Helium Ion Microscopy for Cells and Tissues

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While optical and electron microscopy are well established techniques in the life sciences, the newly developed helium ion microscope is gaining a reputation for providing insightful, easy to interpret images over a wide range of biological samples. This presentation serves as both an introduction to this novel technique and a review of recent results.

Helium ions do not suffer appreciably from diffraction and can therefore be focused to a sub-nanometer probe, providing nanometer scale resolution with a depth of focus that is well suited to three dimensional structures. As helium ions interact with the sample, they provide an abundance of secondary electrons that convey surface-specific and topographical information. Distinctly different from conventional focused ion beams, helium ions do not sputter appreciably when imaging, so damage is usually not a concern. And importantly, helium ion microscopy does not suffer from charging artifacts when imaging insulating materials, even glass slides, so there is no need for metal over-coating which would otherwise obscure finer details.

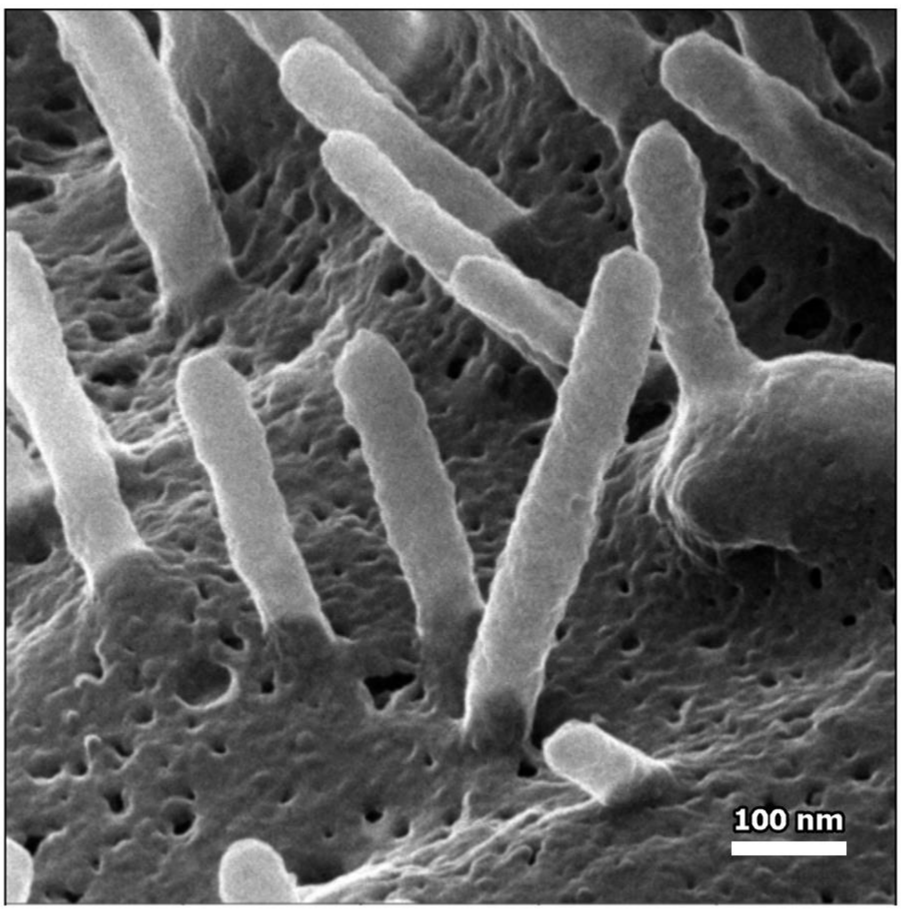

Figure 1: Pancreatic cell membrane imaged with the helium ion microscope and no metal overcoating. Field of view = 800 nm.

Figure 1 shows a high magnification images of pancreatic cell membrane showing the pores and cilia (sample provided by Prof. Walther of the University of Ulm, in conjunction with Bielefeld University). Figure 2 shows the principal cell and intercalated cell of the collecting duct of a rat kidney. (Sample courtesy of D. Brown and T. Paunescu, Massachusetts General Hospital, Boston, MA). Figure 3 colorfully shows the multicialiated epithelial trachea of an adult mouse. (Image courtesy of Eva Mutunga and Kate Klein, University of the District of Columbia and the National Institute for Standards and Technology. Sample courtesy of Eszter Vladár, Stanford University). Other imaging results from diverse fields include stony corals, collagen networks, bone minerals, stereocilia, otoconia, T4-phages, actin filaments, and cryptococcus neoformans. These examples serve to demonstrate the breadth of results that can be attained with this relatively new technique. An emphasis will be placed on the physics principles that enable these imaging results.

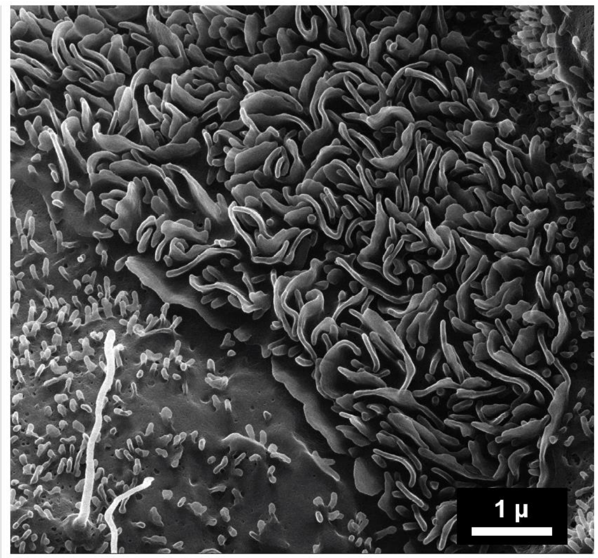

Figure 2: Kidney cells as imaged by the helium ion microscope with no metal over coating necessary. Field of view is 7 microns.

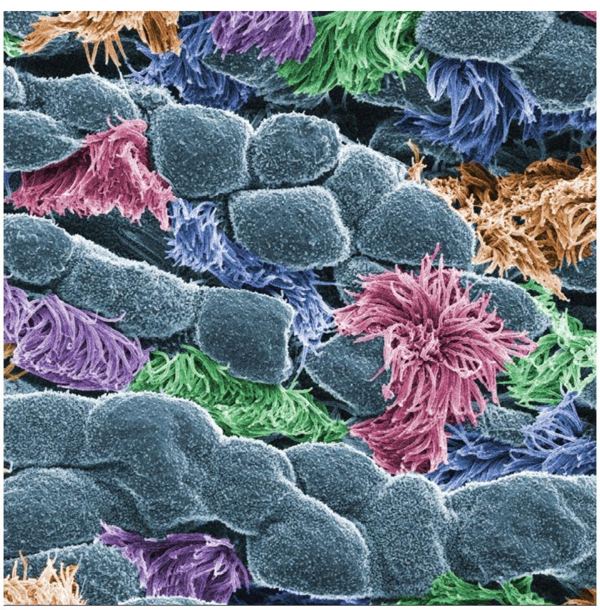

Figure 3: Multicialiated epithelial trachea of an adult mouse as imaged with a helium ion microscope. Colorization was manually applied. Field of view is approximately 8 microns.