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? _____

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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 _____

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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 _____

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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 _____

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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. _____

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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. _____

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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 _____

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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

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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:

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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? _____

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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 coeffiecient? _____
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? _____

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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 _____

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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_{O_2} in one portion of the lung:
    a. Causes arterioles to _____ blood flow
    b. This reroutes blood _____

_____

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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 _____

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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

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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.

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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 _____

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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 _____ _____

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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? _____

      _____

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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 _____

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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 _____

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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 _____

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b. The number _____ & their rate of

_____

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