Researchers develop a method for cross-species comparison of biological surfaces

May 3 2016

One thing is obvious: moth's eyes and snake's skin are entirely different. Researchers at Kiel University have taken a closer look, however, and have now brought the supposed 'apples and oranges' to a common denominator. They have opened up a completely new, comparative view of biological surfaces using a newly developed method, and have thus come closer to the solution of how these surfaces work. Dr. Alexander Kovalev, Dr. Alexander Filippov and Professor Stanislav Gorb from the Zoological Institute at Kiel University have published their findings in the current edition of the scientific journal *Applied Physics A*.

One surface demonstrates reduced light reflection, the other is water repellent and resistant to abrasion. Surfaces in the animal world are evolved to adapt to their environments and give the animal they cover the greatest possible evolutionary advantage. Scientists are today still puzzled by exactly how and why these different structures develop in detail.

Current research looks right into the surface nano-structures using the latest research techniques. Normally, we would limit ourselves to comparisons within closely related species and just look thoroughly at small areas of the surface, says Gorb: "That is why we asked ourselves which structural differences can be found between completely different species. To do so, we changed biology's typical perspective and addressed larger surface areas from various species." These types of cross-species or cross-material studies of nanostructures are common in other technical or inorganic fields. In Biology, however, this method is completely new, Gorb continues.

They got the idea from the decorations in the hallway of their own institute, where scanning electron microscope images of moth's eyes and snake's skin are displayed. At some point, theoretical physicist Filippov noticed similarities between the images, which showed the surfaces at a resolution of a few millionths of a millimetre. Nipples and dimples could be seen which seemed to the human eye to follow a certain pattern. Using methods that are normally used in crystallography, the scientists were finally able to recognise the particular patterns that distinguish the two species. "The structure of moth's eyes is perfectly organised. Nipples are highly ordered, and preferred directions are exhibited in the structural organisation," explains Kovalev, biophysicist and main author of the study. The scientists were already aware of the eye structure's strict symmetry. However, the fact that this goes right through to the nano-level and is repeated across the entire surface in so-called domains, is an important new finding.

So which symmetry does snake's skin have, which at first glance appears similar, perhaps even more perfectly organised? "Compared to the structure of the moth's eye, the structure of the snake's skin is unorganised," explains Kovalev. He continued: "If we concentrate on one dimple in the skin, like one nipple in the eye, we only see a diffuse cloud of further dimples in the close surroundings. Neither particular directions nor the regular arrangement can be defined. This unorganised structure continues across the entire surface."

On their own, these findings about the organised eye structure on the one hand and the unorganised skin structure on the other hand are not especially significant. But by taking the common denominator, i.e. investigating both structures with the same degree of resolution, it is possible for the first time to compare fundamentally different structures, explains Gorb: "However, the 'coincidental' degree of organisation is not coincidental, but a result of evolution. That would mean that the perfect organisation gives the moth its incredible night vision, while the imperfect organisation in snake's skin ensures the best friction properties." That sounds logical, when you consider the laws of physics, that a symmetrical structure is necessary for good vision and good friction properties require the surface ordering in the contact with the ground to be as low as possible.

If the Kiel-based researchers had followed the usual approaches and compared snakes to snakes and moths to moths, the organisation of the elements at nano-level would have hardly been considered significant. "By comparing evolutionary distant species, we now see that the key to understanding surface functions must be right at the smallest level. Every biological surface is adapted to its environment, and these adaptations are reflected in the organisation of their smallest elements in a certain perfect or imperfect degree," Gorb concludes.

More information: A. Kovalev et al. Correlation analysis of symmetry breaking in the surface nanostructure ordering: case study of the ventral scale of the snake Morelia viridis, *Applied Physics A* (2016). DOI: 10.1007/s00339-016-9795-2

Provided by Kiel University