Sea Urchin Sperm Follow Their Noses

Using concepts from control theory, researchers link the complex navigation behavior of a sea urchin sperm to a single parameter: its response to changing chemical "smells."

By **Maggie Hudson**

To reproduce, sperm cells from male sea urchins follow weak chemical signals through a few square meters of open ocean to reach and fertilize the eggs of females. Researchers across biology, physics, and mathematics are fascinated by this phenomenon and have searched for simple models to explain how sea urchin sperm navigate. Now Mahmoud Abdelgalil at the University of California, Irvine, and colleagues have discovered an unexpected synergy between established sperm navigation models and concepts from control theory [**1**]. They developed a robust navigation model that relies on a single parameter: the local concentration gradient of the chemical the sperm cells track. The team says that their model could be used to describe the motion of other organisms that move in response to chemical gradients.

The team modeled the swimming behavior using an "extremum-seeking" approach from control theory. In this approach, the real-time response of an organism to some dynamic variable exclusively relies on the variable's instantaneous local signal; the organism has no knowledge of the signal across space and time.

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Abdelgalil and colleagues showed that their approach captures the sperm's navigation dynamics and provides a simpler interpretation of a "switching" behavior in its spiral swimming pattern. Previous models explained this behavior as the action of two modes, switching between an "on-response" along the concentration gradient and an "off-response" in any other direction. However, this work shows that only a single, dynamic mode is needed to reproduce the predicted swimming pattern.

Abdelgalil says that their model could help researchers in designing robot systems to have similar sensing capabilities. "The strategies at which nature arrived after years of evolutionary optimization present a promising starting point to tackle these challenges for microrobots," he says.

Maggie Hudson is an Associate Editor for *Physical Review Materials*, *Physical Review Applied*, and *PRX Energy*.

REFERENCES

1. M. Abdelgalil *et al.*, "Sea urchin sperm exploit extremum seeking control to find the egg," **Phys. Rev. E 106, L062401 (2022).**