Inspired by a desert beetle, cactus and pitcher plant, researchers design a new material to collect water droplets

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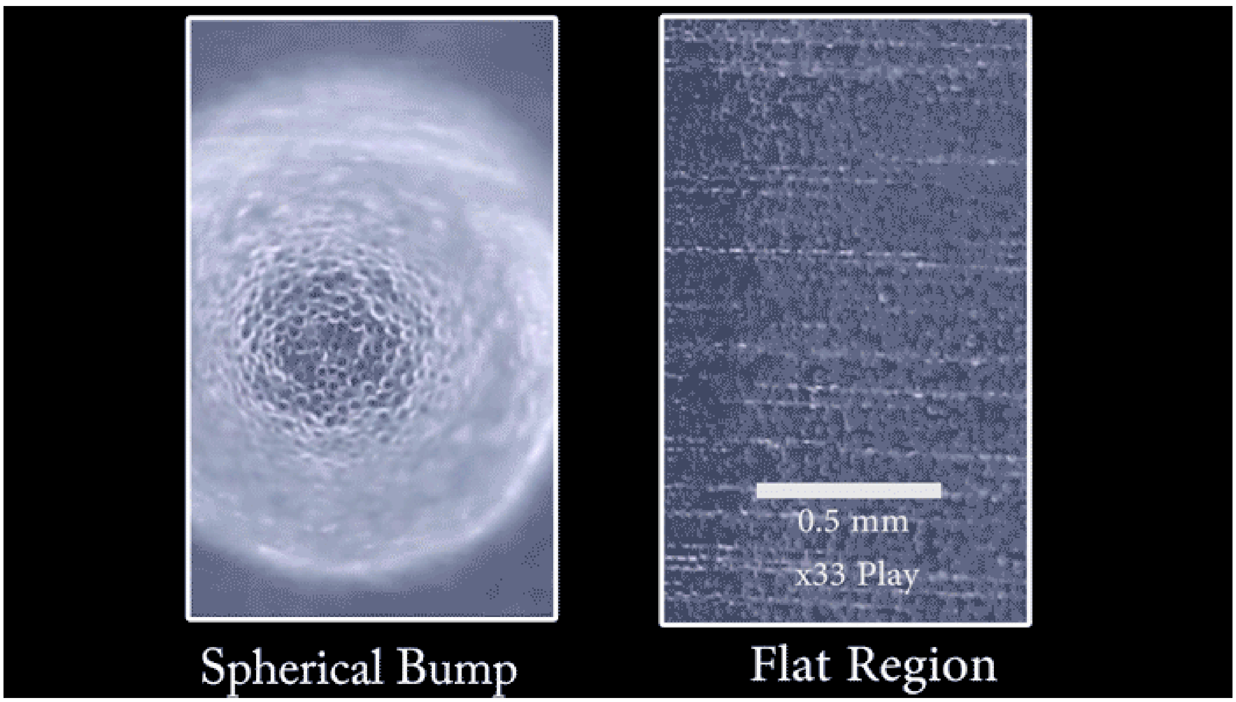


Time lapse of droplets growing faster on the apex of the bumps compared to a flat region with the same height. Credit: Aizenberg Lab/Harvard SEAS

Organisms such as cacti and desert beetles can survive in arid environments because they've evolved mechanisms to collect water from thin air. The Namib desert beetle, for example, collects water droplets on the bumps of its shell while V-shaped cactus spines guide droplets to the plant's body.

As the planet grows drier, researchers are looking to nature for more effective ways to pull water from air. Now, a team of researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) and the Wyss Institute for Biologically Inspired Engineering at Harvard University have drawn inspiration from these organisms to develop a better way to promote and transport condensed water droplets.

"Everybody is excited about bioinspired materials research," said Joanna Aizenberg, the Amy Smith Berylson Professor of Materials Science at SEAS and core faculty member of the Wyss Institute. "However, so far, we tend to mimic one inspirational natural system at a time. Our research shows that a complex bio-inspired approach, in which we marry multiple biological species to come up with non-trivial designs for highly efficient materials with unprecedented properties, is a new, promising direction in biomimetics."

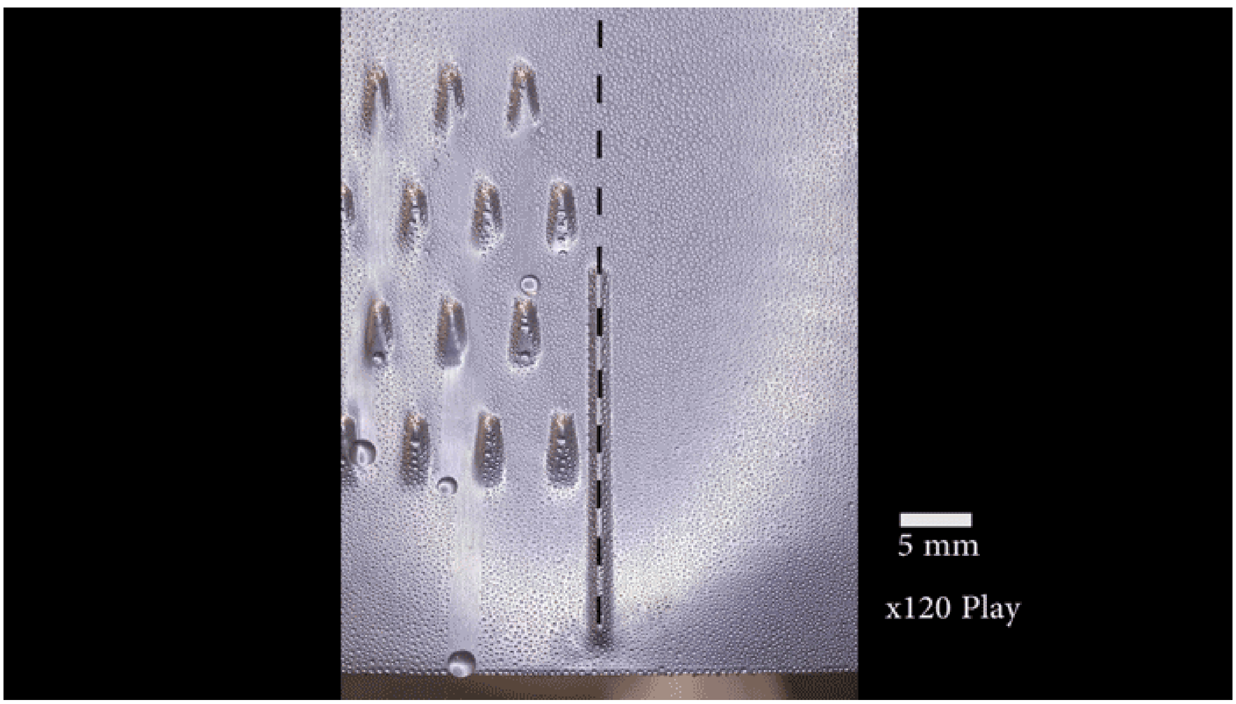
The new system, described in *Nature*, is inspired by the bumpy shell of desert beetles, the asymmetric structure of cactus spines and slippery surfaces of pitcher plants. The material harnesses the power of these natural systems, plus Slippery Liquid-Infused Porous Surfaces technology (SLIPS) developed in Aizenberg's lab, to collect and direct the flow of condensed water droplets.

This approach is promising not only for harvesting water but also for industrial heat exchangers.

"Thermal power plants, for example, rely on condensers to quickly convert steam to liquid water," said Philseok Kim, co-author of the paper and co-founder and vice president of technology at SEAS spin-off

SLIPS Technologies, Inc. "This design could help speed up that process and even allow for operation at a higher temperature, significantly improving the overall energy efficiency."

The major challenges in harvesting atmospheric water are controlling the size of the droplets, speed in which they form and the direction in which they flow.



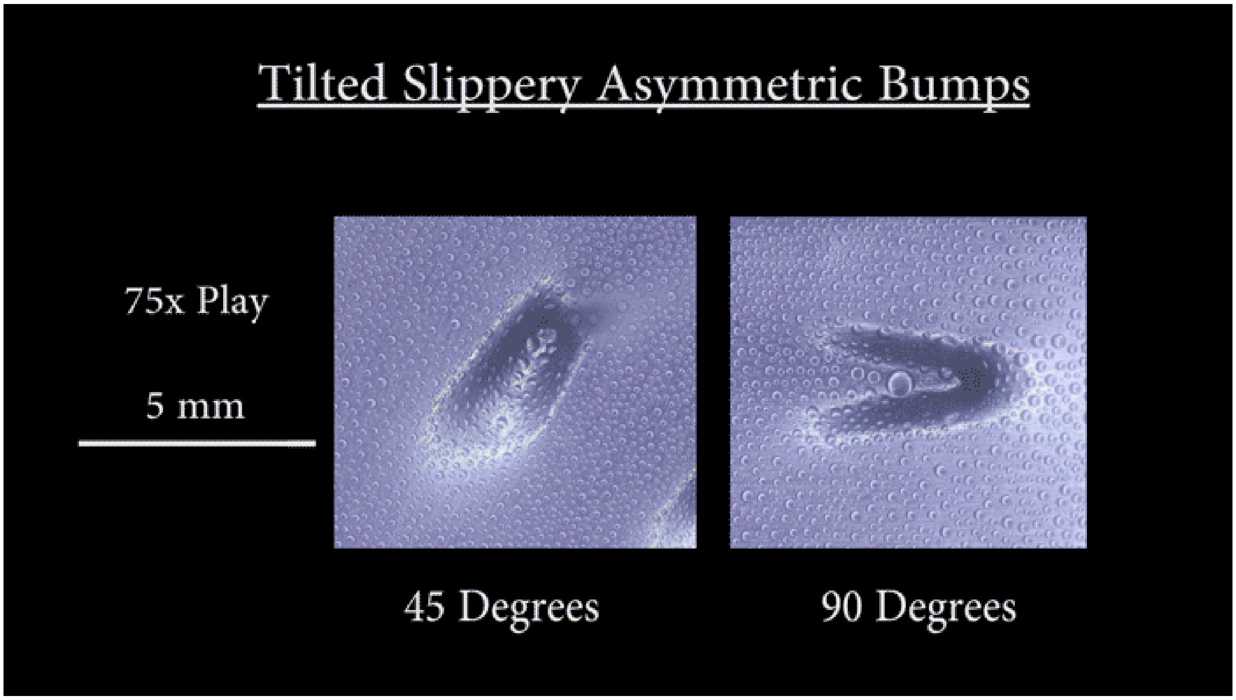
An array of slippery asymmetric bumps shows a significantly greater volume of water collected at the bottom of the surface compared to the flat slippery surfaces. Credit: Aizenberg Lab/Harvard SEAS

For years, researchers focused on the hybrid chemistry of the beetle's bumps—a hydrophilic top with hydrophobic surroundings—to explain how the beetle attracted water. However, Aizenberg and her team took inspiration from a different possibility - that convex bumps themselves also might be able to harvest water.

"We experimentally found that the geometry of bumps alone could facilitate condensation," said Kyoo-Chul Park, a postdoctoral researcher and the first author of the paper. "By optimizing that bump shape through detailed theoretical modeling and combining it with the asymmetry of cactus spines and the nearly friction-free coatings of pitcher plants, we were able to design a material that can collect and transport a greater volume of water in a short time compared to other surfaces."

"Without one of those parameters, the whole system would not work synergistically to promote both the growth and accelerated directional transport of even small, fast condensing droplets," said Park.

"This research is an exciting first step towards developing a passive system that can efficiently collect water and guide it to a reservoir," said Kim.



Inspired by a cactus spine, asymmetric topography guides the droplet off the bump. Credit: Aizenberg Lab/Harvard SEAS

More information: Condensation on slippery asymmetric bumps, nature.com/articles/doi:10.1038/nature16956

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