Cell Structures in Bacteria

Bacteria Communication within a Biofilm

 When most people think of bacteria, they picture small round objects that somehow move around and take up nutrients and divide. However, bacteria can do so much more and actually can even talk to each other in a way. In certain environments, bacteria will accumulate on top of a sticky surface and on top of each other in what is known as a biofilm. The cells then begin producing a sticky substance (the biofilm) that holds them all together like a community of cells. Once integrated into the biofilm community, cells actually begin talking to each other using chemical signals. One cell or group of cells will begin secreting certain chemicals which indicate to other cells or groups of cells to active or inactivate certain genes. Some genes remain inactive until this cell to cell chemical signaling is utilized. Once the biofilm reaches certain conditions, whether that be temperature, size, or another factor, cells begin to activate genes which allow them to thrive even more in the biofilm (see figure 1). Ordinary people tend to not give cells the credit they deserve for unique and remarkable processes that bacterial cells can carry out, but the first step to learning about cells and these special traits is understanding the structure and features of bacterial cells. In this chapter, you will be exposed to general features of all bacterial cells as well as more specified aspects only certain cells display.

After reading this chapter, you should:

* Understand the basic components of cell structure
* Be able to distinguish between Gram-positive and Gram-negative cells
* Know the 4 main types of nutrient uptake in cells
* Be able to list some general types of motility
* Recognize the shared structures inside each cell
* Be aware of variable structures (items not in every cell)

Bacterial Cell Shapes and Sizes

 If you have ever seen pictures of cells, then you know that bacteria can be of a wide range of different shapes and sizes. Bacterial cells generally can be divided into 6 main categories: cocci, bacilli, vibrios, spirilla, spirochetes, and pleomorphic.

A typical bacterial cell is between 1.1 and 1.5 µm wide and from 2.0 to 6.0 µm long. That being said, some cells fall far outside of that range reaching up to 500 µm in length and 7 µm in width. It is thought by most scientists that the size and shape of a cell was evolutionarily selected for efficiency and protection for each individual species.

Cocci cells are spherically shaped and although they can exist individually, cocci cells sometimes cluster together. When one cocci divides into two cells and the cells remain paired, they are called diplococci. Different cocci cells exhibit specific patterns as well, simply sharing the circular shape of each individual cell.

 Bacilli cells are rod shaped and can vary immensely. For example, a coccobacilli shaped cell is so wide and short that it almost looks like a cocci shaped cell. Similar to cocci cells, bacilli can also exist individually or in pairs. They also can form long chains as seen in Bacillus megaterium, which is one of the largest known bacterial species.

 The other shapes are less common but still notable enough to mention. Vibrios cells look like a comma under a microscope while spirilla cells are stiff and, as the name indicates, spiral-shaped. Spirilla cells tend to have flagella (like small tails) on one or both ends, making them differ from spirochetes, which are not stiff and contain internal flagella, but are also spiral shaped.

 Pleomorphic cells include the cells which do not easily fit into these categories. These cells tend to be variable in shape and size and usually lack a general shared feature. This category includes cells which change their shape in response to environmental factors.

Bacterial Cell Membrane and Cell Wall Structures

 Since bacteria are constantly being exposed to the environment and other cells around them, they need a protective covering which usually occurs in the form of a plasma cell membrane and a cell wall. These structures are collectively referred to as the cell envelope. The plasma membrane has countless functions including vital cellular processes like diffusion and endocytosis. The cell wall maintains the shape of the cell and protects it.

 A plasma cell membrane can be described using the “fluid mosaic model.” This means that it can be seen as a lipid bilayer with various specialized proteins floating inside of it, like a mosaic. The lipid bilayer consists of two layers of lipid molecules with their hydrophobic tails toward each other and the hydrophilic heads on both outside areas of the bilayer. Within this lipid bilayer are proteins which accomplish various actions related to nutrient uptake, waste elimination, and more. Nutrient Uptake mechanisms will be discussed later in this chapter.

 The cell wall of bacteria is mostly made up of a complex sugar material called peptidoglycan and can be divided into two categories, based on their structure: Gram-positive and Gram-negative. Gram-positive cell walls do retain a special stain during a common staining method called Gram staining (they appear purple under a microscope after Gram staining), while Gram-negative cells do not (they appear red after Gram staining). This occurs because Gram-positive cells have a thick layer of peptidoglycan outside of the aforementioned plasma membrane (See figure 2). On the other hand, gram-negative cells have a thinner layer of peptidoglycan between the plasma membrane and an outer membrane (See figure 3).

Nutrient Uptake Methods in Bacteria

Cells must be able to protect themselves while also allowing certain things to enter the cell, mainly nutrients. This can be accomplished by a cell in a number of ways, four of which will be discussed in this chapter. These include passive diffusion, facilitated diffusion, and primary and secondary active transport.

 Passive diffusion, also called simple diffusion is when molecules move from an area of higher concentration to an area of lower concentration. This method is used to allow gases (namely oxygen and carbon dioxide) and water to easily enter the cell.

 When specified channels or carriers are added to a passive diffusion system, it becomes known as facilitated diffusion. Facilitated diffusion is “facilitated” by transport proteins called carriers and channels. Carriers which show specificity for the molecule being taken into the cell (such as sugars and ions) and channels (which show less specificity).

 Active transport differs from both above types of transport in one key manner: active transport requires the input of energy from proteins or elsewhere in the cell. There are three main divisions of active transport: primary, secondary, and group translocation (a specified sugar uptake system). Active transport does involve carrier proteins and is therefore a specified process. This mechanism allows for absorption of mainly sugars and ions.

Figures and Diagrams

Figure 1: The process of biofilm communication

Figure 2: Cell envelope of Gram-positive cell

Figure 3: Cell envelope of a Gram-negative cell wall

References

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