Getting in touch: microbial molecular devices for cell-cell and cell-surface interactions

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Editorial

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An essential part of the biology of any life form is its ability to interact with other organisms from its own or from different species. In recent years, it has also become evident that populations of microorganisms often alternate between being nomadic "hunter-gatherers" (i.e. motile, free-living single cells) and becoming "settlers". This second lifestyle requires a number of appendages and cell surface contrivances that allow the colonization of a certain niche and serve a structural or communication purpose within the community. In this issue of Research in Microbiology, we present a series of comprehensive reviews and two original articles focused on those devices that bacteria and archaea have developed to establish interactions among themselves and with other organisms, as well as with inert surfaces.

Myxobacteria are considered the social microorganisms *par excellence*. They show concerted migration and the fascinating ability to coordinate their gliding movement to form multicellular fruiting bodies in response to nutrient depletion. In their paper, Pathak et al. (2012) revise the different signaling circuits that constitute the social communication system of Myxococcus. Besides the well-studied A and C developmental signaling systems, and the less known B, D and E systems, they also discuss new information on how outer membrane fusion and protein transfer can be a relevant part of the interaction between myxobacterial cells during biofilm formation and in social behavior. Outer membrane vesicles and their roles in microbial and microbe–host interactions are the focus of the review by MacDonald and Kuehn (2012). First observed in the late 1960's and early 1970's as being released during normal bacterial growth, outer membrane vesicles were considered the result of cell lysis or of an imbalance between outer membrane and peptidoglycan expansion during cell growth and division. In recent years, however, it has become apparent that they constitute an important mechanism to deliver toxins or other virulence factors in microbe–host interactions, as well as a means for protection and for exchanging information – in the form of proteins – among microbial communities.

Besides exchanging signals, a microbial community settled on a surface also requires certain structural elements that function as a scaffold and protective barrier. Among these structural components, proteins in the form of amyloid fibers are commonly found. The ways in which microorganisms have exploited these polymers as functional rather than aberrant protein folds, avoiding their toxicity, are enticingly examined by DePas and Chapman (2012).

Colonization of a surface, be it abiotic or that of a host, often involves bacterial movement by means of flagella and/or pili, to establish initial contact or to displace across the surface before settlement. These well-studied types of motility are revisited by Conrad (2012) from a different angle: physics. This point of view not only complements the biological characterization of bacterial appendages, but also provides insight into the new avenues open to biofilm research by combining physics and biology with micro- (or nano-) engineering.

Three other reviews deal with prokaryotic appendages playing roles in motility and/or microbial interactions. Archaea possess various surface structures, among them the archaeal flagella, also called archaella. Lassak et al. (2012) highlight the assembly mechanism and biochemical properties of such appendages, that resemble bacterial type IV pili, and they discuss recently identified regulatory mechanisms underlying the construction of archaeal pili. The role of pili of Gram-positive bacteria in adhesion to surfaces and cells and their participation in host colonization are discussed by Danne and Dramsi (2012). The regulation of pilus expression, as part of a larger regulatory network and connected to host responses, are still in too early a stage to be clearly understood, but will provide relevant information with respect to infection and persistence processes. In Gram-negative bacteria, two subclasses of Type IV pili exist; Type IV A and Type IV B. Roux et al. (2012) review what is known about the assembly, function and regulation of Type IV B pili, the different examples of these appendages described thus far and their distinctive characteristics.

This special issue includes two original research papers. In one, Ivanov et al. (2012) present a brief description of how a combination of two techniques, atomic force microscopy and three-dimensional structured illumination microscopy, enable direct visualization of the large adhesin LapA on the bacterial surface. This protein is a key element in the initial stages of attachment and biofilm formation by *Pseudomonas fluorescens*, and similar or related surface proteins are present in different microorganisms. This technical advance, combined

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with more classical genetic studies, may soon be widespread in biofilm research. In the second paper, Xu et al. (2012) explore regulation of adhesin production and biofilm formation in *Agrobacterium* in response to phosphate limitation. In this bacterium, PhoB and PhoR are essential and participate in the increased attachment observed in response to phosphate starvation, a phenomenon that requires synthesis of unipolar polysaccharides.

Thus, a variety of examples of protein surface structures and membrane vesicles important for cell–cell interactions and communication are highlighted in this special issue. Other surface components such as lipopolysaccharides, lipoteichoic and wall teichoic acids and capsules are also likely to play an important role. We hope that this collection of papers will kindle interest in future studies aimed at demonstrating how microorganisms are able to modulate their surfaces in order to interact with and manipulate their environment.

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