Cuticle materials and chemistry: towards a car that moults

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On September 8th and 9th the Arthropod Cuticle Special Interest Group (SIG) of the Royal Entomological Society brought together 27 scientists working on multifarious aspects of the cuticle at Dresden in Saxony. As far as we know, this was the first SIG meeting to take place outside the UK. Many of those attending were German, but scientists from six nations were present. To attract bio-materialists, zoologists, physiologists and molecular biologists, and thus ferment a fertile interdisciplinary atmosphere, the meeting's themes were "Cuticle Material Properties" and "Cuticle Chemistry". The idea that insect cuticle can provide a model for technological innovation was also a sub-theme.

The meeting began with a tour of the Max-Bergmann Center of Biomaterials (a joint initiative of the Technical University (TU) of Dresden and the Leibniz Institute for Polymer Research) where the director of the "Biomaterials" department, Hans-Peter Wiesmann, reported on the exciting and astonishing activities of his research group, which is part of one of the most important centres of German biomaterials research.

The meeting continued under the aegis of the hosts Stuart Reynolds (University of Bath), Klaus Reinhardt and Bernard Moussian (Applied Zoology, TU Dresden) in the Biology department building; a wonderful architectural masterpiece, by the way.

A central issue of several presentations was the cuticle surface, where contact with the environment is made with distinct structures and specific chemistry, both required for the insect to occupy its ecological niche. In his keynote presentation, Thomas Schmitt from Würzburg University addressed the role of surface hydrocarbons (HC) in interactions between hymenopteran species competing for the same resources. The cuckoo wasp female, for instance, sports a cocktail of HCs also found at the surface of the digger wasp. With this cocktail the cuckoo wasp is able to enter incognito the digger wasp's brood cells and there deposit its eggs on the paralysed honeybee that was intended to serve as a food source for the larvae of the latter. Thomas also reported on a new substance class, Crematoenones, identified at the cuticle surface of the ant *Crematogaster modiglianii*. Crematoenones potentially appease *Camponotus rufifemur* ants that host *Crematogaster modiglianii* in their nest. In the next talk, Tobias Otte (Free University Berlin) demonstrated that HC production depends on the food source. Moreover, males of the leaf beetle *Phaedon cochleariae* recognized females that had fed on the same plant species and preferred to mate with them. Subsequently, Julia Nickerl (IPF, Dresden) and Jonas Wolff (University of Kiel) focused on cuticular surface structures in Collembola (regular comb-like patterns, figure 1) and arachnids (hairs with viscoelastic droplets), respectively, that have quite opposite effects: repellence of liquids and dirt and high adhesion.

After an evening's sampling of local (beer) flavour, the next day started with the second central theme of this meeting - cuticle stability. Applying high-end technology at the Max-Planck Institute of Colloids and Interfaces in Potsdam, Yael Politi showed in her keynote presentation how chitin orientation in the cuticle of the spider *Cupiennius salei* defines the physical properties of specialized cuticular organs such as fangs. Sebastian Kruppert (University of Bochum) shared his data on the ultrastructure of pillars that connect the upper and lower parts of the carapace of *Daphnia*. He speculated that the pillars withstand tensile rather than compressive forces. Among others (e.g. surface bacteria, figure 2), Jasna Strus (University of Ljubljana) detailed her studies on possible habitat-borne differences in cuticle thickness and colour in isopods. Stuart Reynolds spoke about the distribution of zinc, its

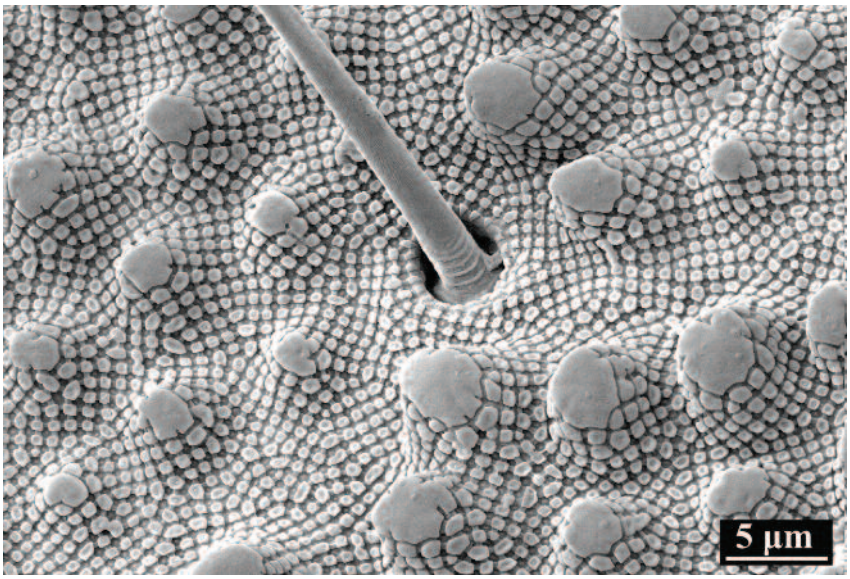

Figure 1. SEM image of the cuticular morphology of *Tetrodontophora bielanensis* (Collembola). The hierarchically structured cuticle is characterized by a tertiary structure in form of thin bristles, a secondary structure built by papillose microstructures (secondary granules) covered by the primary structure, a rhombic comb-like mesh exhibiting nanoscopic tubercles (primary granules) which are connected by ridges. Image provided by Julia Nickerl (IPF Dresden / Max Bergmann Center of Biomaterials).

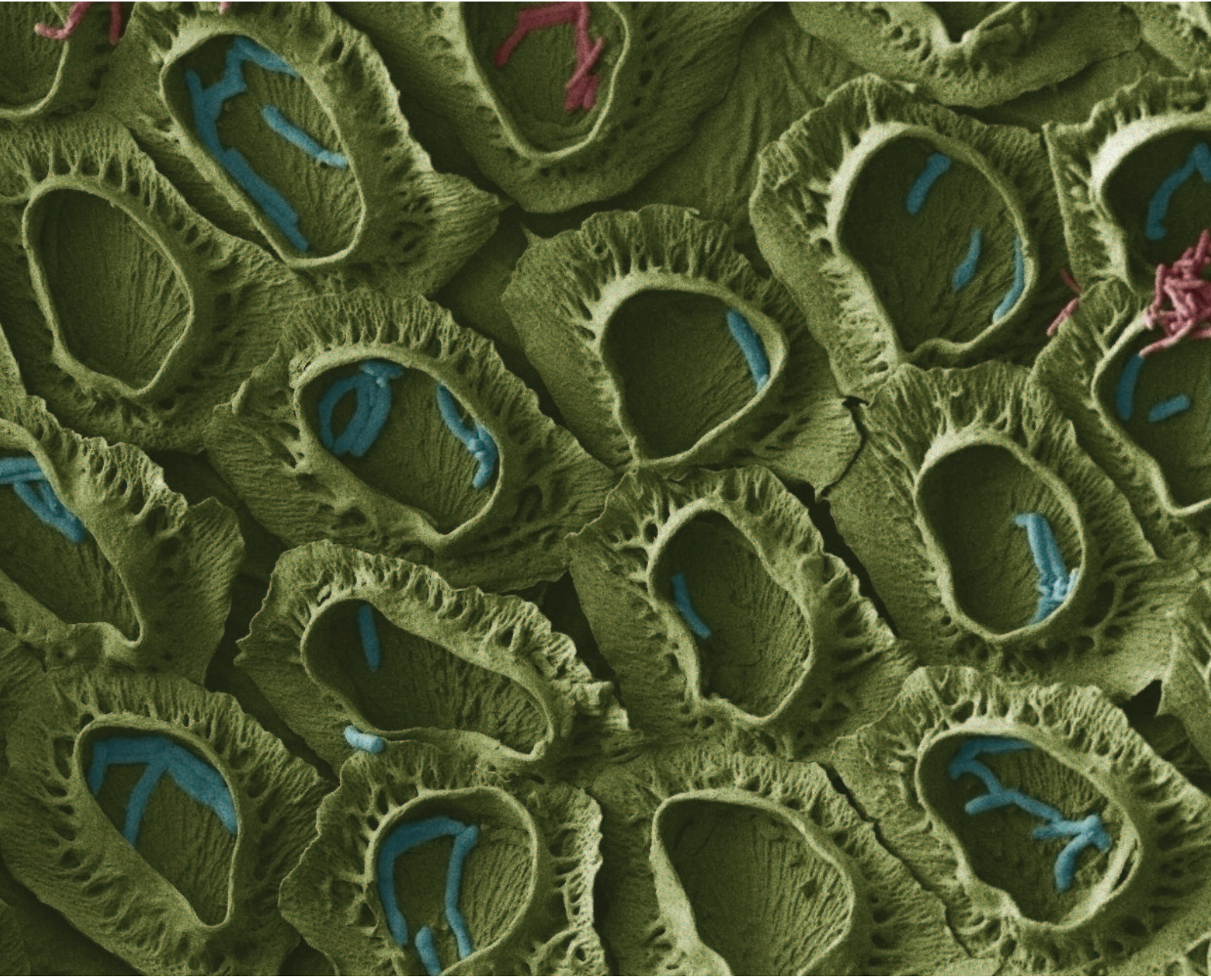

Figure 2. Scanning electron micrograph of the cuticular surface in the terrestrial isopod crustacean *Platyarthrus hoffmannseggii* with epibiotic bacteria (magnification 2700x). Image provided by Jasna Strus and Milos Vittori (Department of Biology, University of Ljubljana).

dependence on pH value and its association with histidine-residues in cuticle proteins in the mandibles of the lepidopteran *Manduca sexta*. Based on his comparative data on cuticle sclerotisation, Tsunaki Asano (Tokyo Metropolitan University) speculated boldly that the use of organic cross-linkers of cuticle components is an evolutionary answer to calcium shortage after the colonisation of land by insects. Three additional contributors variegated the meeting with other approaches to cuticle. A remarkable issue was brought up by Stefan Fränzle (Technical University Dresden). He provided evidence that chitin can absorb metal ions in living insects and can therefore be used for bio-monitoring. Molecular mechanisms of cuticle formation were detailed by Matthias Behr (University of Leipzig). He summarised his work on the factors functioning in the assembly zone of the *Drosophila* cuticle in order to organise the nanofibrillar architecture of chitin in the cuticle. A particular topic concerned infrared (IR) receptors in beetles (e.g. ash beetle) that are adapted to burning environments, as described by Helmut Schmitz (University of Bonn). In these insects, specialised regions of the cuticle in the thorax absorb radiant heat remotely monitoring the temperature of objects in the environment, allowing appropriate responses to be elicited.

Overall, the plan of the hosts to promote interdisciplinary exchange was successful. While the proceedings of the meeting were entirely in English, the zoo of participants nevertheless spoke a variety of different scientific languages, from chemistry and molecular biology to behaviour. As a result, intellectually fertile debates erupted after virtually each presentation. One of these verbal sparring matches led to the biomimetic vision of a moulting car, let's say in the shape of a beetle. An amusing but also stimulating idea! At the same time, technical and methodological issues were deeply discussed. The meeting was also satisfyingly inclusive; all poster presenters were able to talk briefly to the entire group about their work.

At the end of the meeting, many participants embarked on a short suburban train journey along the banks of the Elbe to the nearby fabulous forests of Saxon Switzerland, where a short walk and spectacular climb to a hilltop tavern served to refresh the troop of cuticle scientists after the friendly skirmishes of the scientific sessions. This was an intense and successful get-together, which will hopefully resume in Bath next year.