

Quorum Sensing and Microbial Biofilms

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Abstract Some bacterial species engage in two well-documented social behaviors: the formation of surface-associated communities known as biofilms, and intercellular signaling, or quorum sensing. Recent studies have begun to reveal how these two social behaviors are related in different species. This chapter will review the role quorum sensing plays in biofilm formation for different species. In addition, different aspects of quorum sensing in the context of multispecies biofilms will be discussed.

1 Introduction

Microbiology has traditionally followed a guideline of isolating and studying pure cultures of bacterial species. This has accelerated our understanding of bacterial physiology and molecular biology, particularly in the context of pathogenesis as

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dictated by Koch's postulates (Kaufmann and Schaible 2005). However, conventional pure culture microbiology fails to inform us about aspects of bacterial interactions and group behavior important in the environment and in disease.

Many bacteria and simple eukaryotes are often found growing as surface-associated aggregates, commonly referred to as biofilms. Biofilms have been recognized as a common form of microbial growth on aquatic surfaces in natural, clinical, and industrial environments.

Although natural and laboratory biofilms formed by different species have been shown to exhibit a wide variety of structural characteristics, most appear to be encased in a self-produced extracellular matrix. The contents of the matrix can vary from organism to organism, but are usually abundant in polysaccharides, nucleic acids, and proteins (Sutherland 2001). Biofilm formation has been suggested to result from a developmental programme of gene expression. Indeed, biofilm development and maintenance have been shown to require a wide range of genetic determinants and to involve bacterial subpopulations carrying out different functions. One of the regulatory mechanisms suggested to play a significant role coordinating biofilm formation for many species is intercellular signaling, or quorum sensing (QS) (Parsek and Greenberg 2005).

Microorganisms secrete a wide variety of small molecules that can be self-recognized in a concentration-dependent manner and subsequently induce or repress expression of QS-controlled genes. These QS signals are often referred to as auto-inducers (AIs) and can be classified based upon their structures (Camilli and Bassler 2006). In this review, we will discuss some of the primary classes of QS systems and how (or if) they contribute to biofilm development in different bacterial systems. Additionally, the potential role of QS in multispecies biofilms will be discussed.

2 Different Systems for Sensing a Quorum

The term quorum sensing was coined to describe microbial signaling mediated by self-recognized, secreted molecules, also known as auto-inducers (Fuqua et al. 1994). There are several molecular mechanisms for intercellular signaling in microbes. We will briefly describe a few different, commonly studied quorum sensing systems.

2.1 *Acyl Homoserine Lactones*

The first described acyl homoserine lactone (AHL) QS system was in *Vibrio fischeri* (Nealson 1977). *V. fischeri* is a marine species that can bioluminesce in the light organs of various marine animals, such as the Hawaiian bobtail squid