<u>Bird Notes</u>

by Rick Pyeritz

Adventurers from space would return to
their planet with no reports of our technology,
our skyscrapers. They would tell of the
green, the living green and of the birds,
the soaring, sweeping singing multitude
that live their lives of wonder, free from our
small human concerns.

---- Helen Thomson

Imagine flying in a plane at 35,000 feet. You glance out of your window to see a formation of birds looking back at you. How can it be possible that at an altitude where humans cannot live with supplemental oxygen, grey-lag geese have been observed migrating over the Himalayas? The answer is that the respiratory system of birds is the most efficient known among all animal vertebrates and is the most unique in its structure.

The first clue to the structure of the avian respiratory system was discovered by William Harvey in 1653. This was the same fellow who described the circulation of blood in mammals. He found that birds have large, thin-walled air sacs that fill much of the chest and abdominal cavity. These air sacs are not only connected to the bird's lungs, but also to the hollow cavity of the bird's bones. This fact was demonstrated in 1758 by John Hunter, who wrote, "I next cut the wing through the os humeri (the wing bone) in another fowl, and tying up the trachea, found that the air passed to and from the lungs by the canal in this bone. The same experiment was made with the os femoris (the leg bone) of a young hawk, and was attended with a similar result. Further work showed that the bird's respiratory system consisted of a trachea, bronchi, lungs and nine air sacs. Except for the presence of the air sacs and their connection to bones, there is not much difference with mammals. So how can birds expend so much energy at such high altitudes where the oxygen concentration is very small?

The answer to this question becomes clear when the flow of air through the bird's respiratory system is compared to our own. The typical mammalian respiratory system is tidal in nature, in that it requires breathing in and out to move a parcel of air. The inhaled fresh air is mixed with residual stale air remaining in the lungs ---- the exhalation never completely empties the lungs. This is an inefficient system of oxygen delivery to the blood. Birds, on the other hand, have a one-way lung for the delivery of oxygen. Simplifying it a bit, the flow of air through a bird's respiratory system moves like this:

With the first inhalation ---- air moves into the posterior air sacs
With the first exhalation ----air moves into the lungs

With the second inhalation ---- air moves from the lungs into the anterior air sacs
With the second exhalation ----air moves out of the body

Air is not drawn into the lungs, but through them. With this one-way flow through the lung, the lungs are always exposed to fresh air. Up to 90% of the available oxygen can be extracted by the lungs of birds. Mammals can extract only 20—25% of available oxygen. This is why birds can fly at altitudes where humans would be comatose.

This efficient system allows the lungs of birds to be relatively smaller than humans – about 2% of the body volume to 5% in humans. The air sacs occupy about 20% of the bird's volume. The nine air sacs have functions other than directing the flow of air. They, also, help remove the potentially lethal body heat produced during flight. Birds have no sweat glands to help with thermal regulation. Temperature control in birds will be discussed in a future Bird Notes. Inflated airs sacs help protect delicate internal organs from the considerable muscular forces generated during flight. Air sacs also cushion sea birds from their dives into the water for food. Deep diving birds such as loons have a decreased volume of air sacs to help make diving to depths of at least 55 meters possible.

If you should have any questions or comments on this issue of Bird Notes or have suggestions for future topics please contact me. My Email address is eapyeritz@gmail.com.

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