9.4B: Signaling in Bacteria

Bacterial signaling allows bacteria to monitor cellular conditions and communicate with each other.

Learning Objectives

- Describe how cell signaling occurs in single-celled organisms such as bacteria

Key Points

- Gene expression in bacteria is initiated when the population density of the bacteria reaches a certain level.
- Bacterial signaling is called quorum sensing because cell density is the determining factor for signaling.
- Quorum sensing uses autoinducers, which are secreted by bacteria to communicate with other bacteria of the same kind, as signaling molecules.
- Autoinducers may be small, hydrophobic molecules, or they can be larger peptide-based molecules; regardless, each type of molecule has a different mode of action.
- Some bacteria form biofilms, which are complex colonies of bacteria that exchange chemical signals to coordinate the release of toxins that attack the host.

Key Terms

- quorum sensing: a method of communication between bacterial cells by the release and sensing of small diffusible signal molecules
- autoinducer: any of several compounds, synthesized by bacteria, that have signalling functions in quorum sensing
- biofilm: a thin film of mucus created by and containing a colony of bacteria and other microorganisms
Signaling in Bacteria

Signaling in bacteria, known as quorum sensing, enables bacteria to monitor extracellular conditions, ensure sufficient amounts of nutrients are present, and avoid hazardous situations. There are circumstances, however, when bacteria communicate with each other.

The first evidence of bacterial communication was observed in a bacterium that has a symbiotic relationship with Hawaiian bobtail squid. When the population density of the bacteria reached a certain level, specific gene expression was initiated: the bacteria produced bioluminescent proteins that emitted light. Because the number of cells present in the environment (the cell density) is the determining factor for signaling, bacterial signaling was named quorum sensing. Interestingly, in politics and business, a quorum is the minimum number of members required to be present to vote on an issue.

Quorum sensing uses autoinducers as signaling molecules. Autoinducers are signaling molecules secreted by bacteria to communicate with other bacteria of the same kind. The secreted autoinducers can be small, hydrophobic molecules, such as acyl-homoserine lactone (AHL), or larger peptide-based molecules. Each type of molecule has a different mode of action. When AHL enters target bacteria, it binds to transcription factors, which then switch gene expression on or off. The peptide autoinducers stimulate more complicated signaling pathways that include bacterial kinases. The changes in bacteria following exposure to autoinducers can be quite extensive. The pathogenic bacterium *Pseudomonas aeruginosa* has 616 different genes that respond to autoinducers.

Figure 1: **Autoinducers**: Autoinducers are small molecules or proteins produced by bacteria that

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regulate gene expression.

Some species of bacteria that use quorum sensing form biofilms, which are complex colonies of bacteria (often containing several species) that exchange chemical signals to coordinate the release of toxins that attack the host. Bacterial biofilms can sometimes be found on medical equipment. When biofilms invade implants, such as hip or knee replacements or heart pacemakers, they can cause life-threatening infections.

Figure 1: Bacterial Biofilms: Cell-cell communication enables these (a) Staphylococcus aureus bacteria to work together to form a biofilm inside a hospital patient’s catheter, seen here via scanning electron microscopy. S. aureus is the main cause of hospital-acquired infections. (b) Hawaiian bobtail squid have a symbiotic relationship with the bioluminescent bacteria Vibrio fischeri. The luminescence makes it difficult to see the squid from below because it effectively eliminates its shadow. In return for camouflage, the squid provides food for the bacteria. Free-living V. fischeri do not produce luciferase, the enzyme responsible for luminescence, but V. fischeri living in a symbiotic relationship with the squid do. Quorum sensing determines whether the bacteria should produce the luciferase enzyme.

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