Why Flies Walk with Wet Feet

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Many animals can walk up vertical surfaces or even along the ceiling. And many studies have examined how flies accomplish this impressive task. Whereas these studies have revealed the anatomy of the contact area and there have been many assumptions about the fly attachment mechanism, the main elements that contribute to the attachment force were unknown. However, Mattias Langer, J. Peter Ruppersberg, and Stanislav Gorb have successfully demonstrated that the fluid secreted from the fly's feet is a critical factor in attaching the fly to the ceiling.[2]

Scanning electron microscopy demonstrated that the attachment pads of fly legs are covered with setae, each ending in a small terminal plate. Langer *et al.* then scanned the terminal plate with an atomic force microscope (AFM) and showed that the border of the plate was about 60 nm higher than the center. Using an AFM combined with an upright infrared differential interference contrast video microscope to position precisely the cantilever tip of the AFM on the terminal plate, they then retracted the specimen and measured attractive forces on a nanoNewton (nN) scale. This precise positioning and sensitive force measurements allowed examination of the plate surface point-by-point, rather than being scanned continuously line-by-line. As the sample was retracted, the point of maximum stress was reached when the stress induced by the AFM cantilever exceeded the attractive force, then contact between the plate and tip was broken and the tip was re-positioned with no lateral force being applied to the plate. A median attractive force of 33 nN was measured in the center of the plate, and the force at the border was about half of that.

But what specifically was responsible for the attractive force? Langer *et al.* thought that the forces they measured could not be accounted for with just Van der Waals and Coulomb forces. They isolated small drops of secretions from foot pads. They then dipped the AFM cantilever tip in drops that corresponded to the dimensions of a foot pad, and then measured the attractive forces. The median attractive force was 38.5 nN, corresponding very well with the forces detected in the center of the plate. Interestingly, in measurements repeated on the same drops minutes later, the measured forces were smaller, suggesting that evaporation had diminished the attractive force.

To follow up on this latter observation, Langer *et al.* measured attractive forces on hair plates in a buffered aqueous solution. The forces diminished about 10-fold. This led to the conclusion that attractive capillary forces, mediated by secretions from the pad of the fly's foot, are a critical factor in creating a summed attractive force that exceeds the body weight of the fly. At least one component of this secretion is water-soluble. And that is why flies walk with wet feet! ■

1. The author gratefully acknowledges Dr. Stanislav Gorb for reviewing this article.

2. Langer, M.G., J.P. Ruppersberg, and S. Gorb, Adhesion forces at the level of a terminal plate of the fly's seta, *Proc. Royal Soc. Lond.* ***B*** **271**:2209-2215, 2004.

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ABOUT THE COVER

Quantum dot fluorescence image of a section of the periphery of mouse kidney immunolabeled for actin (QD 525 shown in green) and laminin (QD 655 shown in blue) and the DNA in the cell nuclei counterstained with Hoechst (shown in red). Prominently stained are the proximal and distal convoluted tubules and the renal corpuscles. 300x. Image represents a significant advancement in fluorescence imaging of proteins in fixed tissues in that two of the target proteins shown here (actin and laminin) were localized using Quantum dots, a commercial byproduct of nanotechnology. Quantum dots are solid-state semiconductor nanocrystals composed of cadmium selenide with a capping layer of zinc sulfide and have a number of unique properties that make them advantageous for fluorescence microscopy. These properties include very high fluorescence brightness and photostability, long apparent Stoke's shifts, and narrow-band fluorescence emission. Only recently have high quality secondary antibody conjugates of Quantum dots become commercially available and the immunolabeling parameters been optimized. This image by Thomas Deerinck and Mark Ellisman, NCMIR won 5th place in the Olympus BioScapes™ International Digital Imaging Competition. deerinck@ncmir.ucsd.edu

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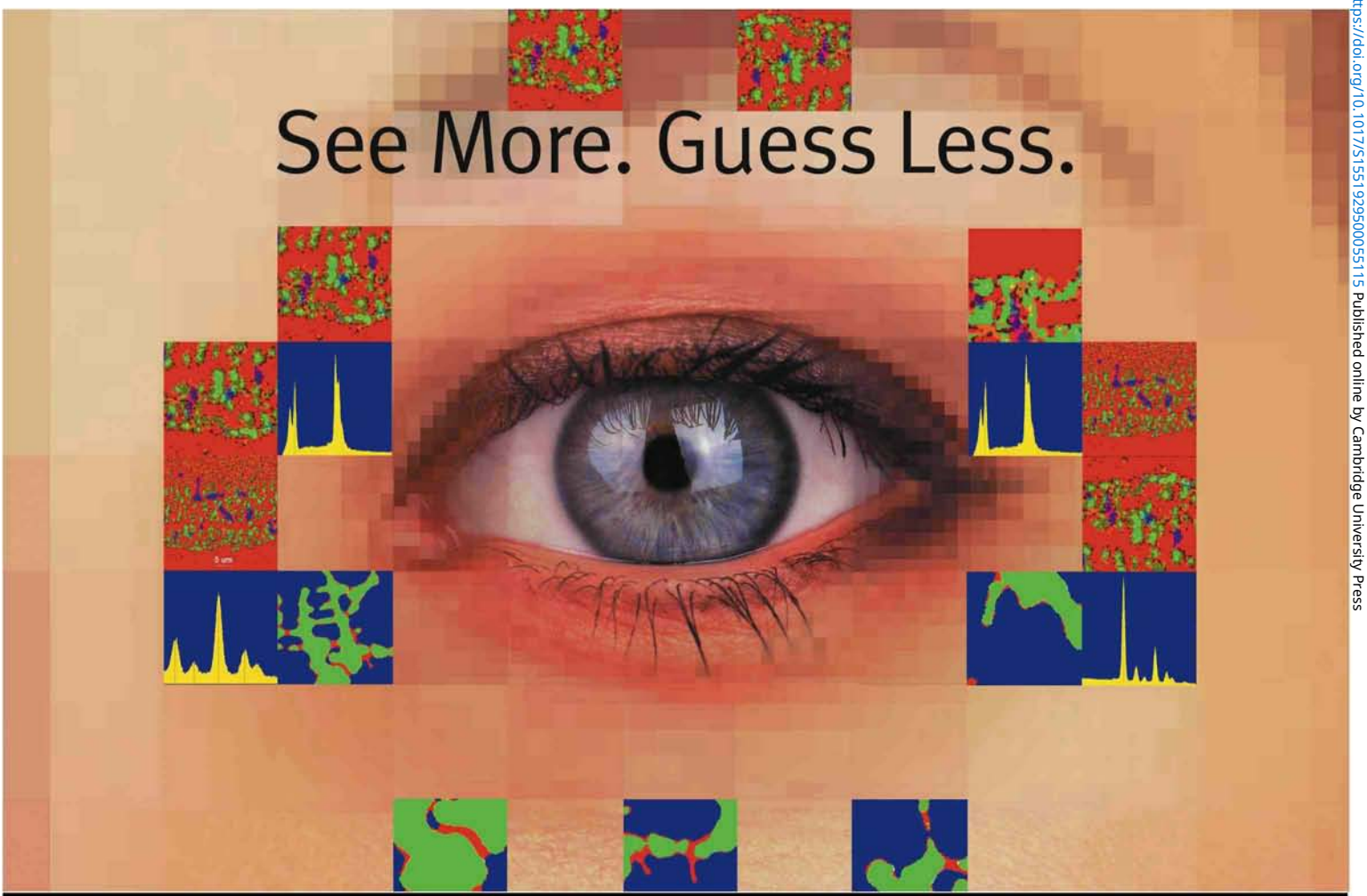

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