Physicists Look at Animal Behavior

By Shannon Palus

APS March Meeting, San Antonio — As Imperial College London physicist Andre Brown reminded his audience at the APS March Meeting 2015, Kepler's laws of planetary motion accurately describe the way that the planets move around the sun. Brown, who studies worms, wonders: Could there be such laws for animal behavior too?

Today, any comparison between the depth of understanding of animal behavior and detailed knowledge of solar system kinematics may seem silly. But three focus sessions on the physics of behavior showed that tracking and modeling animal motion still bears fruit.

A computational model for the predator-prey dynamics of bacteria: Bacteria can be useful for producing biofuels, or cleaning up an act of biological warfare. If there is a uniform concentration of food, they exhibit Brownian motion. A new model, presented by Steve Pressé, a physicist at Indiana University – Purdue University Indianapolis (UPUI), illustrates how microscopic predators can go on a targeted mission.

Although the path of a single organism toward a point-source is not uniform, it is not random. Instead of assuming the bacteria travel along a nutrient gradient, the new model proposes that they take a squiggly path toward a food source (simplified in the model as a single point). The bacterium senses the "prey," and after some delay, uses that information to swim in a new direction. "What [we] can infer is that when bacteria move, they have memory," says Hossein Jashnsaz, a Ph.D. candidate at IUPUI who worked on the research.

From the model, which is applicable to all bacterial species, the researchers can infer a constant for the minutes that it takes to get used to a new environment, called "adaptation time." That time likely varies from species to species.

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High-resolution cameras keep an eye on worms: A worm's repertoire is simple: it wiggles back and forth, explains Brown. But behavior of the 300-neuron dirt-dweller proves that marrying genetics and kinematics, even at its simplest, is tricky. The details of motion are hard to identify without extensive observation time. He presented a multi-worm tracker system that will record the motions of nearly 200 worms around the clock — a substantial upgrade to the singlecamera system that he used before.

The sliding six-camera system captures how fast the worms move, and how often they turn — their "roaming and dwelling" behavior — while recording unexpected, repeated motions. Six cameras generate 2 terabytes of raw video per hour, so to save on storage space, the system identifies the worm's motion and records it, while suppressing the background.

Eventually, Brown hopes to link the worms' wriggling to their genetics and neuronal activity. For now, Brown is glad to have the upgraded instrument: "We're really just at the stage of collecting good quantitative data."

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A standardized environment for burrowing creatures: The long bodies of snakes and lizards come in handy when they need to burrow into sand. Dry sand is easy to replicate in a lab but wet sand — which clumps together — is more difficult. Georgia Institute of Technology physicist Daniel Goldman presented a new method for creating a wet sand environment in a lab, and demonstrated its usefulness in revealing an environmental limitation of Ocellated skink movement. The new method "allows us to create repeatable homogeneous conditions," Goldman explained.

He and his team made a wet granular mixture with water and dry spherical glass particles (each with the same diameter), blended with a kitchen mixer.

The team used an x-ray camera to observe the skink as it burrowed in both dry "sand," and the new wet "sand" environment. In the wet material, there was a limit to how deep the animal could go. Using a cylinder as a proxy for the animal, Goldman found that the wet material was three times more resistive: In the wet material, the animal has to work to disrupt the liquid that holds the sand together.

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Dead frozen diving sea birds show how it's done: Virginia Tech physicist Sunny Jung wanted to know how seabirds can make fast dives into water but not break their necks. A good example is the gannet, a long-necked bird that can enter the water at 55 miles per hour.

Jung froze specimens of dead gannets in the elongated diving position. Researchers dropped the frozen birds into tanks. When a gannet is partly submerged, the drag from the water pushing up, and the downward pull of gravity act as compressing forces. A video camera captured the birds' entrance into the water, and revealed that a protective cavity of air forms around their necks, like an underwater air bag.

To better understand the forces involved, Jung created seabird proxies, with cones for heads, connected to spherical bodies by elastic bands of varying length. He's building on the work with a study of what happens to human necks in extreme diving, which can lead to multiple fractures.

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