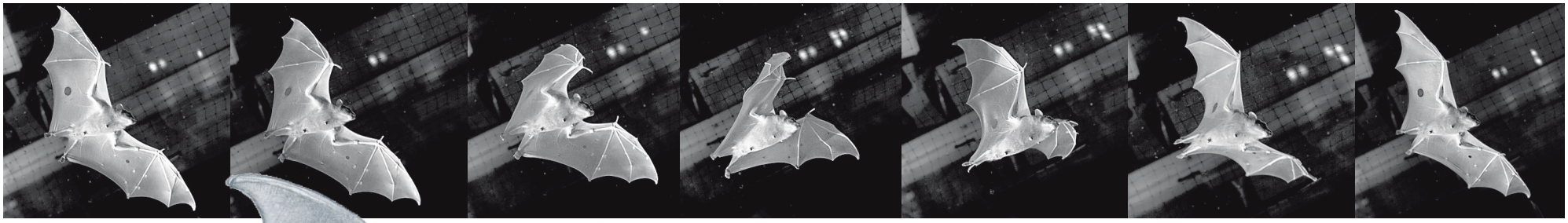
Brown University engineers and biologists have joined forces to record details of bat flight. The articulated bone structure and soft membrane of bats' wings give them maneuverability that is superior to birds, making bats potential models for small air vehicles. To better understand the complex aerodynamics involved, scientists recorded bats in a wind tunnel with multiple high-speed video cameras. In addition, they captured the motion of the air particles left behind to reveal the airflow around the wings.



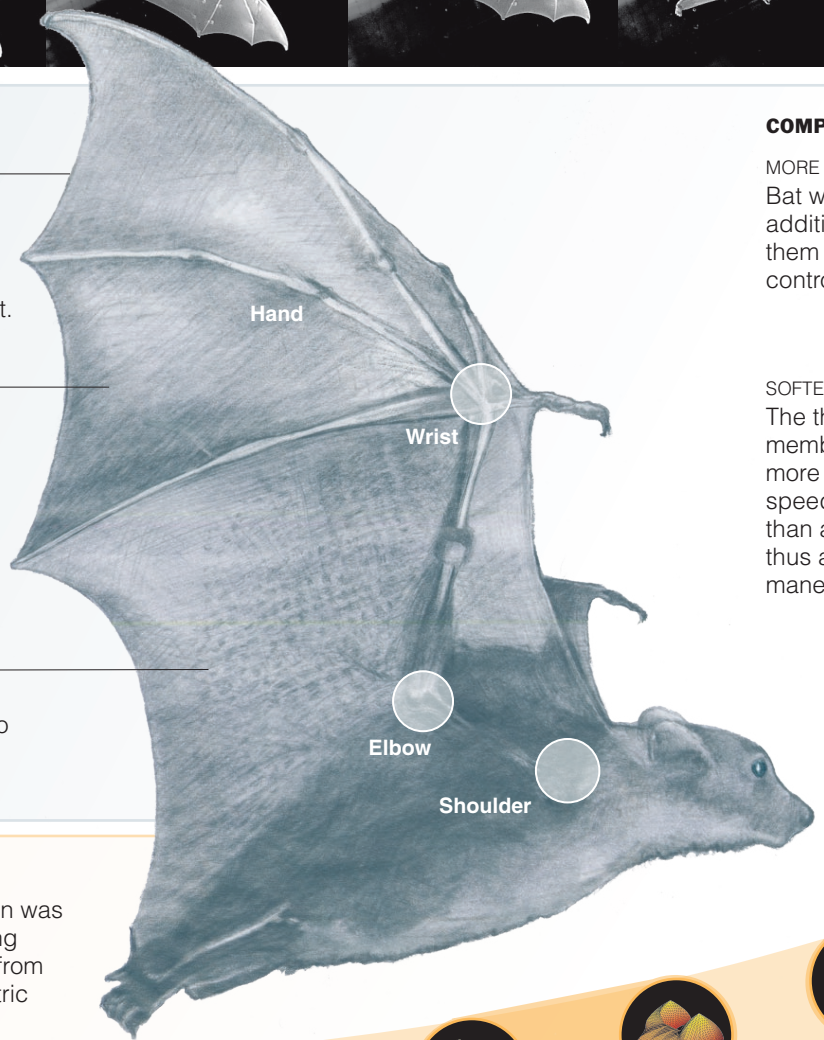
See the wind tunnel video at www.nytimes.com/science ▲

BAT ANATOMY

SKIN
The thin membrane connecting the bones of wings and feet is highly elastic and stretches in flight.

HAIR
Scientists suspect that the short, fine hair can sense speed and perhaps direction of airflow on the wing surface.

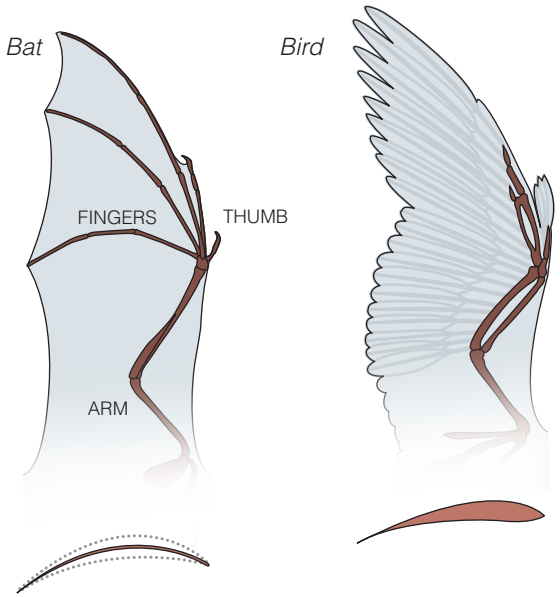
SKIN MUSCLES
Tiny muscles can control skin tension to adapt to the current airspeed.



COMPARING WINGS

MORE JOINTS
Bat wings have distinct fingers in addition to arm bones, giving them more movability and better control of the wing than birds.

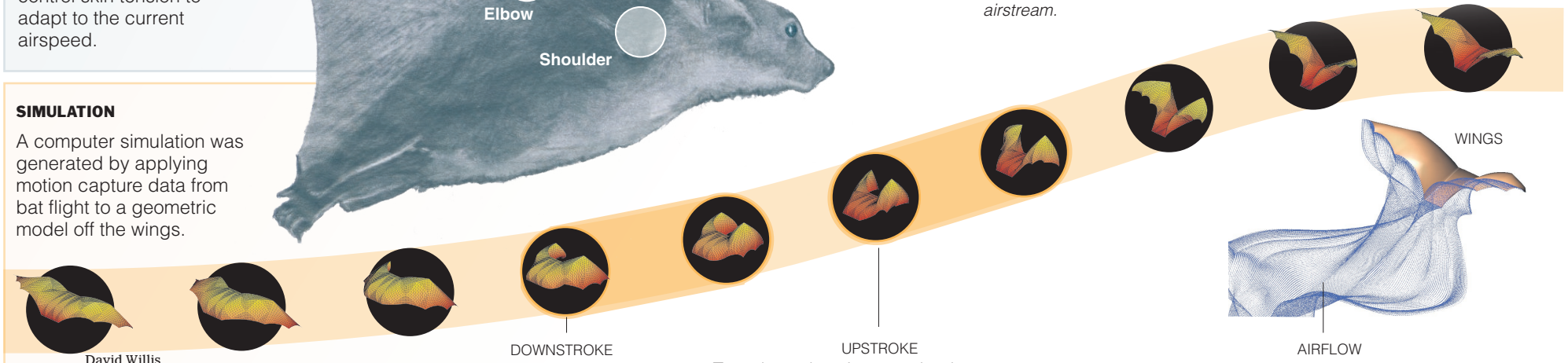
SOFTER AIRFOIL
The thin and compliant skin membrane of a bat wing generates more lift and less drag at low speeds and high angles of attack than a stiffer bird or insect wing, thus allowing for better maneuverability.



Thin wing profile adjusts to the surrounding airstream.

SIMULATION

A computer simulation was generated by applying motion capture data from bat flight to a geometric model off the wings.



David Willis

DOWNSTROKE
Bats sweep their wings forward during downstroke.

UPSTROKE
To reduce drag in upstroke, bats retract wings closer to the body than birds.

AIRFLOW
Scientists hope to learn more about the lift and drag created by studying the airflow bat wings leave behind.

Sources: Sharon Swartz and Kenneth Breuer, Brown University

Mika Gröndahl/The New York Times