Avian Respiratory System

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Respiratory diseases are the most common cause of death in a poultry flock. Knowledge of the avian respiratory system is essential for developing a health monitoring plan for a poultry flock, recognizing problems that may occur, and taking action to correct them.

The avian respiratory system is involved in the following functions:

- absorption of oxygen (O2)
- release of carbon dioxide (CO2)
- release of heat (temperature regulation)
- detoxification of certain chemicals
- rapid adjustments of acid/base balance
- vocalization

An understanding of the functions of the respiratory system begins with an understanding of the parts of the respiratory system.

Parts of the Chicken Respiratory System

As with any avian respiratory system, the chicken respiratory system (shown in Figure 1) begins at the head region. Parts of the respiratory system in this region include the nasal openings and nasal cavities and the pharyngeal region of the mouth. The **cranial larynx** (sometimes referred to as the **superior larynx** or **glottis**), located in this pharyngeal region, is the opening to the **trachea** (windpipe). The pharyngeal region also has the openings of the esophagus. The cranial larynx is normally open to allow air passage, but it closes when feed is passing down the throat so that the feed goes down the esophagus and does not enter the trachea.

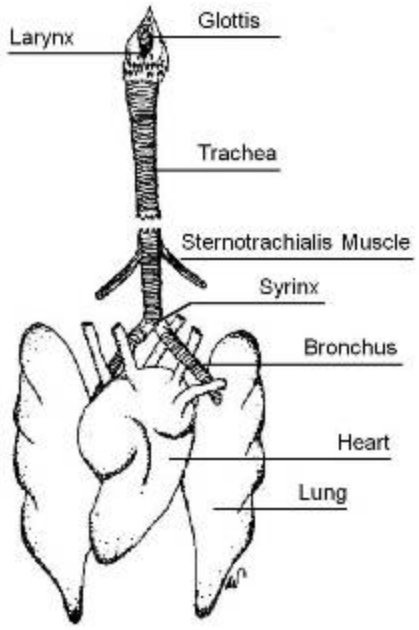
Fig. 1. Chicken respiratory system. Source: Public domain.

After air passes through the cranial larynx, it continues through the trachea. The trachea is made up of cartilaginous rings that keep it from collapsing due to the negative pressure present when a chicken breathes in air.

The **syrinx** (or **caudal larynx**), located near the end of the trachea, is the chicken'svoice box. A chicken does not have vocal cords to produce sound. Instead, a chicken's "voice" is produced by air pressure on a valve and modified by muscle tension. It is not possible to remove the syrinx to prevent chickens from crowing.

After the syrinx, the trachea divides into two much narrower tubes called **bronchi**. In some respiratory diseases, tracheal plugs form and physically block the respiratory tract at the junction of the bronchi, thus suffocating the chicken.

Each bronchus (singular of *bronchi*) enters a **lung**. Chickenlungs are relatively small, are firmly attached to the ribs, and do not expand. Birds have an incomplete diaphragm and chest muscles and a sternum (keel) that do not lend themselves to expansion in the way that a mammal's chest muscles and sternum do. Consequently, a bird's lungs operate differently from those of a mammal. Mammalian lungs contain many bronchi that lead to small sacs called alveoli. Because an alveolus (singular of *alveoli*) has only one opening, air flows into and out of the alveolus but not through it to the outside of the lung. In comparison, air passes through a bird's lungs in one direction. (In fact, the mammalian respiratory system is described as tidal because air goes in and out like the tide, whereas the avian respiratory system is described as nontidal.)



A bird's lungs contain **parabronchi**, which are continuous tubes that allow air to pass through the lung in one direction, and **air sacs**. The parabronchi are laced with blood capillaries, and it is here that gas exchange occurs. The air sacs, which fill a large proportion of the chest and abdominal cavity of a bird, are balloon-like structures at the ends of the airway system. The key to the avian respiratory system is that air moves in and out through distention and compression of the air sacs, not the lungs. The air sacs act as bellows to suck air in and blow it out and to hold part of the total air volume. At any given moment, air may be flowing into and out of the lung and being "parked" in the air sacs.

Air sacs are somewhat unique to avian species, found elsewhere only in certain reptiles. In the chicken, there are nine such sacs: an unpaired one in the cervical area, two interclavicular air sacs, two abdominal air sacs, two anterior thoracic air sacs, and two posterior thoracic air sacs.

Another important feature of the avian respiratory system is also part of the avian skeletal system. Some of a bird's bones are hollow. The air sacs in a bird's lungs connect to the air spaces in these bones, and the bones then act as part of the avian respiratory system. They are called **pneumatic bones** and include the skull, humerus, clavicle, keel, pelvic girdle, and lumbar and sacral vertebrae. A broken pneumatic bone can cause a bird to have difficulty breathing.

Dangers to the Chicken Respiratory System

As part of the avian immune system, the chicken respiratory tract normally is equipped with defense mechanisms to prevent or limit infection by airborne disease agents, to remove inhaled particles, and to keep the airways clean. Specifically, chicken respiratory health is protected by the function of three defensive mechanisms: **cilia**, **mucus** secretions, and the presence of **scavenging cells** that consume bacteria. Cilia are tiny hairlike structures in the trachea that are responsible for propelling entrapped particles for disposal. Mucus is produced in the trachea. Mucus secretions and movement of cilia are well developed in chickens. The consistency of the mucus produced is important for the efficiency of the ciliary activity. Cilia cannot function when the mucus is too thick. Scavenging cells in the lungs actively scavenge inhaled particles and bacteria that gain entrance to the lower respiratory tract. These cells consume bacteria and kill them, thus preventing their further spread. The integration of cilia, mucus, and scavenging cells keeps chicken airways free of disease-producing organisms. The impairment of even one of these components permits an accumulation of disease agents in the respiratory tract and may result in disease.

The defense mechanisms of the chicken respiratory system are important because with each breath, a chicken's respiratory tract is exposed to the inside environment of a poultry house. Poor environments normally do not cause disease directly, but they do reduce chickens' defenses, making them more susceptible to infection from existing viruses and pathogens. The air of poultry houses can contain aerosol particles—dust originating from the floor litter, feed, dried manure, and skin and feathers of the chickens. These aerosol particles can have a range of adverse effects on poultry. They act as an irritant to the respiratory system, and coughing is a physiological response designed to remove them. However, excessive coughing lowers a chicken's resistance to disease. Aerosol particles often collect inside chickens and can increase carcass condemnation at the processing plant. Excessive dust in the air also is believed to result in the formation of caseous tracheal plugs, which adversely affect chickens' health.

In addition to the aerosol particles in a poultry house, gases are generated from decomposing poultry waste, emissions from the chickens, and improperly maintained or installed equipment, such as gas burners. Harmful gases most often found in poultry houses are ammonia (NH_3) and carbon dioxide (CO_2). Research has shown that as little as 10 ppm of ammonia causes excessive mucus production and damages the cilia. Research also has revealed that ammonia levels of 10 to 40 ppm reduce the clearance of *E. coli* from a chicken's air sacs, lungs, and trachea.

Another danger to the chicken respiratory system has nothing to do with what the bird takes into its system. Because birds do not have a diaphragm, they depend on some movement of the sternum and rib cage to breathe. Holding a bird too tightly restricts movement of the rib cage and can suffocate the bird. This often happens when young children hold baby chicks.

Animation of the biomechanics of avian flight has a good overview of the avian respiratory system. It follows an animation of the adaptions of the skeletal system for flight.