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Mechanical Engineering Seminar Series

Impressive Feats without Feet: The Physics of Limbless Movement in Complex Environments

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1200 EECS
December 5, 2023
3:30 PM

ME Seminar Zoom link

Passcode 692510

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Abstract
The diversity and complexity of natural substrates—from flowable materials like sand and mud to steeply sloped tree branches and trunks with vast differences in flexibility and roughness—present significant challenges for animal movement. These surfaces can be particularly difficult for limbless animals, like snakes, who lack appendages that are commonly used for gripping, stabilization, and propulsion; in fact, many limbless animals fail to move on complex and unfamiliar substrates. This talk will be divided into two parts, in which we focus on agile movements—first on sand, then on large trees—and the behavioral strategies and morphological adaptations of snakes that perform well in each environment. First, we focus on sidewinding, a peculiar locomotion that enables some desert-dwelling snakes to ascend sandy slopes. AFM measurements reveal an evolutionary loss of anisotropic microtextures, likely accompanied by a loss of anisotropic friction. A mathematical model predicts such frictional changes would be beneficial for sidewinding. In the second part of the talk, we explore head-first vertical ascents and descents of snakes traversing a custom-built textured climbing wall. "Footholds" are equipped with force-sensing capabilities that provide time-resolved force data that is synchronized with high-speed video recordings. We explore how morphology, textures, footholds, and the direction of movement affect strategies and success of corn snakes. We find that, during upward climbs, the prehensile tail can supply non-negligible lateral forces that act to stabilize the body; during downward climbs, the tail supplies vertical forces that support much of the body weight. AFM measurements reveal similarities in microtextures that may provide a beneficial enhancement of lateral friction. Together, these studies suggest that the interplay between behavioral and morphological adaptations are important for generating the physical interactions necessary for successful movement.

Bio
Dr. Jennifer Rieser is an Assistant Professor in the Physics Department at Emory University, where she runs an experimental research lab at the interface of soft matter physics and organismal biophysics. Through a combination of experimental and modeling techniques, the lab explores how evolutionary adaptations and behavioral strategies allow animals to manage and utilize interactions with complex substrates. She received her PhD in Physics from the University of Pennsylvania working with Doug Durian on deformation and flow in granular materials and went on to do a postdoc at Georgia Tech focusing on the interactions between animals and robots within complex natural substrates.