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Bacteria growing in biofilms often develop multicellular, three-dimensional structures known as microcolonies. Complex differentiation within biofilms of Pseudomonas aeruginosa occurs, leading to the creation of voids inside microcolonies and to the dispersal of cells from within these voids. However, key developmental processes regulating these events are poorly understood. A normal component of multicellular development is cell death. Here we report that a repeatable pattern of cell death and lysis occurs in biofilms of P. aeruginosa during the normal course of development. Cell death occurred with temporal and spatial organization within biofilms, inside microcolonies, when the biofilms were allowed to develop in continuous-culture flow cells. A subpopulation of viable cells was always observed in these regions. During the onset of biofilm killing and during biofilm development thereafter, a bacteriophage capable of superinfecting and lysing the P. aeruginosa parent strain was detected in the fluid effluent from the biofilm. The bacteriophage implicated in biofilm killing was closely related to the filamentous phage Pf1 and existed as a prophage within the genome of P. aeruginosa. We propose that prophage-mediated cell death is an important mechanism of differentiation inside microcolonies that facilitates dispersal of a subpopulation of surviving cells.

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