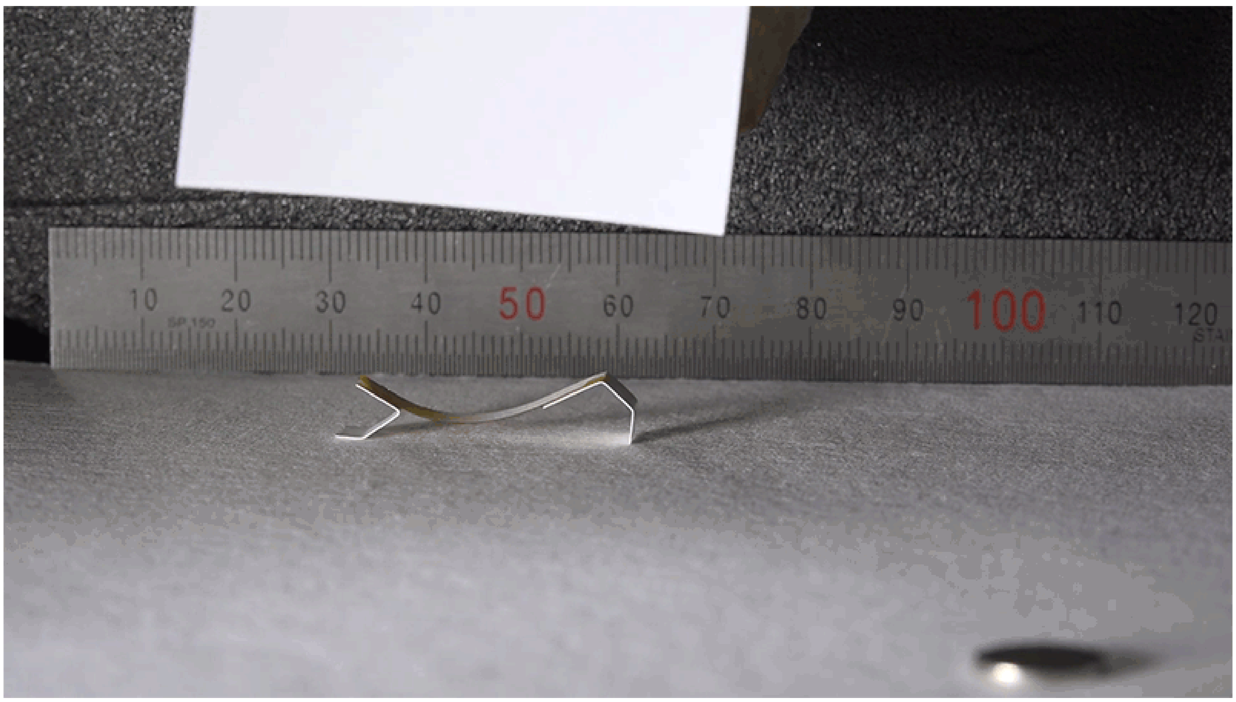
Tiny hygrobots need no batteries—they are powered by water

January 29 2018, by Bob Yirka



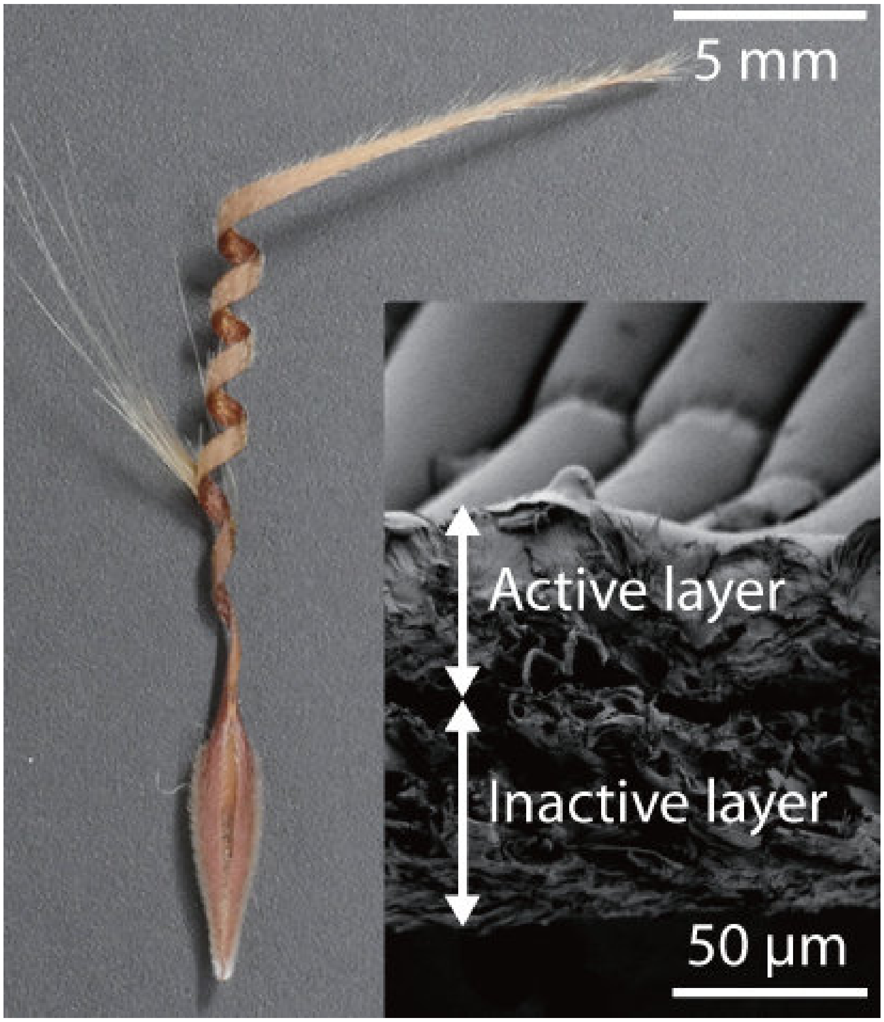
An “inchworming” hygrobot. Credit: Shin et al., *Sci. Robot.* 3, eaar2629 (2018)

A team of researchers at Seoul National University has developed a series of small robots that move without need for an engine or batteries. Instead, as the researchers explain in their paper published in the journal *Science Robots*, the hygrobots, as they are called, move due to absorption and evaporation of water.

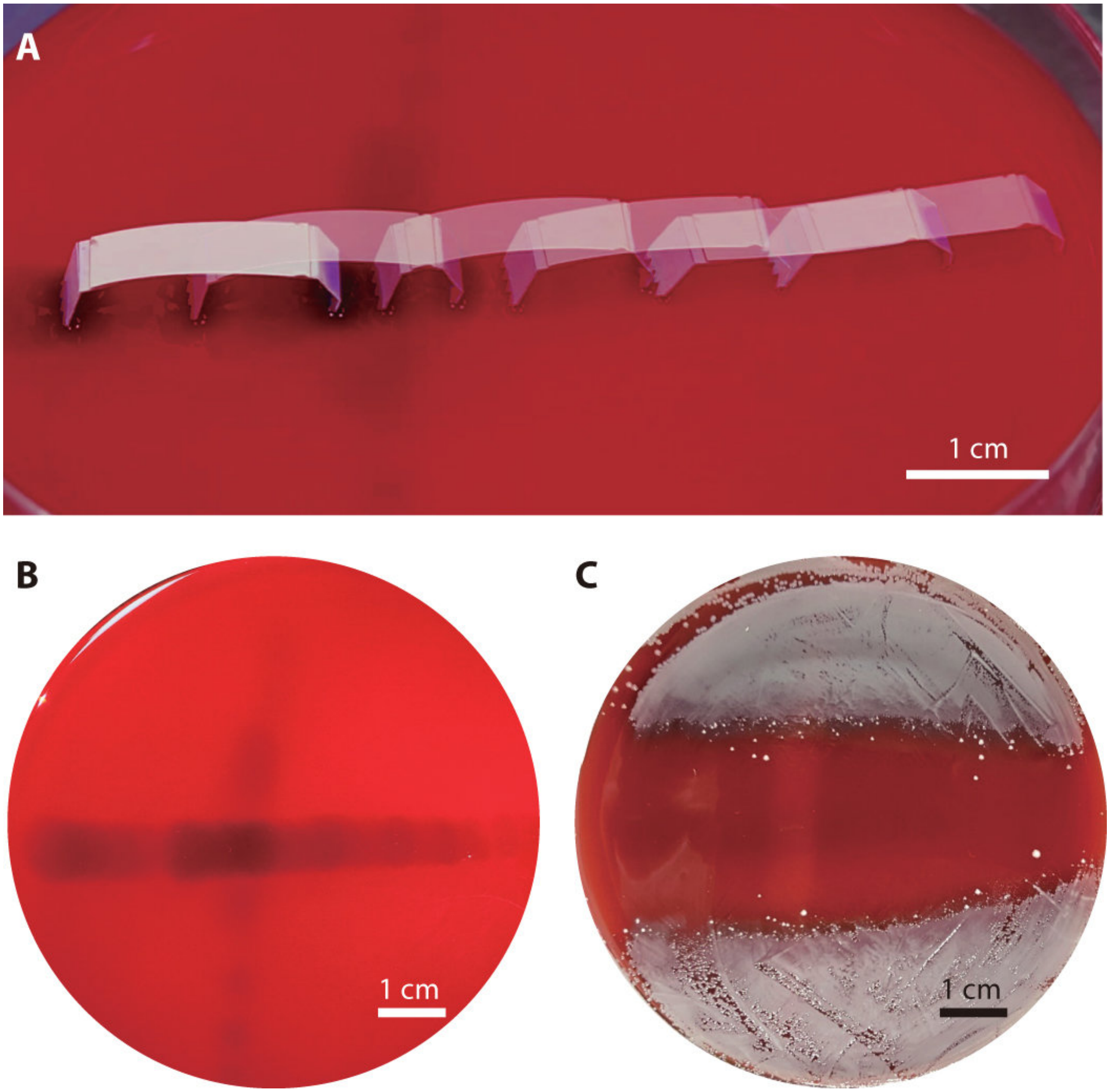
Some seeds are able to drive themselves into the ground—Pelargonium carnosum is one such example. The researchers with this effort studied such seeds to learn how they move themselves without the need for a motor, and found that they have multiple layers on their outer coatings—some absorb moisture from the air, while others do not. When the air is moist, the outer coating stretches, causing bending that results in movement. The team then applied what they had learned to small objects created using nanofibers as an outer coating—some absorbent, some not. The small objects are a form of hygrobots, because they move based on moisture action. To cause movement, each hygrobot was constructed in a particular shape so that as it relaxed, only one end would move, causing the entire bot to move slowly in that direction as it bent and relaxed repeatedly.

Movement of the hygrobots also called for controlling the environment to some extent—in some instances, the team quickly cycled the air in which the hygrobots operated between moist and dry. But they also found that using just the right mix of nanofibers in a dry environment allowed for creating a hygrobot capable of traveling across a wet surface using only the natural differences in humidity levels.

The team videotaped several of their creations in action, such as an inchworm-type bot making its way across a surface and a bot slithering like a sand snake across another surface. And in one instance, a smaller form of their inch-worm-like hygrobot moving across a petri-dish carrying with it antibiotics that cut across a bacterial biofilm. The group suggests their tiny bots might one day prove useful in military applications, as well—and perhaps as medical treatments, or as bots able to deliver drugs inside the body.



The hygrobot design mimics the moisture-responsive bilayer structure of plant seeds and awns, like that of Pelargonium carnosum. Credit: Shin et al., *Sci. Robot*. 3, eaar2629 (2018)



A hygrobot coated with antibiotics crawled across a bacteria-ridden culture plate, sterilizing it without any artificial power sources. Credit: Shin et al., *Sci. Robot.* 3, eaar2629 (2018)

More information: Hygrobot: A self-locomotive ratcheted actuator

powered by environmental humidity, *Science Robotics* 24 Jan 2018: Vol. 3, Issue 14, eaar2629, DOI: 10.1126/scirobotics.aar2629 , http://robotics.sciencemag.org/content/3/14/eaar2629

Abstract
Microrobots that are light and agile yet require no artificial power input can be widely used in medical, military, and industrial applications. As an actuation system to drive such robots, here we report a biologically inspired bilayer structure that harnesses the environmental humidity energy, with ratchets to rectify the motion. We named this actuator-ratchet system the hygrobot. The actuator uses a hygroscopically responsive film consisting of aligned nanofibers produced by directional electrospinning, which quickly swells and shrinks in lengthwise direction in response to the change of humidity. The ratchets based on asymmetric friction coefficients rectify oscillatory bending motion in a directional locomotion. We mathematically analyzed the mechanical response of the hygrobot, which allowed not only prediction of its performance but also the optimal design to maximize the locomotion speed given geometric and environmental constraints. The hygrobot sterilized a trail across an agar plate without any artificial energy supply.