Adaptive Transformation of Pseudomonas aeruginosa Biofilm Structure in Response to Changing Respiration Conditions

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Biofilms are surface-associated multi-cellular communities formed by microbial cells that often exhibit elaborate and complex three-dimensional structure. Because an estimated 90% of all microorganisms exist in biofilms rather than in the planktonic state, the metabolic activity of biofilms has a major role in global element cycles. The structures of biofilms have been indicated to correlate with metabolic efficiency. In animals and plants, a ubiquitous phenomenon is that environmental perturbations induce changes in the posture of individuals, such as mammals curling their bodies to reduce heat radiation in the cold. Using novel methods [1,2], our study demonstrates that such adaptive responses can also be found in bacterial biofilms. Here we demonstrated that, biofilm could adaptively control their structure in response to environmental shift. When aerobic conditions were replaced by under less-energetically efficient denitrifying conditions, mushroom-shaped aerobic Pseudomonas aeruginosa biofilm structures underwent a drastic transformation into three-dimensional mesh-like structures, concomitant with improvements in denitrifying efficiency. The mesh-like structure was more permeable to small molecules, and cells inside the biofilm began to express a critical denitrification gene along with the formation of the mesh-like structure. Based on these results, we conclude that the shift in the available electron acceptor induced a transformation of biofilm structure that increased the fitness of the P. aeruginosa biofilms. These results reveal that bacterial biofilm is a dynamic community that can adapt to environmental shifts by controlling its physical structure.

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References

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