Abstract
Hummingbirds present a unique case of convergent evolution with larger insects and they offer many features to consider when designing miniature autonomous vehicles. Hummingbirds are the only birds that can sustain hovering. To accomplish hovering, they utilize unsteady mechanisms including delayed-stall and rotational circulation at the ends of half-strokes. They have proportionally huge pectoralis and supracoracoideus flight muscles which undergo smaller strains typical of insects rather than other birds. The anatomy of their wing skeleton, with a short, highly-adducted humerus, permits them to use high wing beat frequencies typical of insects with strain rates in their muscles that are nonetheless similar to those of other birds. New three-dimensional skeletal kinematics reveal that wing supination during upstroke is accomplished primarily via supination of the handwing, but aerodynamic or inertial loading of the flight feathers also contributes significantly to dynamic wing posture. Hummingbirds are also adept at fast forward flight, and some species migrate long distances. A key feature of this behavior is that they arrest circulation on the wing during upstroke to circumvent negative thrust. Contrasting with other birds, hummingbirds do not flex their wings during upstroke of forward flight, nor do they regularly use intermittent flight.

Biography
Dr. Bret Tobalske received his B.S. degree in Botany and Zoology from Southern Illinois University at Carbondale in 1988 and M.A. degree in Zoology from University of Montana, Missoula in 1991. He received his Ph.D. degree in Organismal Biology and Ecology at the University of Montana, Missoula in 1994. He is currently working as an associate professor of biological sciences at The University of Montana-Missoula. He is the director of The University of Montana’s Field Research Station at Fort Missoula and head of the station’s flight laboratory. As a comparative biomechanist he enjoys exploring questions that blend biology with physics. His primary passion for science is for furthering understanding of the biology of bird flight. He use a variety of techniques in the laboratory and in the field to measure wing motion, muscle contractile behavior, and aerodynamics with an overall goal of improving understanding of how flight shapes the ecology and evolution of birds and other flying animals. His work is published in top biological and scientific journals. He received various awards including The Outstanding Scholarship Award, Arthur Butine Supplemental Award, D. Dwight Davis Award, Bertha Morton Scholarship, and Charles L. Foote Achievement Award. His research is supported by National Science Foundation, M.J. Murdock Charitable Trust, University of Portland, Arthur Butine Faculty Development Grant, and U.S. Agency for International Development, Fulbright Fellowship.