

THE RESPIRATORY SYSTEM OF BIRDS

Due to the high metabolic rate required for flight, birds have a high oxygen demand. Development of an efficient respiratory system enabled the evolution of flight in birds. Birds ventilate their lungs by means of air sacs, structures unique to birds, and perhaps dinosaurs, too.

These sacs do not play a direct role in gas exchange, but are used to store air and act like bellows, allowing the lungs to maintain a fixed volume with fresh air constantly flowing through them.

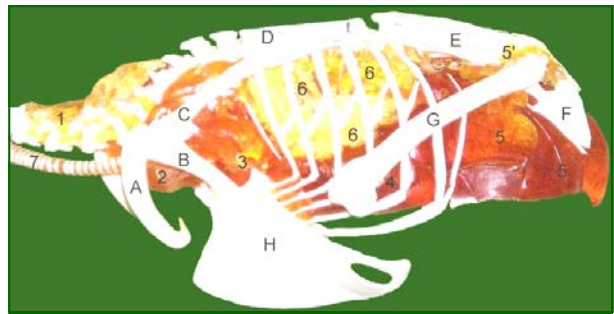
Three distinct sets of organs perform respiration—the anterior air sacs (interclavicular, cervicals, and anterior thoracics), the lungs, and the posterior air sacs (posterior thoracics and abdominals). The posterior and anterior air sacs, typically nine, expand during inhalation. Air enters the bird via the trachea. Half of the inhaled air enters the posterior air sacs, the other half passes through the lungs and into the anterior air sacs. Air from the anterior air sacs empties directly into the trachea and out the bird's mouth or nares (nostrils). The posterior air sacs empty their air into the lungs. Air passing through the lungs as the bird exhales is expelled via the trachea. Some taxonomic groups (Passeriformes) possess seven air sacs, as the clavicular air sacs may interconnect or be fused with the cranial thoracic air sacs.

As air flows through the air sac system and lungs, there is no mixing of oxygen-rich air and oxygen-poor, carbon dioxide-rich, air as in mammalian lungs. Thus, the partial pressure of oxygen in a bird's lungs is the same as the environment, and so birds have more efficient gas-exchange of both oxygen and carbon dioxide than do mammals. In addition, air passes through the lungs in both exhalation and inspiration, with the air sacs functioning as a reservoir for the next breath of air.

Avian lungs do not have alveoli*, as mammalian lungs do, but instead contain millions of tiny passages known as parabronchi, connected at either ends by the dorsobronchi and ventrobronchi. Air flows through the honeycombed walls of the parabronchi into air vesicles, called atria, which project radially from the parabronchi. These atria give rise to aircapillaries, where oxygen and carbon dioxide are traded with cross-flowing blood capillaries by diffusion.

Birds also lack a diaphragm. The entire body cavity acts as a bellows to move air through the lungs. The active phase of respiration in birds is exhalation, requiring muscular contraction.

*Found in the lung, the pulmonary alveoli are spherical outcroppings of the respiratory sites of gas exchange with the blood. Alveoli are particular to mammalian lungs.



Air always flows from right (posterior) to left (anterior) through a bird's lungs during both inhalation and exhalation. Key to a Common Kestrel's circulatory lung system: 1 cervical air sac, 2 clavicular air sac, 3 cranial thoracic air sac, 4 caudal thoracic air sac, 5 abdominal air sac (5' diverticulum into pelvic girdle), 6 lung, 7 trachea.

A clavicle (furcula), B coracoid, C scapula, D notarium (fused thoracal vertebrae), E synsacrum, F pelvic bones, G femoral bone, H sternum.

Illustration: Uwe Gille

Source: Wikipedia