The Tinkerer at Work

In a landmark paper in 1977, Francois Jacob [1] likened the evolutionary process to the work of a tinkerer who uses a toolbox of elements shaped by their present function and previous history and assembles them for novel functions. Jacob [1] proposed 3 mechanisms of assembly: gene duplication, reshuffling of genes or parts of genes and recruitment for more than 1 function. In this issue on invertebrate immunity, ample evidence for tinkering during immune system evolution is presented. Rosenstiel and colleagues [2] summarize work on immune receptors from marine invertebrates. Both expansion and reduction in receptor families provide a rich source for studying immune adaptations towards different abiotic and biotic factors of the environment. Local adaptations in the evolutionary landscape are suggested by the work of Bidla et al. [3] who show that phenoloxidase, one of the key enzymes involved in arthropod immunity, is used in different ways in separate insect species and at different time points during an infection. Stanley and colleagues [4] summarize how inhibitors of eicosanoid synthesis affect several aspects of insect immunity and provide some first hints of the underlying molecular mechanisms and their

effects on cellular immunity. Towb and colleagues [5] take the part of the evolutionary tinkerer by creating an in vitro fusion of a protein that combines elements of 2 separate *Drosophila* kinases involved in Toll signaling, thus mimicking potential ancestor enzymes in other species. Quite amazingly, the fusion construct can largely rescue the embryonic defects in double mutants of the individual kinases. Defaye and colleagues [6] answer some long-standing questions about the role of cellular immunity in invertebrates by genetically eliminating *Drosophila* blood cells (hemocytes). The resulting animals show both developmental and immune defects. Finally, Michael Williams [7] describes novel aspects of his work on *Drosophila* blood cells, which spread to form capsules around large foreign objects similar to what occurs during granuloma formation in vertebrates. These results show that we are able to study the traces left by the tinkerer and get an understanding for the achievements but also the imperfections, which have shaped the toolbox of insect immune genes and domains.

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