Microscopy TODAY

## Coming Events

### 2011

**PITTCON**
March 13–18, 2011
Atlanta, GA
www.pittcon.org

**Histochemistry 2011**
March 30–April 1, 2011
Woods Hole, MA
www.histochemistry2011.org

**FASEB Experimental Biology**
April 9–13, 2011
Washington, DC
eb@faseb.org

**Focus on Microscopy**
April 17–20, 2011
Konstanz, Germany
www.focusonmicroscopy.org

**MRS Spring Meeting**
April 25–29, 2011
San Francisco, CA
www.mrs.org/spring2011

**EMAS 2011**
May 15–19, 2011
Angers, France
www.emas-web.net

**IUMAS-V**
May 22–27, 2011
Inchon, South Korea
www.iumas5.org

**Inter/Micro: 62nd Conference**
June 11–15, 2011
Chicago, IL
www.mcri.org/home/section/101/intermicro

**Microscopy & Microanalysis 2011**
August 7–11, 2011
Nashville, TN

**FEMMS 2011**
September 18–23, 2011
Sonoma County, CA
www.femms2011.llnl.gov

**CIASEM 2011**
September 25–30, 2011
Mérida, Mexico
www.ciasem.com

### 2012

**Microscopy & Microanalysis 2012**
July 29–August 2, 2012
Phoenix, AZ

### 2013

**Microscopy & Microanalysis 2013**
August 4–8, 2013
Indianapolis, IN

### 2014

**Microscopy & Microanalysis 2014**
August 3–7, 2014
Hartford, CT

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**More Meetings and Courses**
Check the complete calendar near the back of this magazine and in the MSA journal *Microscopy and Microanalysis*.

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### Carmichael's Concise Review

# All the Better to See You With

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In the animal kingdom, eyes come in a relatively small variety of functional forms. When a new optical system is found, it usually is a variation of a known form. It is very rare to discover a novel form of an eye. Such a sensational discovery has been made by Annette Stowasser, Alexandra Rapaport, John Layne, Randy Morgan, and Elke Buschbeck [1]. Using two different experimental approaches, they demonstrated an eye with a truly bifocal lens, something that has only been suggested for certain long-extinct trilobites

The animal they studied was the third-instar larva of the sunburst diving beetle (*Thermonectus mamoratus*). These beetle larvae have six pairs of eyes and this instar stage has the largest lenses. Two pairs (called E1 and E2) are tubular and look directly forward (see Figure 1). The larvae hunt with these principal eyes by nodding up and down as they approach their prey. This "scanning" behavior will be explained by the anatomy of the E2 eye.

**Figure 1:** Head of third instar larva (copyright Elke Buschbeck)

As visualized by scanning electron microscopy, the retinas of the E2 eye are divided into distinct distal and proximal portions, with the proximal portion being closer to the animal's head. The visual fields of each retinal portion are oval with the distal retina having a horizontal field of 40° and a vertical field of 14°; and the proximal retina having fields of 50° and 3.5°, respectively. The distal retina consists of at least 12 tiers of photoreceptor cells, which are oriented approximately perpendicular to the light path with a central pit to allow some light to pass through to the proximal retina. The proximal retina lies directly beneath and contains photoreceptor cells oriented parallel to the light path. The distal retina lies approximately 424 µm behind the lens, and the proximal retina is about 493 µm behind the lens. With two separate retinas at different distances from the lens, one could ask the question "Which retina receives a focused image from the lens?" The unexpected answer is "both." This appears to be the first demonstration of a truly bifocal lens in the extant animal kingdom.

Stowasser et al. used two independent methods to establish that the lens was bifocal. One, a modified version of the "hanging drop" method, was observed with a microscope square wave image that was focused from effective infinity through the lens. They consistently observed (and quantitatively verified) sharp edges at about 372 µm and 499 µm behind the lens. Furthermore, these images were clearly separated by a region where no sharp focus was formed. This roughly corresponds to the anatomic separation of the retinas. Given variables in the refractive properties of the medium they used experimentally versus what is encountered *in vivo*, it was concluded that the lens could focus separately on the two retinas.

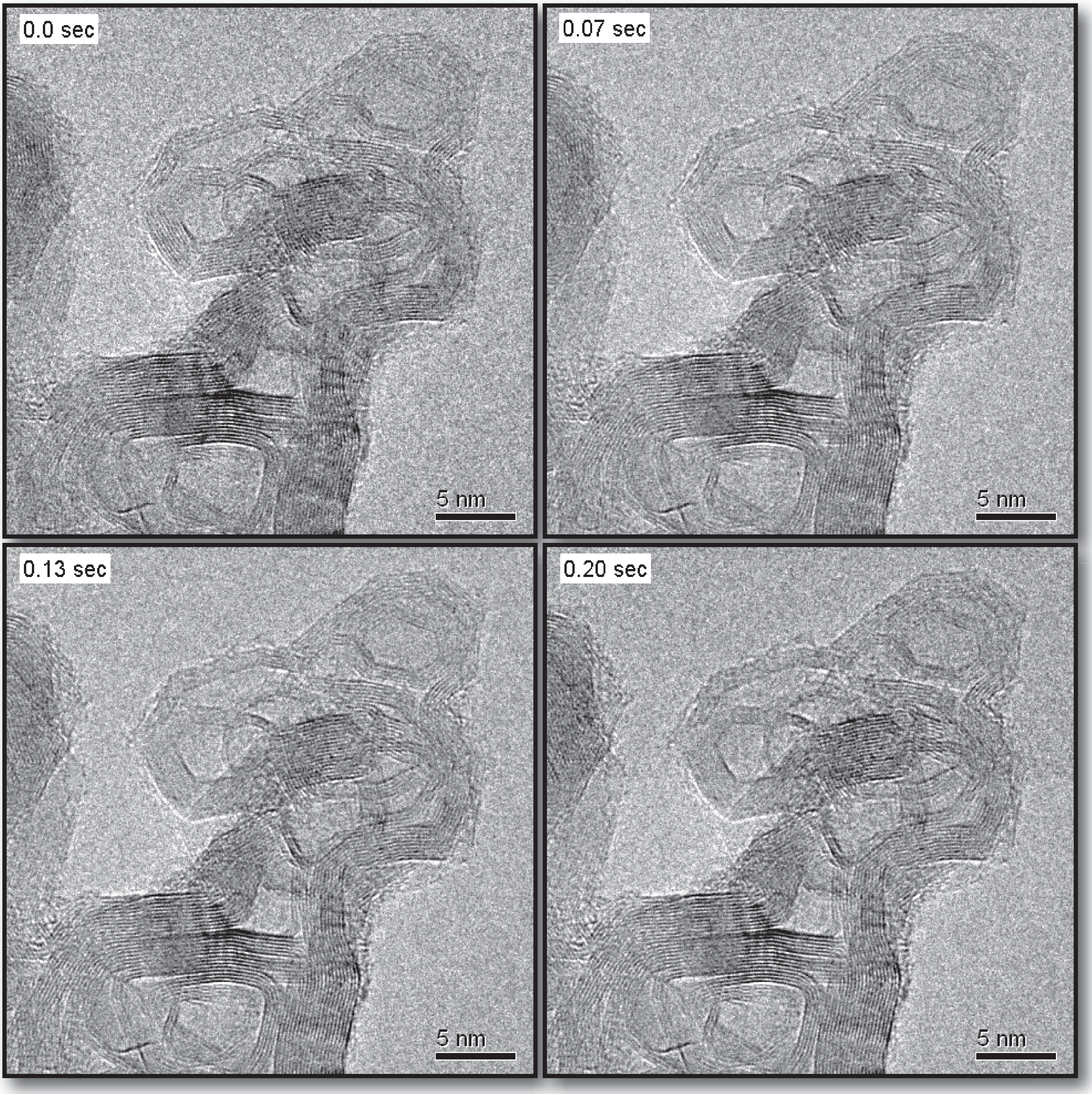
The second method visualized the paths of narrow parallel laser beams projected through the lens. The beams intersected at two different planes that corresponded well to the edge sharpness method. It was not clear what causes the images to be focused on two different planes, but it must be related to the precise location of the two optical centers in relation to their relative apertures. Stowasser et al. discussed how these observations could not be explained by astigmatism or spherical or chromatic aberration.

In addition to the separation in depth, which is a hallmark of bifocal lenses, the images of the animal lens are also separated in the vertical plane. This optical "trick" shifts the blurry region of the unfocused image away from the sharp region of its focused counterpart while the beetle larva performs head nodding behavior as it seeks food.

This is in contrast to what is accomplished by commercial lenses (such as contact lenses or cataract replacement lenses). Stowasser et al. conclude by suggesting that the lens of *T. marmoratus* larvae may serve as a natural model that could be exploited by commercial bi- or multi-focal systems. It will be interesting to see if human ingenuity can mimic the design of the eye of the sunburst diving beetle [2].

## References

[1] A Stowasser, A Rapaport, JE Layne, RC Morgan, and EK Buschbeck, *Current Biology* 20 (2010) 1482–86.
[2] The author gratefully acknowledges Dr. Elke Buschbeck for reviewing this article.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