Prizes for Eels, Algae, Leaves, and More

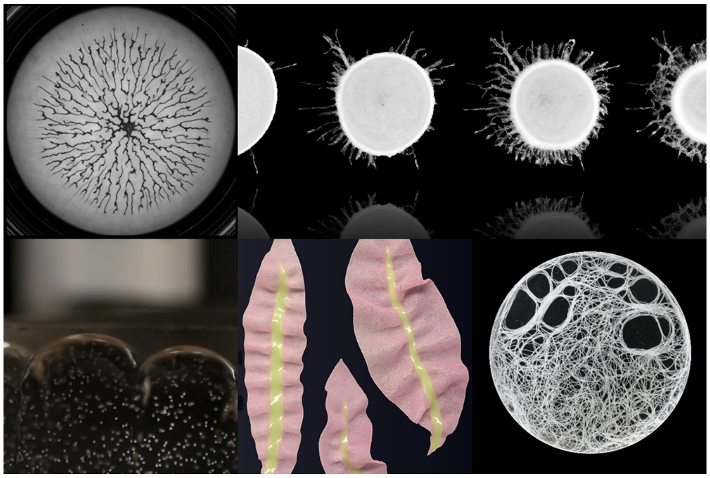
The winners of the annual “Gallery of Soft Matter” competition included posters and videos depicting wiggling worms, wrinkly leaves, sun-shy algae, flowing solids, and drying fibers.

By **Marric Stephens**

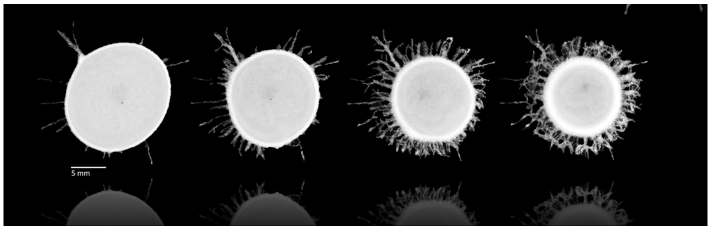
The APS Division of Soft Matter has announced the winners of the 2025 Gallery of Soft Matter video and poster contest. Below are the winners.

Vinegar Eels with Fingers

When a viscous fluid is sandwiched between two parallel plates that are then pulled apart, the edge of the fluid can form a complex pattern of finger-like lobes. This phenomenon, known as viscous fingering, has been characterized for fluids with a wide range of properties. Now University of San Diego biophysics student Kayla Baker and her collaborators have studied what happens when the viscous fluid is a suspension of active particles—namely, millimeter-long nematode worms known colloquially as vinegar eels.



Images from the winning posters and videos.
Credit: Adapted by APS

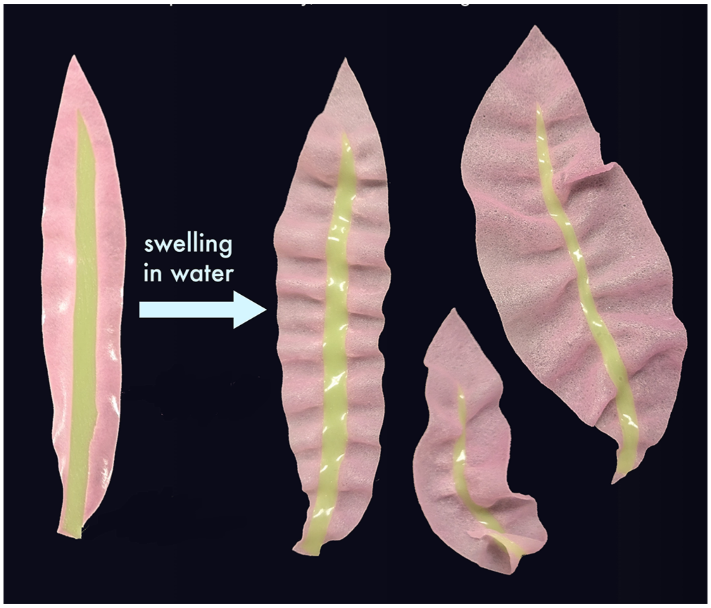


An active-matter suspension produces a fluid instability unlike that exhibited by an inert fluid.
Credit: K. Baker/University of San Diego

As shown in their poster, the researchers found that, when the plates were withdrawn quickly, the nematode suspension behaved like an inert fluid, exhibiting the usual hydrodynamic instability seen in previous experiments—albeit modified slightly by the vinegar eels’ motion. But when the plates were separated slowly, and when the vinegar eels were present at high enough concentrations, the animals’ collective motion generated a moving train of waves at the fluid boundary. This motion changed the nature of the instability and produced protrusions unlike those exhibited in inert-matter experiments. “Our work bridges the fields of active matter and fluid instabilities in a way that has not been extensively explored before,” Baker says.

Moisturizing Causes Wrinkles

In the Keller Lab at the University of Washington, Seattle, Ido Levin and Sarah Keller investigate how soft materials develop wrinkles in the absence of external stresses. Their typical



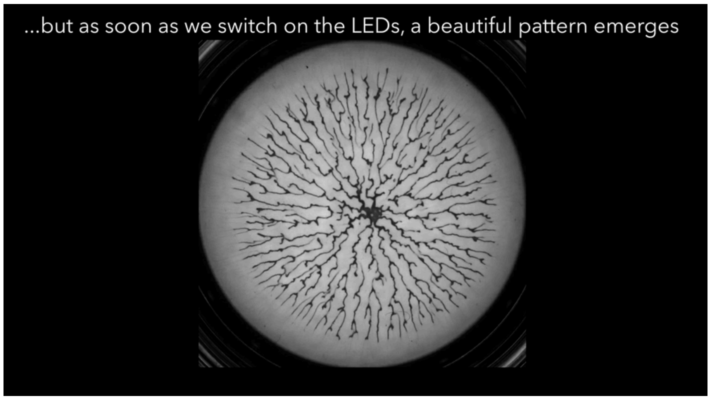
Biomimetic leaves wrinkle when wet.
Credit: I. Levin and S. Keller/University of Washington

experimental subject is a rectangular polymer sheet in which a wrinkling instability is triggered by swelling one half of the sheet. But for their poster, Levin says, the researchers made specimens with more aesthetic appeal: biomimetic “leaves.”

Their leaf-like structures are formed from two materials. The main part of the leaf is an elastomer whose composition is formulated such that it absorbs water, and swells. That material is fixed to a stiff central vein made of a denser, nonhygroscopic elastomer. When the leaf is immersed in water, the differential expansion and rigidity of the two materials cause the water-sensitive part of the leaf to develop ripples perpendicular to the vein. From experiments on leaves with different dimensions, Levin and Keller quantified the relationship between the wavelength of the ripples and the thickness and width of the leaf. Levin says that being able to control the way a material wrinkles could have applications in soft robotics and in the development of optical devices.

Active Matter That Shuns the Spotlight

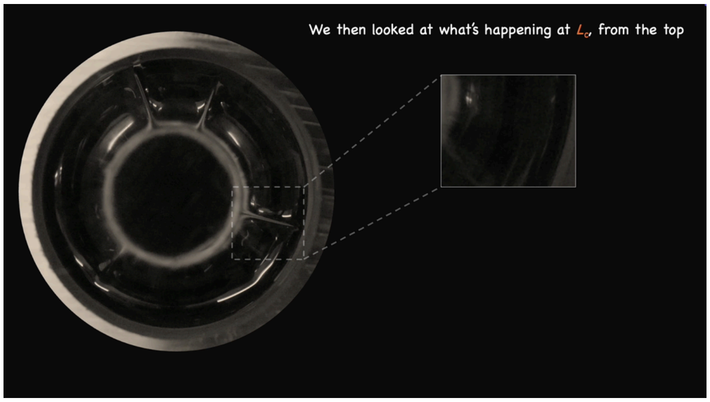
Also showcasing the patterns formed by active matter, the video presented by Isabelle Eisenmann of the Physics Laboratory of the Ecole Normale Supérieure in Paris and her colleagues stars a single-celled green alga called *Chlamydomonas reinhardtii*. Somewhat like a microscopic rowing boat, *C. reinhardtii* propels itself through the water using two tiny arms, or flagella. Green algae depend on light for their energy, but too much can be harmful. Each individual *C. reinhardtii* cell therefore uses its single eye to compare the light level on all sides, and swims in the direction of least illumination.



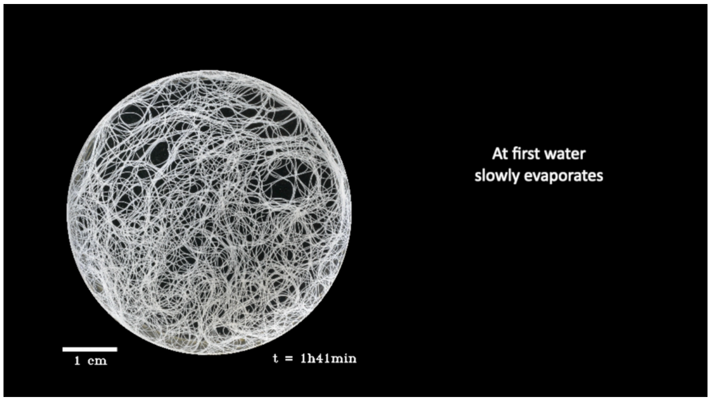
The light-avoiding instinct of the single-celled alga *Chlamydomonas reinhardtii* causes a suspension of the organisms to adopt complex patterns under illumination.
Credit: I. Eisenmann/ENS

The researchers placed a suspension of *C. reinhardtii* in a petri dish that was lit from all sides. With no other shade available, the algae sought shelter from the light in each other’s shadows. This collective behavior amplified random initial density fluctuations, and the swarming cells formed an array of branching radial spokes that then retracted into a central blob. By varying the population density, light intensity, and medium viscosity over a series of experiments, Eisenmann and colleagues derived a model that predicted the properties of the patterns formed by the algae.

Eisenmann compares the light-avoiding behavior of *C. reinhardtii* with that of emperor penguins, which crowd together to escape the cold. But she notes an important difference. Whereas huddling penguins can be driven by purely local interactions, the patterns formed by *C. reinhardtii* require the algae to influence each other over many cell lengths. Such nonlocal interactions could be important in many more



A runny solid flows through an annular channel by turning itself inside out.
Credit: J. Hwang/Princeton University



The microstructure of paper and other fiber networks is determined by a balance between capillary forces and fiber stiffness.
Credit: M. L'Estimé/Paris Polytechnic Institute

phase-separating active-matter systems, Eisenmann says.

Soft Solids Flow Like Fluids

Investigating fluid-like flow in a soft elastic solid, Jonghyun Hwang and his colleagues, all at Princeton University, chanced upon a new type of interfacial instability (see **Video: Soft Solid Flows Through a Pipe**). "I first observed the instability by happenstance when I was working on another problem," Hwang says. "As we worked on explaining its cause, we realized that it could not be explained with the knowledge that came from other types of instabilities."

The researchers' video reports the results of experiments on this instability. They studied a polymer whose nonzero shear strength defines it as a solid, but whose stiffness—about one-millionth that of a gummy bear—means that it can be poured like a thick liquid. They observed the fluid instability when they forced this runny solid through a channel with a ring-shaped cross section. The leading surface of the solid quickly developed a convexity caused by the edges dragging against the channel walls. But after a short distance, that convex surface broke up into distinct lobes separated by radial valleys.

Hwang and colleagues visualized the polymer's internal flow by tracking the motion of tracer particles embedded within it. They found that the solid flows by a convection-like process of eversion—turning inside out. This process builds up a large store of elastic strain energy, which is minimized when the surface breaks up into distinct lobes.

Watching Paper Dry

Paper is made by mixing cellulose fibers with water, pouring the suspension onto a grid to align the fibers and then draining and drying the resulting fiber sheet. Manon L'Estimé at the Paris Polytechnic Institute and her colleagues wanted to better understand the influence of the fibers' characteristics on the microstructure of the fiber network.

The researchers created hydrogel fibers by zapping a jet of liquid photopolymer with pulses of ultraviolet light. The lengths of cured polymer settled in a random tangle on the bottom of a water-filled petri dish, which was left to dry out. Over the course of a day, the water level fell enough to expose the fibers and the bottom of the dish between them. Capillary forces exerted by water still adhering to the fibers pulled the fibers into bundles, expanding voids in the network. Then the fibers themselves dried out and shrank, pulling the edge of the network inward from the side of the petri dish.

In their experiments, L'Estimé and colleagues varied both the thickness and the rigidity of the fibers. They found that the properties of the resulting networks were controlled by a balance between capillary forces and the fibers' resistance to deformation. Softer and thinner fibers deformed more, forming denser networks with smaller, rounder voids. L'Estimé says that controlling the fiber properties could let manufacturers tune the microstructure not only of paper but of aerosol filters and devices for fog harvesting.

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