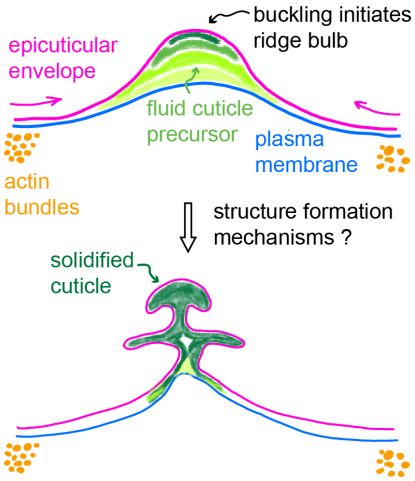
Cellular Mechanics and Processes Involved in Butterfly Wing Scale Formation

Butterfly scales are (literally) brilliant examples of natural multifunctional materials. Many of the principles underlying the scales' functions are well known. Less well understood are the mechanisms that allow wing cells to secrete functional micro- and nanostructures. This presentation is focused on visualizing butterfly scale structure formation *in vivo* and on modeling the underlying physical processes. Attention will be given to the scales' ridge structures, which in finished scales provide intriguing clues about potential formation mechanisms. Mechanical instabilities and the evolution of shape resulting from the interplay between a growing soft compartment formed by the cells' plasma membrane and an epicuticular envelope appears to be the general foundation for scale ridges. Paired with the constraints imposed on the soft compartment by the cell's actin cytoskeleton, and the spatio-temporally heterogeneous sclerotization of the cuticle precursor, this results in a picture of structure formation dynamics that might be sufficient to explain the observed wide variety of scale ridge morphologies in adult butterflies. The discussed fundamental mechanical processes are not constraint to butterflies only but rather appear to be essential for the secretion of non-living structural and multifunctional biological materials.



Schematic cross-section of growing ridge in the early formation stages (top) and at a later time (bottom).

Biography: Mathias' research focuses on the translation of unique biological light manipulation concepts into bio-inspired, adaptive, and actively tunable micro-optical devices. Through experimentation and optical modeling, and by employing unconventional manufacturing principles, his group is developing novel optical technologies. He joined the faculty of MIT in November 2013. Prior to that, Mathias held a Feodor Lynen research fellowship of the Alexander von Humboldt - Foundation for postdoctoral studies at the School of Engineering and Applied Sciences of Harvard University, where his research was focused on bio-inspired photonics, bio-imaging, and optical spectroscopy. He earned degrees in physics from the Saarland University in Germany and the University of Lorraine (formerly Henri Poincaré University) in France in 2006. Mathias was a graduate student with Prof. Ullrich Steiner at the University of Cambridge, receiving his Ph.D. in 2010. Ulli offered Mathias patient, enthusiastic mentorship and an amazing research environment where butterfly optics could take flight.