How Insects Fly—Secrets Revealed

When conventional laws of aerodynamics are applied to investigating insect flight, they reveal that insect lift forces are insufficient for flight. According to these principles, insects should not be able to fly. Obviously, however, insects do fly. Where does the extra lift come from? Recently, Charles Ellington and his coworkers at the University of Cambridge found the answer. They used hawkmoths *(Manduca sexta)* tethered in a stream of air, smoke particles to reveal air movements, video equipment, and a giant, computer-controlled hawkmoth with a wingspan greater than 1 m to investigate how air flows around the wings during insect flight.

Small streams of smoke particles carried over the wings of a flying hawkmoth revealed a vortex or cylinder of air that curled up from the front edge of the wing during the downstroke. The vortex then spiraled toward the tip of the wing with a velocity equal to the wing-stroke velocity. As it moved toward the wingtip, the vortex enlarged. This vortex creates a low-pressure area above the wing that sucks the top of the wing upward, providing lift to keep the insect airborne (figure 1).

The vortex that a 10 cm hawkmoth creates is very small. The researchers used the mechanical model to investigate the exact place and moment at which a vortex is created. Colored smoke particles released from the leading edge of the wing demonstrated precise air movement patterns within the vortex. The vortex originates at the beginning of the downstroke at the base of the wing. Elevation of the front edge of the wing helps to create lift, and the vortex moving toward the tip of the wing helps prevent the insect from stalling and crashing to the ground. (Stalling can be duplicated by tilting the forward margin of a paper airplane wing to provide extreme lift but a very short flight.) Thus, the vortex created during insect flight results in low pressure on the upper surface of the wing and a delay in the threatened stall that the upward tilt of the front margin of the wing creates.

Many insects are adept fliers. Others are awkward and inefficient.

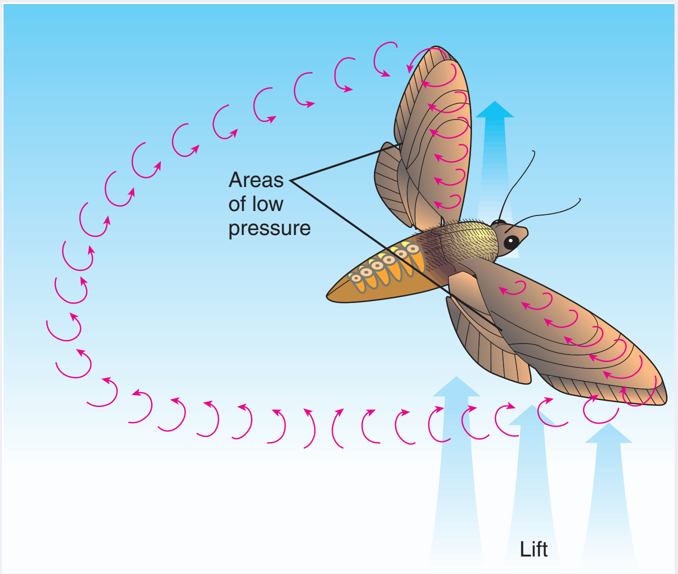

Figure 1 **Insect Flight.** The downstroke of a wing creates vortices (red arrows) at the base of the wing's leading margin. The vortices enlarge and move toward the tip of the wing during the downstroke. These moving vortices create low pressure on the upper surface of the wing that increases lift (blue arrows), and they stabilize the insect's tendency to stall from the upward tilt of the wing's front margin. (Miller/Harley: *Zoology*, 5th ed. © The McGraw-Hill Companies.)

As this account demonstrates, our initial perceptions of natural phenomena are often inadequate, and further investigation can yield valuable lessons. Studies of insect flight may help us better understand bird flight and perhaps provide aerodynamic lessons that influence how we humans construct our own flying machines.