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## Quorum Sensing: Phenomenon of Microbial Communication

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Bacteria communicate with one another using chemical signal molecules. Signaling mechanisms that govern physiological and morphological responses to change the cell density are common in bacteria. Quorum sensing is signal transduction processes which involve the production and release of and response to hormone-like molecules (auto-inducers) that accumulate in the external environment as the cell population grows. Quorum sensing is found in a wide variety of bacteria, both Gram-positive and Gram-negative and the spectrum of physiological functions that can be regulated is impressive. Variation in the nature of the extra-cellular signal in the signal detection machinery and in the mechanisms of signal transmission demonstrates the evolutionary adaptability of quorum sensing systems for multiple uses.

### Introduction

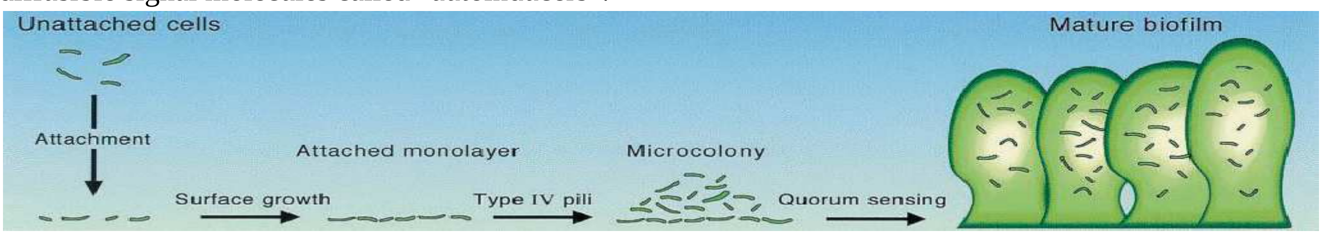
Quorum sensing is a mechanism of chemical communication among bacteria that enables collective behaviours. Quorum sensing controls group behaviours including virulence factor production and bio film formation. Bacteria can assess their local population densities using low molecular-weight molecules (auto inducers) and alter gene expression at high cell number to behave as a group. This process is termed as quorum sensing and it is widely used by bacteria to initiate group behaviours that have direct and often devastating impact on human health. This process of intercellular communication was first described in the marine bioluminescent bacterium *Vibrio fischeri*. Quorum sensing systems are studied in a large number of gram-negative bacterial species belonging to α, β, and γ subclasses of proteobacteria. Among the pathogenic bacteria, Pseudomonas aeruginosa is perhaps the best understood in terms of the virulence factors regulated and the role the *Quorum sensing* plays in pathogenicity.

### Quorum Sensing Regulation in Bacteria

Quorum sensing regulation involves the exchange of small signal molecules like AHLs between nearby bacterial cells. As the local population of bacteria increases, so does the number of signal producing cells and the signal concentration. Operationally, a "quorum" of bacteria is present when the population density (the signal concentration) reaches levels capable of triggering changes in the gene expression. Quorum sensing regulation is particularly important for the ability of pathogenic bacteria to successfully infect animal hosts, allowing them to remain "stealthy" until the local population is big enough to overwhelm host defences. Mutants with defective quorum sensing are usually avirulent or have significantly reduced virulence. Quorum sensing is similarly important to bacterial symbionts of both plant and animal hosts.

### Mechanism

Quorum sensing involves subsequent interaction of the signal with an intracellular effector. Bacteria in a community may convey their presence to one another by producing, detecting, and responding to small diffusible signal molecules called "autoinducers".



These microbially derived signalling molecules can be divided into two main categories (i) Amino acids and short peptide derivatives, commonly utilized by Gram- positive bacteria. (ii) Fatty acid derivatives, called Homoserine Lactones (HSLs) utilized by Gram-negative bacteria.

***Gram-positive bacteria*:** Most of the signaling systems found in Grampositive bacteria use oligopeptides as signals that are detected by two-component phosphorelay proteins. In many cases, the receptor is a membrane spanning histidine kinase, while in other systems the receptor is a cytoplasmic phosphatase that dephosphorylates a response regulator. A third type of peptide receptor, found in *Enterococcus faecalis,* is a transcriptional repressor. However, in contrast to the common use of peptide signals, one group of Gram-positive bacteria, the Actinomycetes, uses butyrolactone signals to regulate the production of antibiotics and other secondary metabolites. Several peptide-dependent signalling systems in Gram-positive organisms have been intensively studied.

***Gram-negative eubacteria:*** Proteobacteria generally signal via Acylhomoserine Lactones (AHLs), the archetypical quorum sensing molecules, were first discovered in *Vibrio fisheri*. Acyl homeserine lactone are synthesized from S-adenosyl-L-methionine (SAM) and acylated acyl carrier protein. Most AHLs are made by proteins that resembles the LuxI protein of *V. fisheri*, and are detected by AHL dependent transcription factors that resemble the *Vibrio fisheri* LuxR protein. *V. Fischeri* colonizes the light organs of various species of fish or marine invertebrates. As the population of cells grow within the light organ of *Vibrio fischeri* the concentration of external AHL increases. When the auto inducer concentration reaches the micromolar range, its efflux from the cells becomes balanced by an influx, so that it can interact with LuxR. LuxR autoinducer complexes bind the luciferase promoter and activate transcription.

**Functions of Quorum Sensing**

For many organisms of interest within biotechnology, the role of quorum sensing is complicated and unobvious. Quorum sensing is believed to regulate competence development, sporulation, antibiotic synthesis, virulence factor induction, cell differentiation, and nutrient flux along with other physiological events in pathogenic bacterial infections. More recently, quorum-sensing was linked through proteomic analysis to increased pathogenic competence in *Pseudomonas aeruginosa* .

**Applications**

Pathogen management comprises most of the current applications of quorum-sensing technology. Inhibition of quorum signalling is the most obvious and, in practice, most ubiquitous application of quorum sensing knowledge. Quorum sensing can be targeted for the treatment of bacterial infections. It can be used to prevent the formation of biofilms and also to improve the performance of the antibiotics. In biotechnology, quorum sensing could be used to control fermentation processes either by triggering early production of a desired metabolite or by making the onset of synthesis of a toxic product dependent on the addition of an exogenous AHL. Applications for quorum sensing are presently limited by our understanding of quorum-sensing mechanisms. Although advances have been made in the use of quorum sensing, further understanding of quorum functionality is required before the power of this tool can be fully realised. So far we have been able to block quorum sensing and make use of isolated components for driving protein expression. However, the full-scale manipulation of the bacterial quorum circuit in a biotechnological application remains an unfulfilled goal

**Conclusion**

It is clear that the interface between quorum sensing and bacterial virulence represents a promising area from which new, effective antivirulence drugs can emerge. Since many important animal pathogens use quorum-sensing to regulate virulence, strategies intended to interfere with their signalling systems, will likely have many potential applications. The disruption of signalling systems offers an opportunity to prevent the bacteria from responding to the signal and thereby prevent the expression of virulence factors.