Amerman Active-Learning Workbook: Chapter 21 Answers

Key Concept: What is respiration? Which processes make up respiration?
Respiration is the process that provides the body's cells with oxygen and removes the waste product carbon dioxide. Its processes include pulmonary ventilation, pulmonary gas exchange, gas transport in the blood, and tissue gas exchange.

Key Concept: What are the other functions of the respiratory system and how do they help maintain homeostasis?
Other functions of the respiratory system include producing speech, detecting odors, helping to expel contents of the abdominopelvic cavity (e.g. childbirth), assisting in the flow of venous blood and lymph, and assisting in the production of angiotensin-II. The last two functions are important for maintenance of blood pressure and fluid homeostasis. Also, the respiratory system helps maintain acid-base homeostasis though regulation of CO_2 levels.

Key Concept: Where are the paranasal sinuses located? What are their functions? Could they perform these functions if they were lined with stratified squamous epithelium instead of respiratory epithelium?
The paranasal sinuses are hollow cavities located within the frontal, ethmoid, sphenoid, and maxillary bones. They lighten the skull, enhance voice resonance, and warm, humidify, and filter the air. Respiratory epithelium with its cilia and mucus-producing goblet cells do the work of trapping foreign particles and pushing them toward the posterior nasal cavity. Stratified squamous epithelium would have no such filtering ability.

Key Concept: What delineates the three different regions of the pharynx? How do they differ, structurally and functionally?
The different regions of the pharynx are designated for the cavity or structure with which they are most closely associated. The nasopharynx is posterior to the nasal cavity, is lined with respiratory epithelium, and functions similarly to the nasal cavity in warming, humidifying and filtering air. The oropharynx is located posterior to the oral cavity, and is lined with stratified squamous epithelium since it is exposed to friction as a common tube for both food and air. The laryngopharynx is close to the larynx, extends from the hyoid bone to the esophagus, and is structurally and functionally similar to the oropharynx.

Key Concept: How does the change in tension on the vocal cords and the size of the glottis affect the loudness and pitch of the sound produced?

The tension of the vocal ligaments and the speed of their vibration contribute to pitch, as more tightly pulled vocal ligaments produce a higher pitch, and loosely pulled vocal ligaments produce a lower pitch. The loudness of the sound is mostly determined by the force of the airstream, but closing the glottis may play a role in reducing sound volume.

Key Concept: Which structures make up the respiratory membrane? Would the function of the membrane change if it were to become thicker? How?
The respiratory membrane is made of the simple squamous epithelium of the alveolus and the endothelium of the pulmonary capillary. As it is the divider through which gases diffuse, a thin membrane functions better than a thicker one.

Key Concept: What is a pressure gradient? How do pressure gradients drive the movement of gases into and out of the lungs?
A pressure gradient is the difference in pressure between two areas. Gas molecules move from areas of higher pressure to areas of lower pressure. So, when pressure is lower in the lungs, air moves in, and when pressure is higher in the lungs, air moves out.

Complete It: Overview of Pulmonary Ventilation

Fill in the blanks to complete the following paragraphs that describe the basic principles of pulmonary ventilation.
The main inspiratory muscle is the diaphragm. It creates a pressure gradient when it contracts by increasing the volume of the lungs, which decreases the pressure in the lungs. When the pressure in the lungs, or the intrapulmonary pressure, falls below atmospheric pressure, air enters the lungs via inspiration. During forced inspiration, other muscles called external intercostals assist in the process.
The process of expiration is largely passive due to the lungs' elastic recoil. This causes the volume of the lungs to decrease, which increases intrapulmonary pressure. When intrapulmonary pressure is higher than atmospheric pressure, expiration occurs.

Key Concept: Why is intrapleural pressure slightly lower than intrapulmonary pressure? What happens if it rises above intrapulmonary pressure?
Intrapleural pressure is slightly lower than intrapulmonary pressure because of the slight suction effect created by the tendency of the lung to recoil and the chest wall to expand, and because of the slight vacuum created when pleural fluid is lost to the lymphatic vessels. If intrapleural pressure was above intrapulmonary pressure, we would lose the suction effect that prevents the lungs from collapsing.

Key Concept: What are the three physical factors that influence ventilation? How does each influence the efficiency of ventilation?

The three physical factors that influence ventilation are airway resistance, alveolar surface tension, and pulmonary compliance. Airway resistance is impedance to air flow, and any increase in airway resistance decreases the effectiveness of pulmonary ventilation. Alveolar surface tension is the force of attraction between moist surfaces due to hydrogen bonding between water molecules. This tends to collapse the alveoli and decreases the effectiveness of pulmonary ventilation unless sufficient surfactant reduces alveolar surface tension. Pulmonary compliance refers to the ability of the lungs to stretch. If pulmonary compliance decreases, the lungs are less able to expand, and decreases the effectiveness of pulmonary ventilation.

Complete It: The Behavior of Gases

Fill in the blanks to complete the following paragraphs that describe the behavior of gases and relevant gas laws.

Each gas in a mixture exerts its own pressure on the mixture, which is known as partial pressure. The partial pressures of gases in a mixture determine whether the gases will move by diffusion—gases move from an area of high pressure to an area of low pressure, following a pressure gradient. A second relevant gas law is Henry's law, which states that a gas' ability to dissolve in a liquid is proportional to its partial pressure and its solubility in the liquid. Henry's law helps to explain why we find very little nitrogen gas in plasma in spite of its high partial pressure in the air we breathe.

During pulmonary gas exchange, oxygen moves from an area of higher partial pressure in the alveolus to an area of lower partial pressure in the pulmonary capillaries. Carbon dioxide moves in the opposite direction, going from an area of higher partial pressure in the pulmonary capillaries to an area of lower partial pressure in the alveolus. In the tissues, the opposite occurs, with oxygen moving from a high partial pressure in the systemic capillaries to an area of low partial pressure in the tissues, and carbon dioxide moving from an area of high partial pressure in the tissues to an area of low partial pressure in the systemic capillaries.

Key Concept: In which direction would oxygen diffuse if its partial pressure in the blood were 40 mm Hg and its partial pressure in the alveoli were 35 mm Hg? How would this affect homeostasis overall?

Oxygen would diffuse out of the blood and into the alveoli instead of the expected reverse of that. Although blood does still have significant amounts of oxygen bound to hemoglobin at 35 mmHg, oxygen supply to active tissues may be inadequate if this situation persists.

Key Concept: Why is most oxygen transported on hemoglobin?
Oxygen has relatively low water solubility, yet demand for oxygen by most metabolically active tissues is very high. Hemoglobin is a specialized molecule that quickly absorbs and transports oxygen that would otherwise be inadequately dissolved in blood.

Key Concept: How does the percent saturation of hemoglobin affect hemoglobin's ability to unload oxygen? Why is this important to maintaining homeostasis?
The oxygen-hemoglobin dissociation curve suggests that hemoglobin unloads relatively little oxygen at higher P_{O2} levels where it is more fully saturated, and unloads oxygen rapidly at lower P_{O2} levels. This helps ensure that tissues that are low in oxygen will rapidly receive the oxygen they need.

Key Concept: Why does the carbon dioxide level of the blood influence the pH of the blood and body fluids?
Carbon dioxide reacts with water to form carbonic acid. Therefore high levels of carbon dioxide would be related to increased acidity.

Key Concept: What is the respiratory rhythm generator? Which nuclei work with the RRG to maintain eupnea?
The respiratory rhythm generator is a collection of neurons in the medulla oblongata that generates the basic rhythm for breathing. The ventral respiratory group nuclei and dorsal respiratory group nuclei are the main nuclei associated with respiratory rhythm.

Key Concept: Why is carbon dioxide such an important stimulus for the central chemoreceptors?
Carbon dioxide can react with water to form carbonic acid. Although hydrogen ions do not readily cross the blood-brain barrier, carbon dioxide can, and can lower the pH of CSF. Therefore, it is arterial carbon dioxide rather arterial H^+ that can influence the pH of CSF and result in stimulation of central chemoreceptors.

Key Concept: What is the key difference between a restrictive and an obstructive respiratory disease?
Restrictive lung diseases decrease pulmonary compliance and reduce the effectiveness of inspiration. Obstructive lung diseases increase airway resistance and typically decrease the efficiency of expiration.