

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. _____

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. _____

- b. _____

- c. _____

- d. _____

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_{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 PO_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 P_{O_2} within the alveoli averages approximately _____
2. The P_{O_2} of the blood as it flows into pulmonary capillaries is _____
 - a. Therefore, oxygen diffuses from _____ into _____
3. Does the blood P_{O_2} ever reach equilibrium with the alveoli P_{O_2} ? _____
4. Blood leaving the pulmonary capillaries has a P_{O_2} of _____ but blood leaving the lungs in the pulmonary veins has a P_{O_2} of _____
 - a. What causes this decrease in P_{O_2} ? _____
5. The P_{O_2} of blood entering tissue capillaries is approximately _____
6. The P_{O_2} of the interstitial spaces is close to _____
7. The P_{O_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 P_{CO_2} is approximately _____
 2. The interstitial fluid P_{CO_2} is approximately _____
 3. The blood entering the tissue capillaries has a P_{CO_2} of _____
 - a. Therefore, carbon dioxide diffuses from _____ to _____
 - c. As the blood leaves the tissue capillaries it has a P_{CO_2} of _____
 2. At the lungs:
 - a. The P_{CO_2} of blood entering the pulmonary capillaries is _____

- b. The P_{CO_2} of the alveoli is approximately _____
1. Therefore, carbon dioxide diffuses from _____ into _____

- c. The P_{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_{O_2}
 - a. What is the oxygen-hemoglobin dissociation curve? _____

 - b. When is hemoglobin saturated with oxygen? _____

 - c. At any P_{O_2} above 80 mm Hg the hemoglobin is about _____ saturated
 - d. At the P_{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_{O_2} of _____
 - a. At this P_{O_2} the hemoglobin is approximately _____ saturated
 1. Therefore the hemoglobin released _____ of the oxygen
 - f. During vigorous exercise the blood P_{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_{O_2} _____ and _____
4. Effect of pH, P_{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_{CO_2}
1. An increase in P_{CO_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 _____

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 _____
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_{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_{O_2} must decrease to approximately _____ to have a large stimulatory effect on respiratory movements
 - d. Why is a small change in P_{O_2} not a problem? _____
 - e. The carotid and aortic body chemoreceptors respond to decreased P_{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
