

### 2014

#### NANOSMAT-USA 2014

May 19–22, 2014  
Houston, TX  
[www.nanosmat-usa.com](http://www.nanosmat-usa.com)

#### European Light Microscopy

May 20–23, 2014  
Oslo, Norway  
[www.mn.uio.no/ibv/elmi2014](http://www.mn.uio.no/ibv/elmi2014)

#### 66<sup>th</sup> Inter/Micro

June 2–6, 2014  
Chicago, IL  
[www.mcrl.org/home/section/101-915/inter-micro-2014](http://www.mcrl.org/home/section/101-915/inter-micro-2014)

#### Gordon Research Conference on Imaging Science

June 8–13, 2014  
Stonehill College, Easton, MA  
[www.osa.org/en-us/meetings/global\\_calendar/](http://www.osa.org/en-us/meetings/global_calendar/)

#### SCANDEM 2014

June 11–13, 2014  
Linköping University, Sweden  
[www.scandem2014.se](http://www.scandem2014.se)

#### EBSD-2014

June 17–19, 2014  
Carnegie Mellon University, Pittsburgh, PA  
[www.microbeamanalysis.org/topical-conferences/EBSD-2014/welcome](http://www.microbeamanalysis.org/topical-conferences/EBSD-2014/welcome)

#### EMC 2014: 56th Electronic Materials Conference

June 25–27, 2014  
Santa Barbara, CA  
[www.mrs.org/56th-emc](http://www.mrs.org/56th-emc)

#### MMC 2014: MICROSCIENCE

June 30–July 3, 2014  
Manchester Central, UK  
[www.mmc2014.org.uk](http://www.mmc2014.org.uk)

#### Microscopy & Microanalysis 2014

August 3–7, 2014  
Hartford, CT  
[www.microscopy.org](http://www.microscopy.org)

### 2015

#### Microscopy & Microanalysis 2015

August 2–6, 2015  
Portland, OR  
[www.microscopy.org](http://www.microscopy.org)

### 2016

#### Microscopy & Microanalysis 2016

July 24–28, 2016  
Columbus, OH  
[www.microscopy.org](http://www.microscopy.org)

### 2017

#### Microscopy & Microanalysis 2017

July 23–27, 2017  
St. Louis, MO  
[www.microscopy.org](http://www.microscopy.org)

### 2018

#### Microscopy & Microanalysis 2018

August 5–9, 2018  
Baltimore, MD  
[www.microscopy.org](http://www.microscopy.org)

#### More Meetings and Courses

Check the complete calendar near the back of this magazine.

## Carmichael's Concise Review

# We See Through Cells Every Day

Stephen W. Carmichael

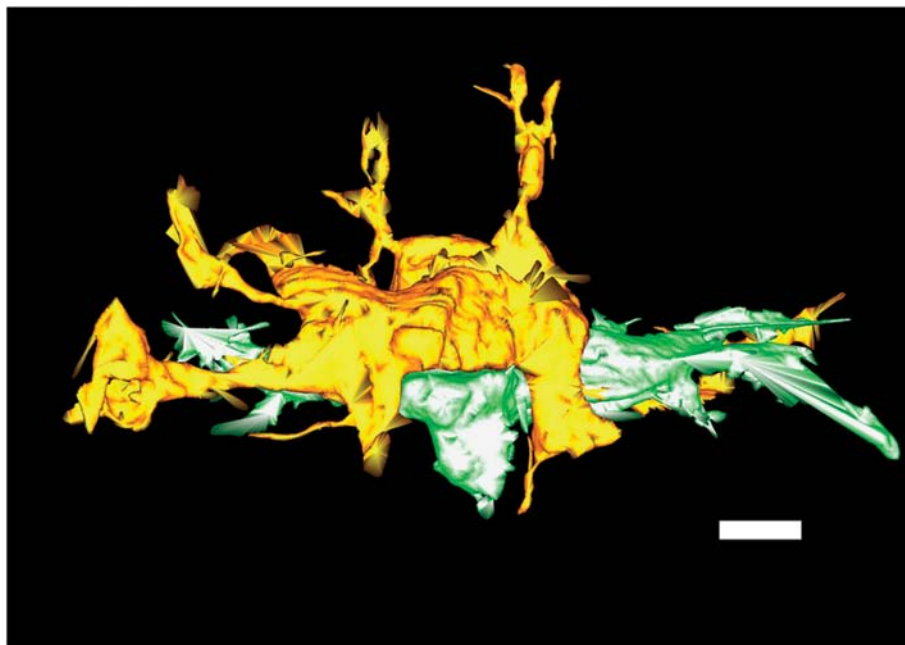
Mayo Clinic, Rochester, MN 55905

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Typically when we think of cells we envision opaque (or at best translucent) membrane-bound structures. However recently in a study of the developing avian cornea, Robert Young, Carlo Knupp, Christian Pinali, Kenneth Png, James Ralphs, Andrew Bushby, Tobias Starborg, Karl Kadler, and Andrew Quantock found a surprisingly large proportion (20%) of the volume is made up of cells. The cornea is where light enters the eye. It also provides the majority of the focusing power (the lens is for “fine tuning” of focus). If this study in birds also applies to primates, then we could be looking through many cells all the time!

The microscopic structure of the cornea is well known. It is an avascular specialized connective tissue assembled as a remarkably ordered array of superimposed collagenous lamellae, made of collagen fibrils, essential for optical transparency. It also must be biomechanically stable to restrain ocular pressure. In addition to immunocytochemistry and other conventional methods, Young et al. used volume-scanning electron microscopy to examine the ultrastructure of the cornea in three dimensions and in larger tissue volumes than were previously possible. The tissue volume was gradually decreased from the surface by two different methods: a focused ion beam essentially milled down the surface, or ultrathin sections were removed with an ultramicrotome. Scanning electron micrographs taken after each ultra-thin removal could be reconstructed for examination and analysis. The two different methods revealed unique features of the fibroblasts of the cornea, which are called keratocytes (Figure 1).

The surprising finding was that the volume of the cornea occupied by cells relative to extracellular matrix was 20%, higher than expected. The additional



**Figure 1:** 3D reconstruction of two keratocytes in embryonic chick corneal stroma at day 12 of development, obtained by 3View<sup>®</sup> serial block face scanning electron microscopy and IMOD segmentation. The cells and their processes exhibit orthogonal alignment in common with collagen fibrils (not shown in this image) in the developing extracellular matrix. Bar = 1  $\mu$ m.

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volume is apparently due to an extensive network of cellular processes that could not be fully appreciated using other methods. During development it appears as though relatively spherical cells are flattened as collagen is deposited, and as that happens the keratocytes extend long slender processes into the growing stroma. Young et al. showed that these tubular membrane extensions travel more than 30 microns from the main body of the cell. They also showed that these extensions were rich in actin, which is reminiscent of filopodia. These filopodia are much longer than usually described, but this study on fixed specimens could not provide evidence of motion. Young et al. propose that they be called “keratopodia” because they appear to be unique structures that have a cornea-specific function in orienting and organizing collagen into lamellae, crucial for transparency. Keratopodia permit a system of cell-matrix associations to be maintained at sites distant from the main secretory machinery of the cell during a period when collagen bundles increase and grow to fill the extracellular space. It will be interesting to see if similar structures exist within other tissues that form highly organized matrices.

## References

- [1] RD Young et al., *Proc Nat Acad Sci* 111 (2014) 687–92.
- [2] The author gratefully acknowledges Drs. Robert Young and Andrew Quantock for reviewing this article.

MT

## INTERNATIONAL UNION OF MICROBEAM ANALYSIS SOCIETIES



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*“My Lab is on Mars, Geochemical Adventures with the Mars Curiosity Rover”*

Plenary presentations on microanalysis techniques and applications

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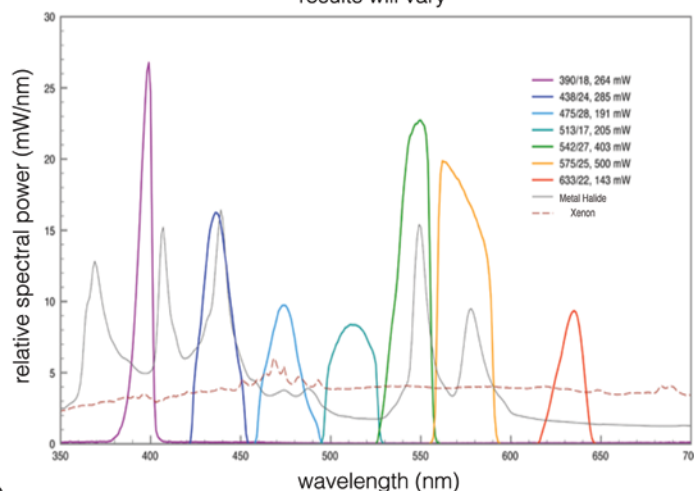
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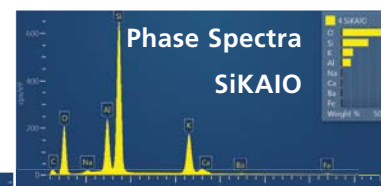
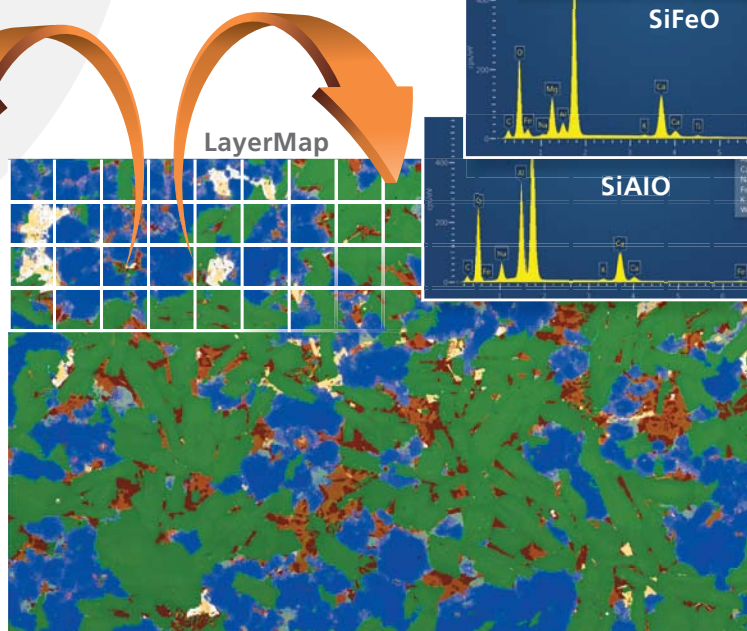
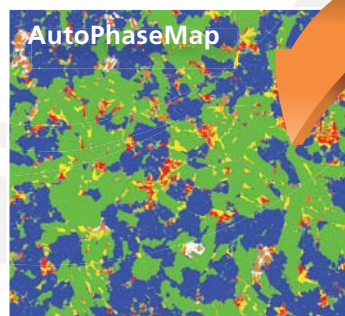


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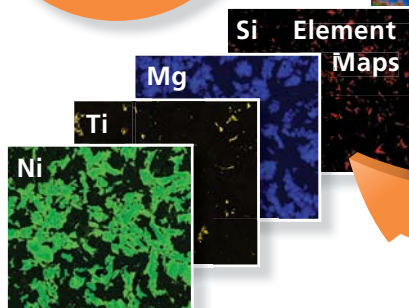
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4 SiAlO - K-feldsptr		4.5	3,007,415
5 FeTiO - Ilmenite		2.0	1,330,023
6 FeO - Magnetite		0.9	581,477
7 FeSO - Pigeonite		1.9	1,262,059
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9 FeSO - Biotite		0.5	331,548
10 FeS - Pyrite		0.0	15,804
11 CaSiO - Hercynite		0.2	131,591
12 FeCuS - Chalcopyrite		0.0	14,078
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14 ZnO - Baddeleyite		0.0	2,611

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