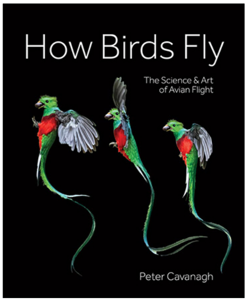
ORNITHOLOGY

How Birds Fly: the Science and Art of Avian Flight

By Peter Cavanagh. 2024. Firefly Books. 336 pages and 350 colour photos and illustrations, 49.95 CAD, Hardcover.



This book is a masterpiece. Well-written and superbly illustrated, it explains the current scientific understanding behind how (and why) birds fly. It is also a wonderful celebration of birds. The author's credentials shine throughout the book; Cavanagh is a retired professor of human biomechanics, a distinguished scientist, a world-class bird photographer, and an experienced pilot of small planes. His writing evokes some laugh-out-loud moments. The quality of the book's production is remarkable. It includes breathtaking and well-chosen large photographs of birds in flight that were selected from the author's many images of birds from every continent. The quality and variety of the other illustrations and diagrams—which include examples of figures from in-depth scientific studies of flight—are uniformly exceptional and informative. I liked the digital artistic representations of theropod dinosaurs at different stages of evolution; a modern birdwatcher would have felt quite at home 100 million years ago.

The extraordinary nature and variety of bird flight is on full display in this stunning tour de force. No flying bird will ever look quite the same to me. Although scientists have figured out so much about the secrets of bird flight, there is clearly a lot more to discover with the application of technologies, including high-speed photography and other novel photographic techniques, wind tunnels, computer-assisted modelling, and electronic tracking of body sensors in birds. Bird flight has many surprises, but there are many more to come.

Thirteen chapters cover topics such as: the changes in anatomy that supported the evolution of flight in birds; the extraordinary nature and diversity of feathers; the uses of different types of muscles; the aerodynamics of takeoff, landing, gliding, soaring, flapping, in-flight maneuvering, and hovering; formation flying and flocking; and migration. There is also a discussion of selected flight specialists such as albatrosses, hummingbirds, owls, and swifts. What struck me most was the diversity of bird flight and the numerous adaptations to the different types of flight by so many birds. In asking "How do birds fly?", one should not expect a simple one-size-fits-all answer. There are no standard methods for flying because all anatomies and adaptations require different strategies. For example, birds continuously change the size, shape, warping, and camber of their wings to adjust, often with subtle fine-tuning, to different atmospheric conditions and flying speeds. As first recognised by Charles Darwin in the finches of the Galápagos Islands, birds can evolve surprisingly quickly, leading to their extraordinary diversity, including that of flight. Bird evolution and adaptation are constant themes of the book, but the adaptations discussed are not just anatomical; they are also physiological, biochemical, and neurological. There is so much more to birds than what we see.

As a bird carver, this reviewer was forcefully reminded that the primary wing feathers are anatomically the 'hand wing' and the secondary feathers are the 'arm wing'. The primary feathers provide the propulsive thrust (and lift) required for movement, whereas the secondaries attached to the ulna are more for maintaining lift and gliding. The emargination (notching) of the terminal primary feathers is critical to producing lift in birds. The tertiary feathers (tertials), between the secondaries and the body, presumably originated from the humerus. These major feather groups control the aerodynamics of flight through their positioning. I hadn't realized the importance of the flexibility of the wrist between the hand and arm wings, which can act quite independently, as can both wings. The alula feathers, originating from the thumb, are an important part of bird flight (especially in some species), acting as a leading-edge vortex generator to produce a novel form of lift. For carvers, they are a minor detail, but not for birds. All flight feathers, whether main or minor (the various coverts), are movable and integrated into the dynamics of flight. *How Birds Fly* shows these details in breathtaking photographs. (I loved the photos of Red Kite and Northern Gannet flying upside down.) The magic, of course, is how this is all integrated by a bird into its needs for successful flight, including takeoff and landing (moments that many people who have flown in airplanes will always find a bit scary), because this is all carried out instinctively.

The complex aerodynamics of the different types of bird flight is skillfully discussed and illustrated. Cavanagh often compares bird flight to that of airplanes, which uniformly come out as a very poor second to birds. The author walks us gently through the application of Newtonian mechanics to explain the complex aerodynamics of flight.

There is a spectacular photograph of the air vortices generated by Northern Goshawk's wing and tail tips, which provide some of the lift required for flight. The role of the bird's tail in flight is still not well understood. Although relatively small compared to the wing, the tail likely has an outsized influence on flight because of its distance from a bird's centre of gravity. Bird carvers tend to carve tails narrowly, with closely overlapping feathers, which not only is technically quite difficult but also does not give the tail the attention it deserves.

In a chapter called Bioinspired Flight, Cavanagh discusses the potential applications of what has been learned about the variety of bird flight. For example, there is evidence that the dark colours on the upper surface of the wings of some birds (including the black tips of some flight feathers) increase the temperature of the boundary air around the wing by absorbing sunlight and thus improving flight lift. Perhaps one day the upper surface of aircraft wings will be painted black. By contrast, Great Snipe avoid solar-induced overheating (which adds to the heat from their own muscles) in their more than three days of non-stop migration from Sweden to Sub-Saharan Africa by climbing during the day to over 5000 m, where temperatures are around –20°C.

Congratulations to Peter Cavanagh and his publisher for such a wonderful and important book.

JOHN PRESCOTT
Bird Carver and Retired Veterinary Scientist
Ottawa, ON, Canada