Abstract Submitted
for the MAR17 Meeting of
The American Physical Society

Hierarchical organization of butterfly gyroid nanostructures provide a time-frozen glimpse of intracellular membrane development[1]
BODO WILTS, Adolphe Merkle Institute, BENJAMIN WINTER, University Erlangen-Nuremberg, MICHAEL KLATT, KIT, BENJAMIN BUTZ, University Erlangen-Nuremberg, MICHAEL FISCHER, Adolphe Merkle Institute, STEPHEN KELLY, Zeiss, ERDMANN SPIEKER, University Erlangen-Nuremberg, ULLRICH STEINER, Adolphe Merkle Institute, GERD SCHROEDER-TURK, Murdoch University — The formation of the biophotonic gyroid material in butterfly wing scales is an exceptional feat of evolutionary engineering of functional nanostructures. Previous work hypothesized that this nanostructure forms by chitin polymerization inside a convoluted membrane of corresponding shape in the endoplasmic reticulum. In vivo imaging however cannot yet elucidate this dynamic formation process, including whether membrane folding and chitin expression are simultaneous or subsequent processes. Here we show an unusual hierarchical ultrastructure in a Hairstreak butterfly that allows high-resolution 3D microscopy. Rather than the conventional polycrystalline space-filling arrangement, the gyroid occurs in isolated facetted crystallites with a pronounced size-gradient. This arrangement is interpreted as a sequence of time-frozen snapshots of the morphogenesis. This provides insight into the formation mechanisms of the nanoporous gyroid material, especially when compared among other butterflies with different arrangements.

[1]Financially supported through DFG, the NCCR Bio-inspired Mateirals and the SNF Ambizione programme.

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Date submitted: 13 Nov 2016 Electronic form version 1.4