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 ______________________________

g. 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. _______________________________________________________
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
      during ______________________________
   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\textsubscript{O\textsubscript{2}}) is higher in ________________
      than the ________________
   d. Normally the partial pressure of carbon dioxide (P\textsubscript{CO\textsubscript{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 Po₂ 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 \( P_{O2} \) within the alveoli averages approximately ________________
2. The \( P_{O2} \) of the blood as it flows into pulmonary capillaries is ________________
   a. Therefore, oxygen diffuses from ________________ into ________________
3. Does the blood \( P_{O2} \) ever reach equilibrium with the alveoli \( P_{O2} \)? ____________
4. Blood leaving the pulmonary capillaries has a \( P_{O2} \) of ________________
   but blood leaving the lungs in the pulmonary veins has a \( P_{O2} \) of ___________
   a. What causes this decrease in \( P_{O2} \)? ______________________________
   ___________________________________________________________
5. The \( P_{O2} \) of blood entering tissue capillaries is approximately ____________
6. The \( P_{O2} \) of the interstitial spaces is close to ____________________
7. The \( P_{O2} \) 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 \( P_{CO2} \) is approximately ________________
   2. The interstitial fluid \( P_{CO2} \) is approximately ________________
   3. The blood entering the tissue capillaries has a \( P_{CO2} \) of ________________
      a. Therefore, carbon dioxide diffuses from ________________
      to ______________________________
   c. As the blood leaves the tissue capillaries it has a \( P_{CO2} \) of ___________
2. At the lungs:
   a. The \( P_{CO2} \) of blood entering the pulmonary capillaries is ________________
b. The P\textsubscript{CO}_2 of the alveoli is approximately \______________
   1. Therefore, carbon dioxide diffuses from \______________ into
       \______________
   c. The P\textsubscript{CO}_2 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 P\textsubscript{O}_2
   a. What is the oxygen-hemoglobin dissociation curve? \______________
   b. When is hemoglobin saturated with oxygen? \______________
   c. At any P\textsubscript{O}_2 above 80 mm Hg the hemoglobin is about \______
      saturated
   d. At the P\textsubscript{O}_2 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 P\textsubscript{O}_2 of \______________
         1. Therefore the hemoglobin released \________
            of the oxygen
   f. During vigorous exercise the blood P\textsubscript{O}_2 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 P\textsubscript{O}_2
      \______________ and \______________

4. Effect of pH, P\textsubscript{CO}_2, 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\textsubscript{CO\textsubscript{2}}
   1. An increase in P\textsubscript{CO\textsubscript{2}} _________________ 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 _________
6. 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? _________
       __________________________________________

f. What happens to BPG levels in stored blood? _________________

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
g______________ 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\textsubscript{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\textsubscript{O}_2 must decrease to approximately ________________
      to have a large stimulatory effect on respiratory movements
   d. Why is a small change in P\textsubscript{O}_2 not a problem? ________________
   e. The carotid and aortic body chemoreceptors respond to decreased P\textsubscript{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
____________________________