chemoreceptors located? ________________
      ______________________________________________________________________________________
   d. Where are the peripheral chemoreceptors located? ________________
      ______________________________________________________________________________________
2. Effect of pH
   a. Cerebrospinal fluid bathes the ______________________________
      1. The cerebrospinal fluid pH is altered by changes in ______________
      2. Therefore the ________________ is indirectly sensitive to blood pH
   b. The carotid and aortic bodies are directly sensitive to ________________
   c. If blood pH decreases:
      1. Respiratory center is ________________
      2. Results in ________________________ &
      3. ________________ in blood pH back to normal
   d. If blood pH increases:
      1. Respiratory rate ________________
      2. Carbon dioxide levels ________________
      3. Causing blood pH to ______________________________

3. Effect of Carbon Dioxide
   a. Blood carbon dioxide levels are a ______________________________
   b. Even a small increase in carbon dioxide triggers ________________
   c. What is hypercapnia? ______________________________
   d. What is hypocapnia? ______________________________
   e. Carbon dioxide exerts its effect on the chemosensitive area by
      ______________________________
   f. If blood carbon dioxide levels increase:
      1. Carbon dioxide diffuses ______________________________
      2. Carbon dioxide joins with water to form ____________________
         which then dissociates into:
         a. ______________________________
         b. ______________________________
      3. The increased concentration of ________________________ pH
         and stimulates the ________________________ which then
         stimulates the ______________________________
4. Resulting in ____________________________________________
5. This eliminates __________________ from the body

  g. The carotid and aortic bodies also respond to changes in carbon dioxide
     because of ________________________________

  h. Which is most important for regulating P\text{CO}_2 and pH? ________________

  i. During intense exercise which responds fastest? ________________

4. Effect of Oxygen
  
    a. What is hypoxia? ___________________________________________
    
    b. The effect of oxygen on the regulation of respiration is ______________
    
    c. Arterial P\text{O}_2 must decrease to approximately ______________
       to have a large stimulatory effect on respiratory movements
    
    d. Why is a small change in P\text{O}_2 not a problem? ________________
       _______________________________________________________
    
    e. The carotid and aortic body chemoreceptors respond to decreased P\text{O}_2 by
       _______________________________________________________

C. Hering-Breuer Reflex
  
    1. What does the Hering-Breuer reflex accomplish? ________________
       _______________________________________________________
    
    2. The reflex depends on stretch receptors in the _________________
    
    3. Action potentials are initiated in the stretch receptors when ______________
       _______________________________________________________
    
    4. The action potentials reach the medulla via the _______________
    
    5. The action potentials have an ________________ on the respiratory
       center and result in ______________________________
    
    6. With expiration the stretch receptors are __________________________
    
    7. The decreased inhibitory effect on the respiratory center allows
       _______________________________________________________

IX. Respiratory Adaptations to Exercise
  
    A. In response to training:
    
    1. Vital capacity _______________________________

2. Residual volume ______________________________
3. At rest tidal volume ______________________________
4. At maximal exercise tidal volume ______________________________
5. At rest respiratory rate is ______________________________
6. At maximal exercise respiratory rate is ______________________________
7. Minute ventilation at rest is ______________________________
8. Minute ventilation at maximal exercise is ______________________________
9. Blood flow through the lungs is _________ especially in the _________

X. Effects of Aging on the Respiratory System

A. Vital capacity decreases with age because of a:
   1. Decreased ability to ______________________________ &
   2. Decreased ability to ______________________________
      a. As a result maximum minute ventilation rates __________________
   3. The changes are related to:
      a. Weakening ______________________________
      b. Decreased ______________________________ caused by ______________________________

B. Residual volume increases with age as the __________________________ and many __________________________ in diameter
   1. This __________________________ the dead space
      a. Which __________________________ the amount of air available for gas exchange

C. Gas exchange across the respiratory membrane is reduced because:
   1. Parts of the ______________________________ which decreases the ______________________________
   2. The remaining walls __________________________, which decreases ______________________________

D. Elderly are more susceptible to respiratory infections and bronchitis because:
   1. Mucus ______________________________
   2. The mucus-cilia escalator is less able to move the mucus because:
      a. The mucus ______________________________
b. The number ______________________________ & their rate of
_______________________________