The Biological Significance of Bacterial Biofilm

By Ken Bayles, Ph.D., Professor, UNMC

Bacterial biofilm is one of the hottest topics in microbiology today. Although dentists have been dealing with biofilms for ages during routine dental exams where plaque (a form of biofilm) is scraped off neglected teeth, only recently has the bacteriology community learned of its significance for other types of infections. Having been trained to think of bacteria as independent single-celled organisms, it has been an epiphany to realize that they are, in fact, highly "social" organisms that live and multiply in large organized communities. Biofilms can even be thought of as multicellular organisms as they exhibit cell-to-cell communication and cellular differentiation during biofilm growth.

A bacterial biofilm is a collection of bacterial cells held together by an extracellular polymeric matrix composed of polysaccharide, protein, DNA, or any combination of these three molecules. It can contain a heterogeneous mixture of bacterial species, as often occurs in the lungs of cystic fibrosis (CF) patients, or can be comprised of a single species such as on the surface of an artificial hip. Like more complex eukaryotic organisms, biofilms develop into what appears to be specialized groups forming mushroom-like structures that maximize nutrient acquisition and waste dispersal. Because of the multilayered organization of biofilms, the cells that comprise the biofilm are extremely heterogeneous at the physiological level, likely due to gradients of oxygen, nutrients, and waste byproducts that are formed within this structure.

The unique nature of a bacterial biofilm makes it a formidable foe to the immune system as well as to modern medicine. Similar to a flock of birds or a school of fish, there is power in numbers that the immune system has a hard time dealing with. This is especially true for phagocytic cells as studies have shown that the biofilm matrix provides a barrier to phagocytosis compared to free-living planktonic cells (2). A diffusion barrier, however, is not responsible for the increased tolerance to antibiotics that biofilm cells exhibit. Although the mechanism by which biofilm tolerance occurs is unclear, several models have been proposed to offer an explanation (1, 3-5).

Unfortunately, biofilms are a major mode of growth in a variety of bacterial infections. More than 60% of all microbial infections are estimated to be caused by biofilms. As mentioned above, the best known examples of this include dental plaque, CF lung infections, and colonization of implantable devises. However, other forms of infections are also thought to involve biofilm formation including infectious endocarditis and middle ear infections. The presence of biofilms in these types of infections likely explains the high level of treatment failures that are associated with them.

In summary, despite the fact that biofilms play a major role during bacterial infection we are only now beginning to understand the complexities of these multicellular communities. This lack of understanding has hindered the development of effective therapeutic strategies to fight many types of bacterial infections. Fortunately, with increased interest in studying this fascinating bacterial lifestyle, there is reason to be optimistic that these new strategies are on the horizon.

References:

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