THE RESPIRATORY SYSTEM

INTRODUCTION

Respiration* is a physical process by which living organisms inhale oxygen from the surrounding atmosphere and then exhale carbon dioxide. The respiratory system is made up of organs that deliver oxygen to the circulatory system for transport to the cells in the animal’s body. The most critical requirement of life support to an animal is oxygen. An animal may be able to survive several weeks without food or several days without water, but when it comes to trying to survive without oxygen, the period is measured in several minutes. The major functions of the respiratory system are providing oxygen to tissues and cells and removing carbon dioxide from the body. Other important functions include controlling body temperature, eliminating water (as vapor), and aiding in voice production. The respiratory system of animals includes the lungs and the passages that provide transportation of air into the lungs. These passages include the nostrils, nasal cavity (chamber), pharynx, larynx, trachea, and bronchial tubes.

ANATOMY OF THE RESPIRATORY SYSTEM

The organs of the respiratory system extend from the nasal opening (nose) to the lungs. They are divided into two parts - the upper and lower respiratory tracts. The upper respiratory tract consists of the nostrils, nasal cavity, and pharynx, whereas the lower respiratory tract contains the larynx, trachea, bronchial tubes, and lungs.

* Underlined words are defined in the Glossary of Terms.
The muzzle of most domesticated animals is made up of the nose and lips. It holds the nostrils, the external openings of the respiratory tract that lead into the nasal cavity. The shape and size of the nostrils vary in most animals. The soft expandable nostrils and muzzle of the horse allow it to inhale and exhale large quantities of air when needed and is quite sensitive to the touch. It contains many oil glands as well as sweat glands. The snout of swine is much more rigid and does not contain any oil glands. The muzzle of cattle and sheep also do not contain oil glands, however, they do contain many sweat glands. If cattle have dry muzzles, they are often feverish.

The nasal cavity is separated from the mouth by a hard and soft palate. It is divided into two halves by a central structure of cartilage. The front of the nasal cavity is an extension of the nostrils. The rear portion of the nasal cavity is connected to the pharynx. The nasal passages are lined with a membrane composed primarily of one layer of epithelial cells. Each epithelial cell is lined with thousands of microscopic cilia (finger-like extensions). The nasal passages also contain cells that produce mucus to coat the epithelial cells and cilia. After the animal takes a breath and the air comes into the nasal cavities, the cilia and mucus filter the air to remove potential disease-causing particles. The mucus-coated cells and cilia also moisten and warm the air to protect other structures within the respiratory system. In addition to their role in the respiratory system, the nasal passages house cells (called olfactory receptors) involved with the sense of smell. These olfactory receptors are found in the turbinate bones, which are located toward the rear of the nasal cavity.

The sinuses are air-filled cavities in the bones of the animal’s forehead. They are connected to the nasal cavities. The sinuses in domestic animals include the maxillary, frontal, sphenoidal, and palatine sinuses. They are contained in the respective bones of the same name. Cattle and sheep have an additional pair of sinuses (called lacrimal sinuses) located in the lacrimal bones. When mature cattle are dehorned, the frontal sinuses may be opened to the atmosphere. This is because the frontal sinus cavities extend into the horn cores. Foreign materials falling into these openings may cause sinus infections.
As air leaves the nasal passages and flows further into the respiratory tract, it passes through the pharynx. The pharynx is a short, funnel-shaped tube that transports air into the larynx. The pharynx serves as a common passageway for air and food. However, air and food cannot pass through the pharynx at the same time. The epiglottis keeps this from happening. The epiglottis is a valve-like flap of tissue above the trachea that prevents food from entering the trachea and lungs. The epiglottis closes the air passage when the animal is swallowing feed. Several structures empty into the pharynx. These include the two rear openings of the nasal cavity, the mouth, the two eustachian tubes from the middle ear, the esophagus, and the larynx. Similar to the nasal passages, the pharynx is lined with a mucous membrane and ciliated cells that remove more impurities from the air.

The larynx (voice box) of animals is essential for voice production and is located in the middle of the animal’s neck. The larynx also controls breathing and prevents the inhalation of foreign objects into the lungs. In cattle and horses, five large structures composed of cartilage form the larynx. The body of one of the five cartilages, the thyroid cartilage, is commonly called the Adam’s apple. Two of the other cartilages, called the arytenoid cartilages, assist in closing the epiglottis. These two cartilages also tighten or loosen the vocal chords, thus controlling the pitch of the voice. The cricoid cartilage helps maintain the shape of the larynx and provides attachment for many of the muscles in the larynx.

The continuation of the larynx is the trachea (windpipe). The trachea consists of a series of adjacent cartilage rings, similar to the flexible hose of a vacuum cleaner. These cartilage rings are rigid and prevent collapse of the trachea. The trachea enters the chest cavity as a single tube. It extends to a level above the base of the heart where it divides into two branches called primary bronchi. Each of the bronchi passes into one of the lungs. Inside the lungs, the bronchi branch out even further into branches that are called bronchioles. The trachea, bronchi, and the first few bronchioles contribute to the cleansing function of the respiratory system, as they are lined with mucous membranes and ciliated cells.

The bronchioles also divide many more times into smaller branches called intralobular bronchioles, terminal bronchioles, and respiratory bronchioles. The respiratory bronchioles dead-end into tiny air sacs called alveoli (the smallest and final air passageways of the respiratory system). The alveolar walls are the closest air passages to the capillaries of the pulmonary circulatory system. Oxygen is diffused from the alveoli into the bloodstream where it is attached to the red blood cells. Carbon dioxide is diffused from the bloodstream into the alveoli so it can be exhaled out of the body. The exchange of oxygen and carbon dioxide between the bloodstream and body cells is also accomplished by diffusion.

The lungs in mammals consist of elastic, spongy material that greatly expands when filled with air. When the lungs are expanded to total capacity, they completely fill the thoracic or chest cavity. The lungs are cone-shaped and may be incompletely divided into several lobes by deep fissures on the bottom side. In cattle, sheep, and swine, the left lung is divided into three lobes, the apical, cardiac, and diaphragmatic lobes. The right lung has an additional lobe called the intermediate lobe. Lungs in horses have only the intermediate lobe on the right side.

The bronchi, pulmonary artery, and nerves enter the lungs at the same location. The pulmonary veins and lymph vessels also connect to the lungs in this area. Once an animal has taken its first breath, the lungs will never completely collapse and will float in water. Therefore, if the lungs of a newborn sink in water, the newborn was born dead.

A smooth membrane, called the pleura, aids movement of the lungs within the rib cage. The pleura consists of a single layer of mesothelial cells, which are on top of a layer of connective tissue that surrounds each lung. The two sacs that enclose the lungs join to form a double layer of pleura called the mediastinum. The cavity between the two lungs is called the mediastinal space.
The pleura is classified into three types, the parietal pleura, the visceral pleura, and the mediastinal pleura. The parietal pleura lines the thorax, the visceral pleura covers the lungs, and the mediastinal pleural forms the mediastinal space. The space between the three types of pleura, called the pleural cavity, contains nothing but a small amount of fluid. This fluid is used for lubrication of the structures in the chest cavity.

Birds differ from mammals in that their lungs are relatively nonexpandable. Furthermore, birds have accessory air sacs that aid in respiration and add to their ability to float on water. Chickens have nine accessory air sacs and perforations in their long bones (forearms).

**PHYSIOLOGY OF THE RESPIRATORY SYSTEM**

Exchange of gases with the atmosphere is the primary function of the lungs. The gas absorbed by the capillaries from the alveoli during inhalation is oxygen. The gas absorbed from the capillaries by the alveoli during exhalation is carbon dioxide. This is called external respiration because it involves an exchange of gases from outside of the animal’s body. The thin walls of the alveoli and capillaries in the lungs allow for this exchange. Internal respiration refers to the removal of carbon dioxide wastes from body cells to the capillaries. It also includes the absorption of oxygen by the body cells from the capillaries.
Inspiration, or inhaling of air, is accomplished by the contraction of the diaphragm muscles and the enlargement of the thoracic cavity, creating a vacuum. Because of this action, the lungs expand and draw in air. The diaphragm is a dome-shaped structure with the convex side extending into the thorax. When contracted, it expands the thorax to satisfy the need of quiet respiration. This type of respiration, called abdominal or diaphragmatic respiration, causes visible movement of the abdomen. When contracted, the smooth muscles of the diaphragm push the abdominal contents to the rear of the animal. This process creates more thoracic space. A partial vacuum normally exists in the pleural cavity of the thorax. The vacuum is destroyed if the cavity is punctured, resulting in collapse of the lungs.

During labored inspiration, contraction of the muscles connecting the ribs to the front segments of the animal’s body causes the ribs to rotate out and forward. This action increases the capacity of the thorax. The respiratory system is controlled primarily by striated, voluntary muscles. However, the exceptions are the smooth muscles in the walls of blood vessels and the walls of air passages. Respiration, to a degree, is under conscious control, that is, an animal can hold its breath. However, respiration is usually a reflex or automatic process.

If carbon monoxide is inhaled, it will unite with the iron of hemoglobin and prevent the carrying of oxygen. This condition will result in death, caused by lack of oxygen (suffocation). Other chemicals that interfere with respiration include nitrates, chlorates, cyanide, and prussic acid. Artificial respiration, accomplished by rhythmic pressing on the chest cavity, may be helpful when breathing ceases. This may be true in the case of newborns, animals struck by lightning, or animals receiving an overdose of anesthetics or tranquilizers.

Expiration, or exhaling of air, is accomplished by relaxation of the diaphragm muscles and contraction of the chest muscles. Retraction of alveolar elastic fibers also aids in expiration. The abdominal muscles contract forcing the viscera against the diaphragm. This causes the diaphragm to be pushed into the thoracic cavity, thus reducing the size of the cavity. This decreases the capacity of the thorax and helps force air out of the lungs. The elastic tissue of the alveoli naturally returns to its shape, also forcing air out of the lungs. A strong expiratory effort made with the epiglottis closed assists the animal in defecation, urination, or the birth of young.

Differences in respiratory rates of animals are controlled by nerve cells in a portion of the brain called the medulla. This region of the brain, which controls the rate at which air is inhaled and exhaled, is commonly called the respiratory center. There are at least three groups of bilateral nerves that control the respiratory system. These include inspiratory nerves, expiratory nerves, and pneumotaxic nerves. When stimulated, the expiratory center causes contraction of the inspiratory muscles and, therefore, it causes inspiration. The expiratory center causes inspiration to stop and, therefore, it causes expiration or exhaling to occur.

The pneumotaxic center is located in the pons of the lower brain and is connected to the inspiratory center. It also inhibits the inhaling of air. The pneumotaxic center is stimulated by the inspiratory center during inspiration. Consequently, it stimulates the expiratory center resulting in expiration. The rate at which the brain stimulates breathing is influenced by several factors. These include the carbon dioxide content of the blood, body temperature, and messages from other parts of the brain. Increased body temperature increases the breathing rate in animals. Increased acidity in the blood, caused by greater concentrations of carbon dioxide, also results in an increased respiratory rate.
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REFERENCES


GLOSSARY OF TERMS

Bilateral – Affecting two sides of a body.

Convex – Outward (such as the outer surface of a sphere).

Defecation – Elimination of fecal material from the rectum of animals.

Diffusion – Intermingling of the molecules of two or more substances.

Hemoglobin – Red pigment in red blood cells of animals that carries oxygen from the lungs to other body parts.

Mesothelial cells – Cellular membrane tissue that lines most body cavities.

Respiration – Act or process of inhaling and exhaling; breathing.

Viscera – Internal organs of an animal’s body usually are referring to organs in the chest cavity or abdomen (e.g., the heart, lungs, stomach, and intestines).
SELECTED STUDENT ACTIVITIES

SHORT ANSWER/LISTING: Answer the following questions or statements in the space provided or on additional paper.

1. Name four functions of the respiratory system.
   a. _______________________________
   b. _______________________________
   c. _______________________________
   d. _______________________________

2. Name the seven major parts of the respiratory system.
   a. _______________________________
   b. _______________________________
   c. _______________________________
   d. _______________________________
   e. _______________________________
   f. _______________________________
   g. _______________________________

3. What is the purpose of the mucous membranes and cilia inside the nasal passages?
   ___________________________________________________________________________
   ___________________________________________________________________________

MATCHING: Match the term in the left column with its definition in the right column.

   ___ 4. alveoli  a. consists of elastic, spongy material that is expandable
   ___ 5. sinuses  b. final air passageway whose walls allow exchange of
   __  6. nasal cavity c. voice box that controls breathing and prevents inhalation
   __  7. primary bronchi d. contains structures that warm the inhaled air
   __  8. larynx   e. the smaller branches of the bronchi
   __  9. trachea   f. air-filled cavities in the bones of the animal’s forehead
   __ 10. nostrils  g. short, funnel-shaped tube that serves as a common
   __ 11. bronchioles h. two large air passageways that branch from the trachea
   __ 12. pharynx  i. external openings of the respiratory system
   __ 13. lungs   j. valve-like tissue that closes the respiratory tract when
   __ 14. epiglottis k. the windpipe and is given form by a series of rings of
cartilage to prevent it from collapsing

SHORT ANSWER: Answer the following questions or statements in the space provided or on additional paper.

15. How can a recently dehorned, mature cow get a sinus infection?
   ___________________________________________________________________________
16. How do birds’ respiratory systems differ from those of mammals?
____________________________________________________________________________
____________________________________________________________________________

17. What is the primary function of the lungs?
____________________________________________________________________________
____________________________________________________________________________

18. Define the process of inspiration and explain how it is accomplished.
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

19. Define the process of expiration and explain how it is accomplished.
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____________________________________________________________________________
____________________________________________________________________________

20. What controls the respiratory rate of an animal?
____________________________________________________________________________
____________________________________________________________________________
____________________________________________________________________________

ADVANCED ACTIVITIES

1. Research the respiratory system in other available information resources for an animal species (e.g., search the Internet for “respiratory system AND poultry”). Then, in your own words, explain the respiratory system’s function for the animal species. Explain the relationship between the respiratory system and other body organ systems of the animal species.

2. In this topic, you learned that carbon dioxide and oxygen are exchanged in the bloodstream and body cells by the process of diffusion. Conduct further research to determine specifically how diffusion occurs.

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