Joseph Carroll, PhD ’02, is debunking myths.

“The stars don’t twinkle,” he said. “It is only in the last instance that light arriving from a star gets distorted by the atmosphere. So it has the perception of twinkling.”

Another myth lies closer to the cell biologist’s field of vision research – that rod photoreceptors cannot be imaged, that they are much too small to be visualized. It was a belief that was proven incorrect by research published this summer by Dr. Carroll, Associate Professor of Ophthalmology at The Medical College of Wisconsin, and Alfredo Dubra, PhD, Assistant Professor of Ophthalmology and Biophysics at the Medical College, previously with University of Rochester in New York.

These two fallacies in once-conventional wisdom actually share a scientific solution in the technology used to view the objects clearly. Adaptive optics – a field born from astronomy and kindled by the military is beginning to yield results that are likely to have significant bearing on eye disease research, diagnosis and treatment.

Astronomers trying to view objects in space and satellites trying to view objects on earth have essentially the same problem. The atmosphere is filled with turbulence – particles and changes in pressure and temperature that distort light on its journey between space and the earth. Similarly, the eye contains inherent imperfections that induce aberrations in the light path; they typically do not affect a person’s vision but they significantly hinder the ability to clearly visualize the tiny cells involved in sight.

Adaptive optics is a method for characterizing these aberrations, then correcting for them so that the image returned is flawless. It is accomplished in virtually the same fashion for stargazing and satellites as it is for ocular imaging. Scientists use a wavefront sensor to establish the profile of a known light source. For the eye, Dr. Carroll and his team use a super luminescent diode. This provides the baseline or null state of the system.

Then, they take the same light and pass it through the eye, where it is reflected back, and compare the two light profiles – this provides a measurement of the imperfections. The ensuing step is to correct for those imperfections. The mechanism of choice is a deformable mirror, the reflective surface of which can be physically manipulated into any shape by the pushing or pulling of attached actuators that are activated by electric or magnetic current.

“The idea is to make that mirror take on a shape so as to perfectly compensate for those imperfections you just measured,” Dr. Carroll said. “Now, what you’ve got is what we call a diffraction-limited imaging system, a perfect imag-

Joseph Carroll, PhD ’02, reviews ocular images in the Froedtert & The Medical College of Wisconsin Eye Institute.
had no avenue for intervention. Drs.
eases affecting the rods that previously 
rification represents a breakthrough in vision 
photoreceptor mosaic in cellular resolu-
enever to image the tiny light-sensing rods 
when the research team became the first 
collaboration was rewarded this summer 
terms of space, people, philanthropy and 
have a unique collection of resources in 
work anywhere else," he said. "We really 
klieger Professor of Ophthalmology. 
Dr. Carroll directs with 
Advanced Ocular Imaging Program that 
org College of Wisconsin, which is rap-
brought his expertise back to The Med-
University of Rochester where many of 
modern advances took shape. He 
clinical College of Wisconsin Eye Institute is cur-
progression took shape. He 
physicist M.S. Smirnov first proposed 
 begun to catch up to the con-
cept enough to develop a system to do so. 
Dr. Carroll completed a postdoctoral fel-
cept enough to develop a system to do so. 
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The Froedtert & The Medical Col-

The future of adaptive optics is 
likely to involve integrated approaches 
with other imaging modalities. Combin-
ing adaptive optics with photo acoustic 
microscopy or spectroscopic imaging, for 
example, may allow scientists to image 
cells currently thought too small to do so, 
such as ganglion cells.
Dr. Carroll’s team is also making 
strides in the functional imaging of the 
retina. Someday, they may be able to tell 
a patient not only how many cells they 
have, but how well they are functioning. 
That capability doesn’t exist yet, but 
before this year, no one had ever imaged 
the rod photoreceptors. It likely won’t be 
long before adaptive optics dispels 
another myth.