Mimicking nature in engineering

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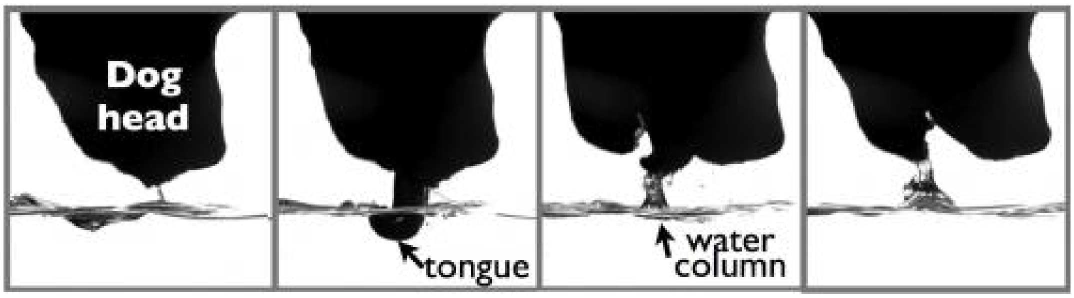

The darting ability of lizards and frogs in water as well as dogs lapping the liquid will be among the animals studied by the Virginia Tech engineers, who will incorporate fluid dynamics in their studies. Credit: Sunny Jung, Virginia Tech

Lizards and frogs are about to take up residence in the laboratories of Virginia Tech's College of Engineering.

The engineers and scientists want to learn more about the water-running lizard's ability to dart across a water surface. In engineering terms, that means how it increases its locomotion efficiency by producing more force on its power stroke and less drag on its recovery stroke.

And these engineers are surprised at how some frog species can jump out of the water, starting from a submerged position, using only one power stroke, to catch a flying insect that may be some 40 centimeters – or three times its body length – above the surface. As problem-solvers, they want to understand how this small reptile achieves such high propulsion.

The National Science Foundation (NSF) is also curious. The government agency has a Physics of Living program that funds research projects at the interface of biology, mathematical modeling, physics, and engineering. NSF has awarded Sunghwan Jung, principal investigator, along with Jake Socha, both assistant professors of engineering science and mechanics, and Pavlos Vlachos, professor of mechanical engineering, a little over a half a million dollars to investigate the water entry and exit problems that are apparent in engineering mechanics based on a better understanding of biology.

"Since there are no engineered systems that operate under conditions similar to these reptiles and amphibians, we have an opportunity to learn how nature effectively uses the interaction of these forces. From our findings we hope to be able to develop bio-inspired systems such as faster dipping and coating processes for materials engineering, or even water-walking robots," Jung said.

The three will also look at the drinking in carnivorous animals, specifically cats and dogs, and incorporate fluid dynamics in their studies. Two years ago, Jung participated in a study with researchers from MIT and Princeton University that showed a cat's drinking strategy works to defeat gravity. A feline will actually pull liquid into its mouth, and this subtle biological trait was the subject of their study "How cats lap: Water uptake by Felis catus" that appeared in the journal *Science*.

For engineers, this finding that a cat can exploit fluid inertia to defeat gravity and pull liquid into its mouth has significant implications for the development of novel microfluidic devices.

By contrast, the domestic dog appears to scoop water into its mouth, using its highly curled tongue that penetrates into the water. The amount of fluid ingested depends on the lapping frequency and the size of the air cavity created by the canine's tongue.

"The animal systems described provide a series of examples in which the hydrodynamics of the water entry or exit enable exceptional and counter-intuitive behaviors," Jung said. "We selected them based on their apparent similarity of air cavity formations compared to numerous engineering applications operating on water surface."

Socha and Vlachos have collaborated previously on a number of projects, and their work with Jung represents another effort among a larger group of researchers at Virginia Tech interested in bio-inspired engineering.

Socha leads a large interdisciplinary team that includes engineers and biologists on the study of how insects move fluids through their bodies, including air, blood, and food. His goal is to derive new engineering principles for fluidic applications.

Vlachos, who is a previous recipient of an NSF CAREER award on arterial flow dynamics, is also a co-principal investigator on an NSF Integrative Graduate Education and Research Traineeship program on multi-scale transport in environmental and physiological systems. Socha also participates in this grant.

Provided by Virginia Tech

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