

Avian Inspired Design

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Maeder Hall, ACEE



Professor David Lentink
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Many organisms fly in order to survive and reproduce. My lab focusses on understanding bird flight to improve flying robots—because birds fly further, longer, and more reliable in complex visual and wind environments. I use this multidisciplinary lens that integrates biomechanics, aerodynamics, and robotics to advance our understanding of the evolution of flight more generally across birds, bats, insects, and autorotating seeds. The development of flying organisms as an individual and their evolution as a species are shaped by the physical interaction between organism and surrounding air. The organism's architecture is tuned for propelling itself and controlling its motion. Flying animals and plants maximize performance by generating and manipulating vortices. These vortices are created close to the body as it is driven by the action of muscles or gravity, then are 'shed' to form a wake (a trackway left behind in the fluid). I study how the organism's architecture is tuned to utilize these and other aeromechanical principles to compare the function of bird wings to that of bat, insect, and maple seed wings. The experimental approaches range from making robotic models to training birds to fly in a custom-designed wind tunnel as well as in visual flight arena's—and inventing methods to 3D scan birds and measure the aerodynamic force they generate—nonintrusively—with a novel aerodynamic force platform. The studies reveal that animals and plants have converged upon the same solution for generating high lift: A strong vortex that runs parallel to the leading edge of the wing, which it sucks upward. Why this vortex remains stably attached to flapping animal and spinning plant wings is elucidated and linked to kinematics and wing morphology. While wing morphology is quite rigid in insects and maple seeds, it is extremely fluid in birds. I will show how such 'wing morphing' significantly expands the performance envelope of birds during flight, and will dissect the mechanisms that enable birds to morph better than any aircraft can. Finally, I will show how these findings have inspired my students to design new flapping and morphing aerial robots.

Professor Lentink's multidisciplinary lab studies how birds fly to develop better flying robots—integrating biomechanics, fluid mechanics, and robot design. <http://lentinklab.stanford.edu> He has a BS and MS in Aerospace Engineering (Aerodynamics, Delft University of Technology) and a PhD in Experimental Zoology *cum laude* (Wageningen University). During his PhD he visited the California institute of Technology for 9 months to study insect flight. His postdoctoral training at Harvard was focused on studying bird flight. Publications range from technical journals to cover publications in Nature and Science. He is an alumnus of the Young Academy of the Royal Netherlands Academy of Arts and Sciences, recipient of the Dutch Academic Year Prize, the NSF CAREER award, he has been recognized in 2013 as one of 40 scientists under 40 by the World Economic Forum, and he is the inaugural winner of the Steven Vogel Young Investigator Award from the Journal Bioinspiration & Biomimetics for early career brilliance.