MICROSCOPY TODAY

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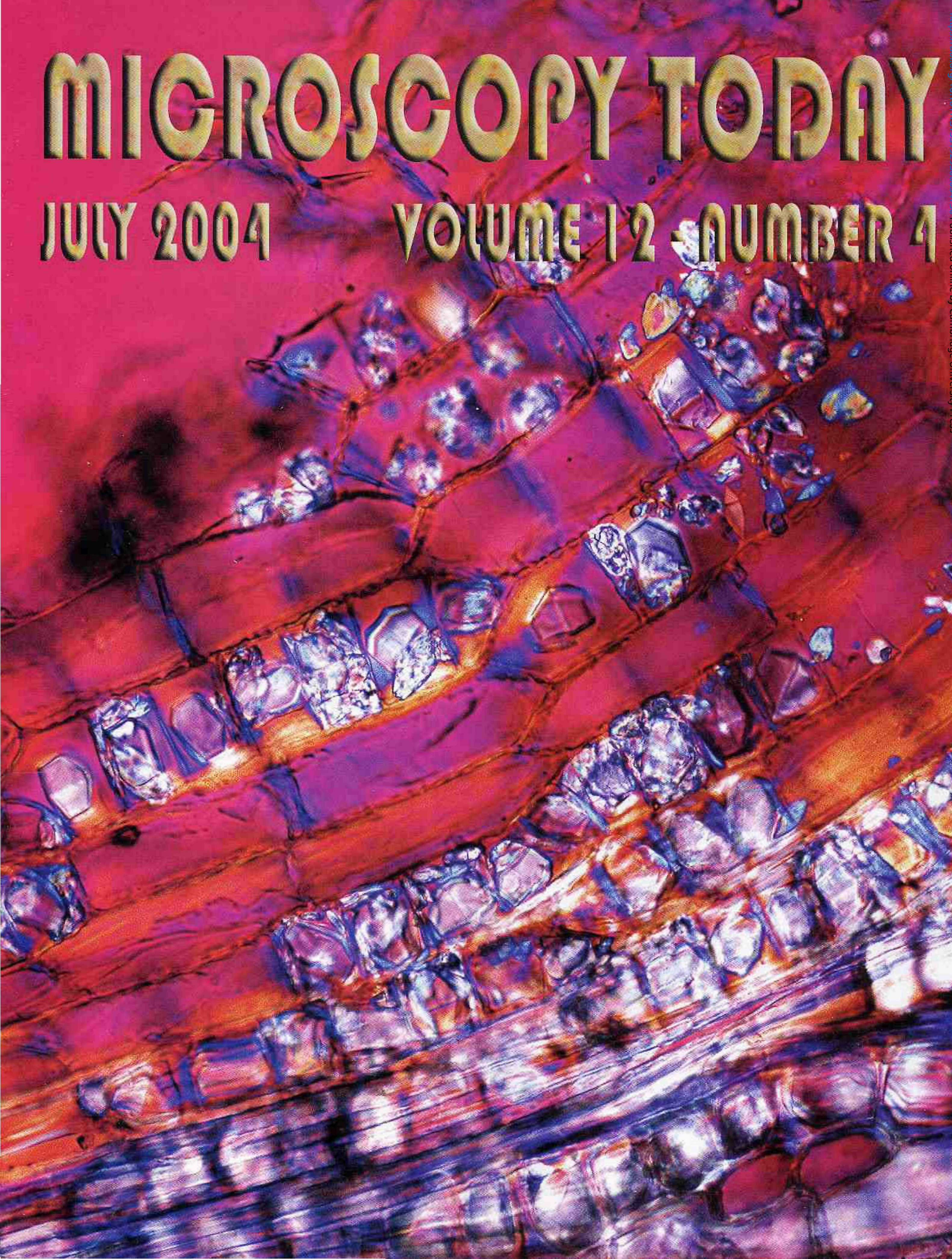

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Right at Your Fingertips

Stephen W. Carmichael[1]
Mayo Clinic
stephen.carmichael@mayo.edu

They're right at your fingertips, but how often do you consider the microscopic anatomy of your fingernails? How is their form fitted to function? Primates, including humans, use fingernails to maintain the anatomic integrity at the distal end of our phalanges, which often serves as the leading edge of our physical sensory apparatus. The nails serve as a stiff backing to the soft pads of our fingers, helping to improve the grip and sensitivity by allowing the pad to "push back" on the object we are touching. Nails also serve specific functions in maneuvering within cracks, scratching, and fighting.

The gross structure of nails helps to resist upward bending forces that are encountered in these functions. The convex curvature contributes, just like a curved piece of paper has more stiffness than a flat sheet. The composition of nails is also suitable. As with the outer layer of skin, and the structure of hair, nails are also composed of keratin. Specifically, long, slender α-keratin protein fibers are embedded in an amorphous protein matrix. But the orientation of these fibers required microscopic analysis. Laura Farren, Stephanie Shayler, and Roland Ennos have now provided an interesting insight in to the structure of the human fingernail.[2]

Scanning electron microscopy (SEM) clearly demonstrated three distinct layers; a relatively thick intermediate layer, and thinner dorsal and ventral layers. The outer layers appeared to be composed of flat, overlapping tile-like sheets, oriented in the plane of the nail. In contrast, the thick intermediate layer was more fibrous, with the fibers oriented transversely, parallel with the edge of the nail. At the sides of the nail, the tile-like outer layers wrapped around the intermediate layer to produce a smooth lateral border of the nail.

Polarized light microscopy gave results consistent with the SEM study. The isolated layers were observed between crossed Nichol prisms. If the fibers in a layer had a predominant orientation, the object would appear bright when the fibers are 45° to the prisms, and dark when they are parallel or perpendicular to the prisms. The intermediate layer demonstrated a clear transverse orientation of the fibers, whereas the image remained dark when the outer layers were examined, indicating no specific fiber orientation.

Mechanical testing demonstrated that the transverse orientation of fibers in the thick middle layer dominated the characteristics of the nail. Specifically, shear stress almost always tore the nail transversely. Measurements of force applied to scissors showed that twice as much energy was required to cut the nail longitudinally, as opposed to transversely (6 kJ m^{-2} versus 3 kJ m^{-2}). When just the intermediate layer was cut, about four times more energy was required! Clearly it is easier to separate the transversely oriented fibers than it is the sever them.

This fascinating study is applicable to everyday life. Whenever a nail is torn or chewed, it preferentially separates transversely. This is better than a longitudinal tear that could extend into the delicate nail bed and cause a more serious injury. Also, one may notice that the top layer may delaminate, which is the tile-like layer separating from the transverse fibers. Farren *et al.* point out that a brittle layer of varnish (for some reason called "fingernail polish") might make nails more prone to destructive cracking, often opposite to the intention of the self-applier. This study sets the standard for future studies that could help improve nail care and related products and prostheses. As Farren *et al.* conclude, a better understanding of nail morphology is well within our grasp!

1. The author gratefully acknowledges Dr. Roland Ennos for reviewing this article.

2. Farren, S. Shayler, and A.R. Ennos, The fracture properties and mechanical design of human fingernails, *J. Experimental Biol.* **207**:735-741, 2004.

INDEX OF ARTICLES

ABOUT THE COVER

Microscopical identification of Colorín (*Erythrina* sp.)wood.

Radial section of Erythrina wood, showing a large numbers of crystals in parenchyma cells using circular polarized light (λ plate). Most of the crystals are prismatic in long chains, with others being smaller "crystal sand" type. The Colorín plant (Erythrina.) was an important part of the native (Tarahumara) religion (the seeds are hallucinogenic) and the wood was incorporated into Catholic statues (*Santos*).