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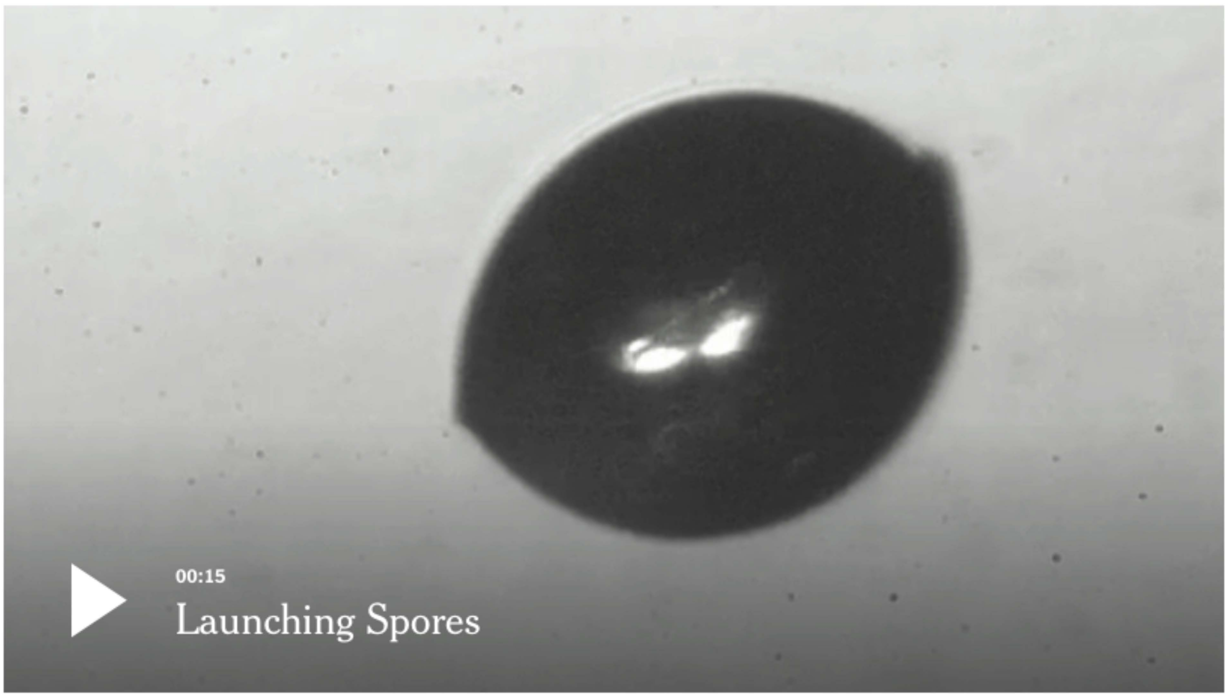
Fungi Physics: How Those Spores Launch Just Right

Trilobites
By KENNETH CHANG JULY 27, 2017



An experiment reproduced the surface tension catapult used by fungi to launch spores. When the two droplets touch, they release energy and launch the spore into the air.
July 27, 2017. Photo by Duke University.

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A new paper published Wednesday helps explain how fungi aim the spores in the right direction. Scientists at Duke University constructed larger spores out of plastic spheres and then used an inkjet printer to build water droplets, which are key to the launching mechanism.

The artificial spores and droplets in the experiment were about 10 times the size of ones in nature. That slowed down the motion so it could be captured on video. "With that system, you get what the real spore is doing," Chuan-Hua Chen, a professor of mechanical engineering and materials science at Duke, said.

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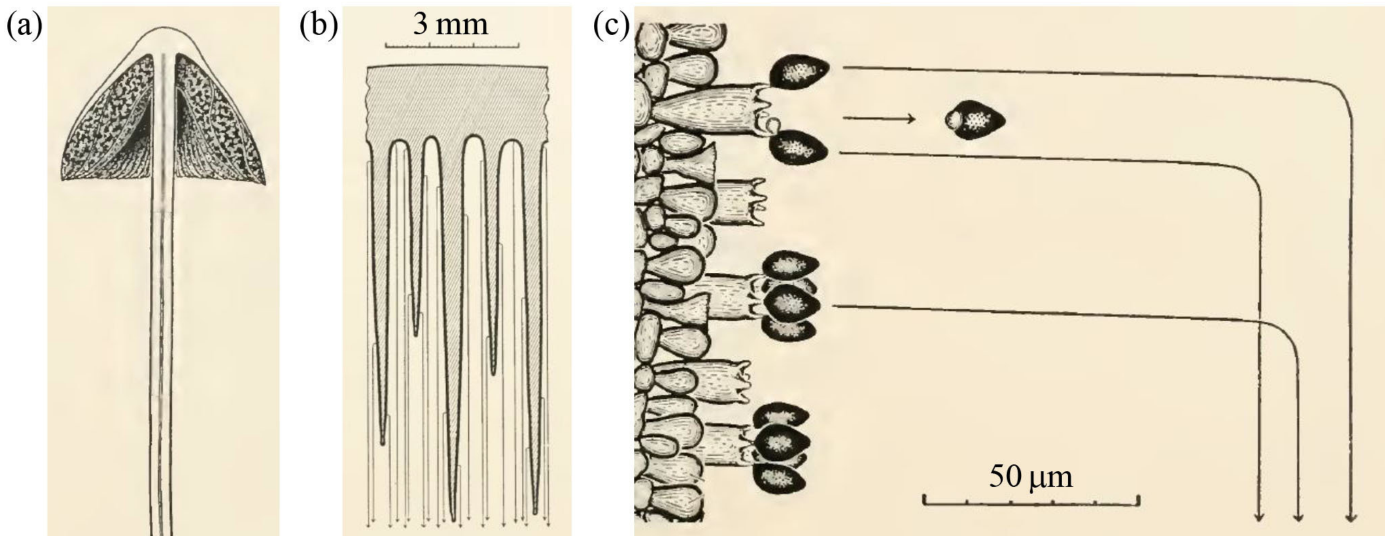
Dr. Chen and his colleagues describe the findings in The Journal of the Royal Society Interface.

"This new paper really is an almost miraculous proof of principle," said Nicholas P. Money, a professor of botany at Miami University in Oxford, Ohio, who was not involved with the experiment.

For more than a century, the spore-firing prowess of fungi, employed by thousands of species, has been an enthralling enigma for mycologists, the scientists who study fungi. Early in the 20th century, a British-Canadian mycologist named Arthur Henry Reginald Buller — "the Einstein of mycology," Dr. Money called him — sketched the trajectories of the spores, and even largely came up with the correct explanation for how the fungi were launching them.



In the early 20th century, Arthur Henry Reginald Buller make sketched the the path of spores ejected by the gills of mushrooms.

On mushrooms, spores grow along the gills on the underside of the caps. The size varies, but a typical spore is about 10 microns, or 1/2,500th of an inch, in width, and it is attached at the end of a stalk called a sterigma. In a single day, a mushroom releases billions of spores.

If the spores were merely dropped, many of them would waft back into the parent mushroom and get stuck. "When a spore launches, it has to go far enough that it clears its apparatus," said Anne Pringle, a professor of botany and bacteriology at the University of Wisconsin and a collaborator on the new research.

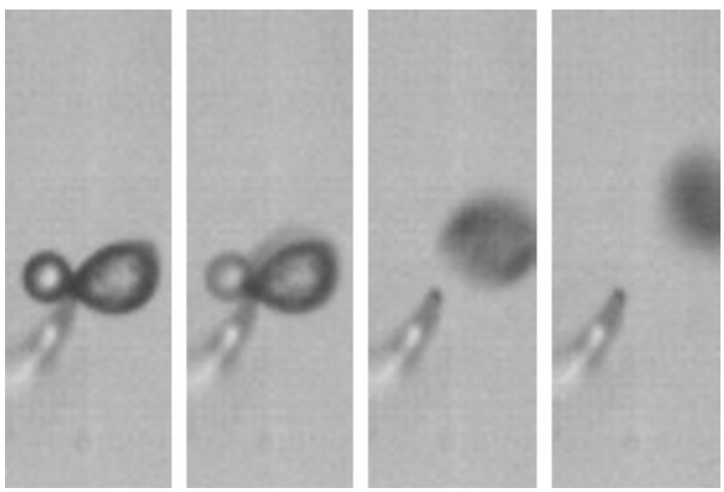
So a mushroom fires the spores away from the vertical gill — but not so far that they fly into the next gill over. The speed is not that fast — less than 10 miles per hour — and the distance is usually just a few hundred microns before air friction slows down the microscopic spores. But the acceleration is explosive, exerting thousands of times the force of gravity.

Scientists call spores launched in this manner ballistospheres.

At the same time they are traveling away from the gills gravity pulls them down and the spores catch a ride on air currents to spawn into new mushrooms elsewhere.

The energy for propelling the spores turns out to come from the surface tension of water — the forces that cause a drop of water to roll up into a bead on a water-repellent surface.

In his early observations, Buller noticed a tiny droplet next to a spore.



In these successive images of a fungal spore launching, the small sphere of liquid on the left is known as the Buller's drop. To the right is the spore. The Buller's drop merges with liquid on the spore, catapulting the spore into the air. Nicholas P. Money/Mycologia

"There's a point at the top of the sterigma, and it has one of the most poetic names in biology," Dr. Pringle said. "It's called the punctum lacryman, which means the point that cries. Something about it, either its texture or its chemistry, means that it accumulates water from the surrounding environment."

Buller hypothesized that when the tiny sphere of fluid — it's now called the Buller's drop — touched the liquid on the spore, the two merged, releasing the surface tension energy and launching the spore.

"He had it very, very close," Dr. Money said.

But the launching was so fast that no one knew for sure. Other scientists offered other ideas like squirty sterigmata, bursting bubbles and electrostatic repulsion.

More than a decade ago, Dr. Pringle and Dr. Money turned to ultrahigh-speed video cameras, capturing 100,000 frames a second, to fill in some of the blanks. Even that was not quite fast enough to capture all of the details of what was going on.

In the new experiment, polystyrene spheres were sliced in the shape of a spherical cap, mimicking the shape of a spore. A lens-shaped drop of water, with some ethanol mixed in to make it sticky enough to stay on the surface, was added on top of the flat side. Drips from an inkjet printer created the Buller's drop next to it until it touched the liquid on the plastic spore.

The merging was still fast — less than a thousandth of a second — but slow enough to be studied. "When they coalesce, they actually get this bounce, which is precisely what we see in nature," Dr. Money said.

The researchers also used computer simulations to show how the merging launched the spore at a right angle to the surface — the perfect direction for the spore to safely ride air currents.

"It's gratifying, after so many years," Dr. Chen said. "We finally saw how to explain this century-old puzzle of directionality."

Mycologists now have a tool to study the process more exactly, varying the shape of the spore or the relative size of the Buller’s drop.

It could conceivably even have practical uses. Imagine a surface that cleans itself, flinging away any dirt particles that land on it.