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Quorum Sensing: It's About Time

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Editorial

Quorum sensing is a form of cell-to-cell communication by which bacteria communicate by secreting signaling molecules called autoinducers that help regulate gene expression. Quorum sensing was first detected in *Photobacterium fischeri* [1]. A specific acylated homoserine lactone was found to regulate transcription of the luciferase operon resulting in light emission [2]. A related organism, *Vibrio harveyi*, uses another signaling molecule in addition to an acylated homoserine lactone [3]. This molecule, termed Autoinducer-2 (or AI-2), is a furanosyl borate dieter [4]. AI-2 is also produced and used by a several Gram negative and Gram positive bacteria.

Given the species used in the initial discovery, it was thought that quorum sensing was confined to marine organisms. However, research into antibiotic synthesis in mutants of *Erwinia carotovora* revealed a dependency on a signaling molecule. [5,6]. This signaling molecule turned out to be the same as the one discovered previously and used by the completely unrelated bacterium, *Vibrio fischeri*. The human pathogen *Pseudomonas aeruginosa* was also found around this same time to have a quorum sensing system like *V. fischeri* [7].

Since then other quorum sensing molecules that regulate cell-density- or growth-phase-dependent processes have also been found for Gram positive organisms. In these bacterial species, the autoinducers are oligopeptides rather than homoserine lactones. Examples include the regulation of pathways leading to the development of competence for DNA uptake in *Bacillus subtilis* and *Streptococcus pneumonia*, the virulence response in *Staphyloccocus aureus*, and the production of antimicrobial peptides by various species of Gram positive bacteria [8].

Quorum sensing also plays an integral role in cannibalism and other cellular processes. Cannibalism has been reported for a dinoflagellate protist, *Oxyrrhis marina* [9]. Similarly, *Bacillus subtilis*, a model bacterium for studies on sporulation, delays entry into sporulation as long as possible due to energy requirements and constraints. It does this by directing a subpopulation of cells down a differentiation pathway that gives rise to so-called cannibals. This pathway together with that for sporulation and biofilm production are activated by a lipopeptide surfactin acting as a "quorum-sensing" molecule [10].

Biofilm formation by *Enterococcus faecalis* is also controlled by quorum signaling and involves the formation of a cyclized peptide lactone [11]. Cannibalism of cells occurs when quorum non-responders, a subpopulation of susceptible cells, fall prey to the majority of quorum responders. Lysing of susceptible cells releases extracellular DNA, a critical structural component of the bio film matrix [12].

Is it possible that quorum sensing systems involve other bacterial processes or signaling molecules? The insect pathogen *Photorhabdus luminescens*, for example, detects endogenously produced α-pyrones that serve as signaling molecules at low concentrations [13].

In addition to cannibalism and fratricide, perhaps certain bacterial species also can self-inhibit their own growth through some sort of quorum signaling process. Whether this will be found to be the case is uncertain. These and other studies suggest that additional modes of bacterial communication may await discovery.

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