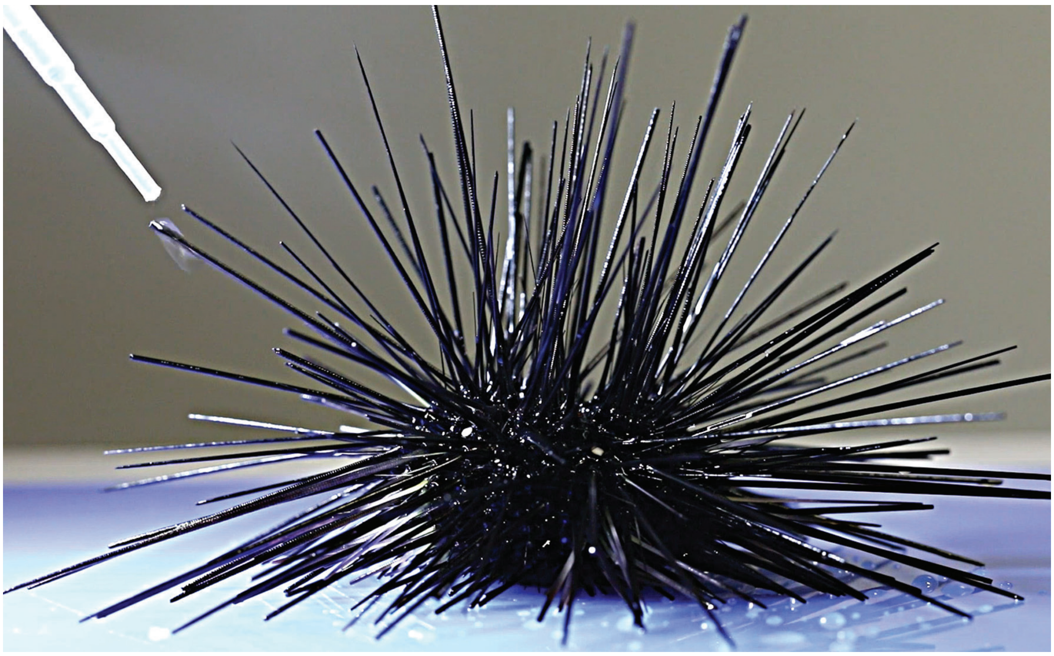
Sea urchin species discerns surroundings with electrically responsive spines

Capitalizing on a mechanoelectrical mechanism that arises from the spines' structure could yield useful sensors for marine environmental monitoring and other applications.

By Alex Lopatka



When a water droplet is applied to the tip of a spine of the sea urchin *Diadema setosum*, the spine rotates about 10° in one second. Each of the spines is 5–8 cm long. (Photo courtesy of Annan Chen.)

The sharp spines of a sea urchin defend it against predators. In at least one species, the spines appear capable of sensing flowing water too.[1] The new information about the spines' alternative function could lead to novel bioinspired designs for underwater monitoring and other applications.

Jian Lu (City University of Hong Kong) and his colleagues applied droplets of seawater to the spines of *Diadema setosum*, a species of long-spined sea urchin that's found throughout the vast tropical waters of the Indo-Pacific region. Within a second of making contact with the water, the spines rotated about 10° from their original positions. Nearby spines untouched by droplets showed no response.

The team further investigated the behavior with imaging and electrical measurements. The spines are hollow and gradually narrow in diameter from the base to the apex. When seawater was injected through the base of an underwater spine, the researchers observed an electric potential of tens of millivolts along the spine's length for both living and dead sea urchin samples. That even spines from dead sea urchins had measurable voltages, which dissipated immediately when the flow stopped, suggests that the electrical response is independent of living tissue and has a structural origin.

The researchers interpret from the electrical measurements that, upon contact with the water, the spine's interior surface acquires an electric double layer: A bottom layer of negatively charged ions quickly attracts a layer of positively charged ions. As the conductive seawater flows through the spine, it deforms the electric double layer and results in an electrochemical potential that peaks at the apex and is lowest at the spine base. The potential then triggers a response in the muscle fibers of the spine's joint, and that response makes the living sea urchins move.

Inspired by the biological mechanoelectrical mechanism, the researchers 3D printed spines with a geometric structure that resembles that of sea urchins. Initial exposures to flowing water yielded similar voltages and potentials in the 3D-printed spines as they did in the biological ones. The researchers also built a three-by-three array of printed spines and demonstrated that they could map the spatial distribution of water passing through. Such a sensor, the researchers say, could be useful for marine monitoring, measurements of water flow, and other applications. PT

Reference

1. A. Chen et al., "Echinoderm stereom gradient structures enable mechanoelectrical perception," *Nature* **651**, 371 (2026).

Quantum drops are spotted in ultracold gas of molecules

Strong and tunable long-range dipolar interactions could help probe the behavior of supersolids and other quantum phases of matter.

By Alex Lopatka

Two years ago, Sebastian Will of Columbia University and colleagues cooled a gas of sodium cesium molecules to nanokelvin temperatures inside an optical trap and formed the first Bose–Einstein condensate of dipolar molecules.[1] A key motivation of the research was exploiting dipole–dipole interactions—at such cold temperatures, they're more energetic than the molecules' kinetic energies—to form ordered structures such as supersolids, which flow with no viscosity. (For more on the 2024 findings, see the *PT* story "A Bose–Einstein condensate of dipolar molecules," by Daniel Garisto.) But the dipolar interactions in that initial demonstration were too weak to realize such phenomena.

Now, using a pair of linearly and elliptically polarized microwave