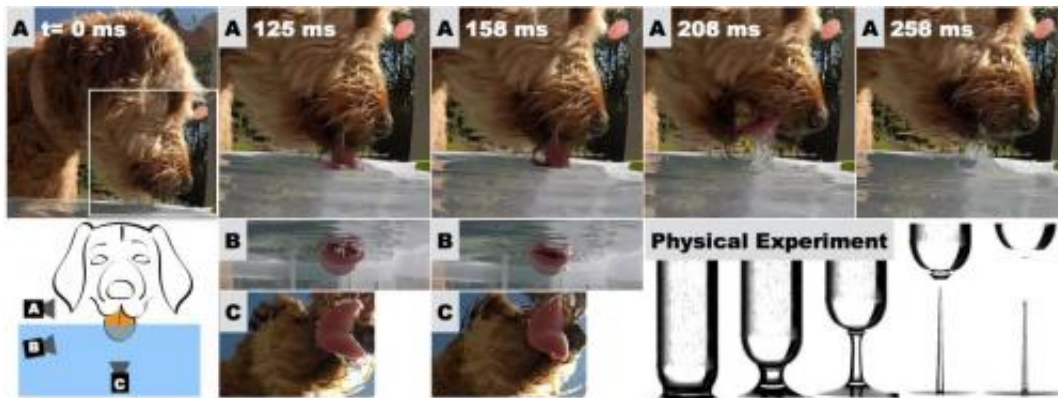


How lapping canine tongues create columns of liquid, allowing them to gulp down water

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The drinking mechanism of a dog is videotaped from three different angles (A, B, and C). The curved tongue is rapidly withdrawn and a water column is formed underneath. A physical experiment is designed to understand and characterize the underlying fluid mechanics.

If you've ever watched a dog drink water, you know that it can be a sloshy, spilly, splashy affair—in other words, adorable.

Behind all of the happy, wet messes, however, lies the mechanical logic of carnivorous compensation—[dogs](#) splash when they drink because they have the cheeks of a predatory quadruped. By studying the drinking habits of various [dog breeds](#) and sizes, a group of researchers at Virginia Tech and Purdue University has recently identified and modeled the [fluid dynamics](#) at play when dogs drink [water](#).

The findings will be described today in a talk at the American Physical Society's Division of Fluid Dynamics (DFD) meeting in San Francisco, Calif.

"Three years ago, we studied how cats drink," said Sunny Jung, an assistant professor at Virginia Tech. Jung's research focuses include biofluid mechanics and the nonlinear interactions between soft bodies and surrounding fluids. His current project is sponsored by the National Science Foundation's Physics of Living Systems program. "I was curious about how dogs drink, because cats and dogs are everywhere."

As members of the order Carnivora, cats and dogs have incomplete cheeks, which allow them to open their mouths wide to deliver killing blows. But what makes pack hunting possible also makes suction drinking impossible. Unable to seal their cheeks completely, there is no way for a dog to suck up water. Conversely, humans have "complete" cheeks, and we drink by creating negative pressure, allowing us to suck water into our mouths and down our throats.

Cats, too, lack suction, and they compensate by drinking via a two-part "water entry-and-exit" process. This consists of a plunging and a pulling phase, in which a cat gently places its tongue on the water's surface and then rapidly withdraws it, creating a column of water underneath the cat's retracting tongue.

"When we started this project, we thought that dogs drink similarly to cats," Jung said. "But it turns out that it's different, because dogs smash their tongues on the water surface—they make lots of splashing—but a cat never does that."

When dogs withdraw their tongue from water, they create a significant amount of acceleration—roughly five times that of gravity—that creates the water columns, which feed up into their mouths. To model this, Jung

placed cameras under the surface of a water trough to map the total surface area of the dogs' tongues that splashed down when drinking.

The researchers found that heavier dogs [drink water](#) with the larger wetted area of the tongue. This indicates that an allometric relationship exists between water contact area of the dog's tongue and body weight – thus the volume of water a dog's tongue can move increases exponentially relative to their body size.

In order to better understand how the physiology works, Jung and his colleagues could only go so far by watching dogs drink. They had to have the ability to alter the parameters and see how they affected this ability, and since they could not actually alter a dog in any way, they turned to models of the dog's tongue and mouth. "We needed to make some kind of physical system," Jung said.

For their model, Jung and his colleagues used glass tubes to simulate a dog's tongue. This allowed them to mimic the acceleration and column formation during the exit process. They then measured the volume of water withdrawn. They found that the column of water pinches off and detaches from the water bath primarily due to gravity. Dogs are smart enough to close their mouth just before the water column collapses back to the bath.

Further research for Jung includes investigating the diving dynamics of plunging seabirds, the skittering motion of frogs and the response of leaves in response to high-speed raindrops.

More information: meetings.aps.org/Meeting/DFD14/Session/R7.2

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