

## Microscopy used to Show how Spiders Hide!

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It has been appreciated that many invertebrates have morphologic and/or behavioral traits that help them survive by camouflage for predator avoidance or being stealthy predators themselves. The morphologic features that are involved have been described in greater detail as the technology has evolved. Recently, Rebecca Duncan, Kellar Autumn, and Greta Binford have used dissecting microscopes and scanning electron microscopes (SEM) to reveal new details of how certain species of spiders hide themselves by covering themselves with sand, and how the sand particles tenaciously stick to the spiders' bodies.<sup>2</sup>

For their studies, Duncan *et al.* concentrated on two genera of spiders (*Sicarius* and *Homalonychus*) collected from North and South America and Africa. These spiders (and others) are mostly covered with hair-like setae that can be visualized with modest magnification. Duncan *et al.* took a closer look using different SEMs. At higher resolution, they could distinguish even smaller projections from most, but not all, of the setae. They created the term "hairlettes" for these smaller projections. Hairlettes are on the order of 10 microns in length and 10 to 40 nm in diameter. Interestingly, they found that hairlettes are difficult to record with SEM because their extremely delicate nature caused them to move due to heating effects.

After carefully describing the morphology of hairlettes and associated structures, Duncan *et al.* then dusted specimens with ceramic microspheres (1 to 200 microns in diameter) to quantifiably simulate sand covering a spider. Particles in this size range correspond to clay, silt, and fine sand. They collected data that suggested that hairlettes facilitate sand capture by adhering to particles via intermolecular forces. Specifically, they model hairlettes as small cylinders that wrap around spherical structures in a fashion that the force of adhesion can be calculated. Using experimental data and two mathematical models, Duncan *et al.* proposed that intermolecular

adhesion, like van der Waals forces, were largely responsible for holding sand particles on hairlettes. Based on one model, the larger particles would only break loose when the pull on them exceeded 500 times their weight. For physical reasons, smaller particles would still cling at forces orders of magnitudes greater! The second, more conservative model suggested that extremely large particles may require more than adhesion to hairlettes to remain attached (like becoming mechanically entrapped between setae), but still strongly supported adhesion as the dominant retaining mechanism for smaller, more typical sized particles.

This is a beautiful illustration of one of the fundamental principles of evolution; small changes in existing structures confer strikingly different adaptive morphology. An alternative mechanism to attract and retain particles (such as development of glands to secrete glue) would require a much more complex evolution. This is the first study to provide experimental and comparative evidence for an adaptive role for setal morphology and a dominant role for intermolecular forces in particle retention in these spiders. Convergent evolution of hairlettes in these two genera of spiders suggests that they represent a general design principle for particle capture and retention. These concepts have endless possibilities in directing future research in bio-inspired engineering with potential applications that could directly benefit mankind!

And if that were not enough, it needs to be pointed out that Duncan *et al.* were careful to preserve their precious specimens by examining portions of the spiders' bodies that were shed during molting, and only sacrificing a few spiders to complete the collection at their college. The surviving specimens were used in other studies. Finally, you will be astonished to learn that Ms. Duncan performed this work as an undergraduate college student!

- 1 The author gratefully acknowledges Dr. Greta Binford and Ms. Rebecca Duncan for reviewing this article.
- 2 Duncan, R.P., K. Autumn, and G.J. Binford, Convergent setal morphology in sand-covering spiders suggests a design principle for particle capture, *Proc. Royal Soc. B*, 274:3049-3056, 2007.

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## ABOUT THE COVER

This striking image of a transverse section of a Meadow Buttercup, *Ranunculus acris*, was taken by Stephen Nagy, M.D. of Montana Diatoms in Helena, Montana. The image was captured from a commercial slide stained blue-green, and the original image was in brightfield. However, digital imaging allowed the photographer to reverse all colors. The photograph was recognized as an Honorable Mention winner in the 2006 Nikon Small World Competition, and is used here by permission of the photographer.

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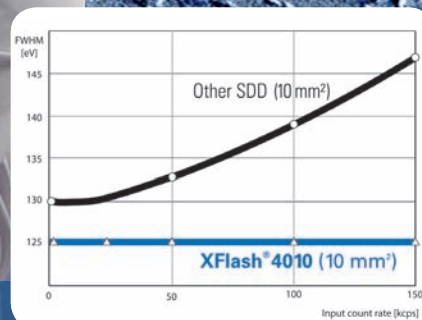
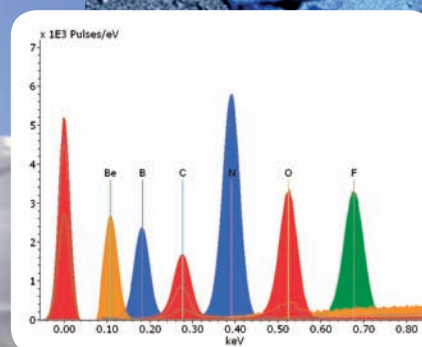
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