**Bacterial Survival: How Bacteria Deals with Environmental Stress**

**Bacteria’s Interaction with the Environment**

When some hear the word bacteria, they may just think of germs that will get you sick if you don’t wash your hands. However, not all bacteria are created equal. While some bacteria may do harm to us, others actually help us every day in digestion! This goes to show that all bacteria are not the same. There are many different species of bacteria and each of these species have varying characteristics. For example, some bacteria may grow well in an environment that may be inhospitable for other bacteria. Temperature, pH, and osmolarity are just a few ways that this diverse group of bacteria may differ from one another. These three values are all characteristics of the environments that these bacteria thrive in.

Just like other organisms, bacteria rely on their environment for survival. However, sometimes the conditions of a bacteria’s environment may not be optimal for the bacteria’s survival. In some ways, bacteria are just like us. If it’s cold outside, we may put on a coat, or in some cases just avoid going outside all together. We take precautions to make sure that we won’t freeze. Bacteria also take precautions to help increase their chances for survival in a challenging environment.

**What is a Stress Response?**

Like other organisms, bacteria can become stressed. This stress can be caused by environmental factors including lack in nutrition, change in temperature, and hostile invaders. These bacterial cells will receive a signal that there is a threat in its surroundings, which may elicit a response. This response is referred to as a stress response. A **stress response** will help the bacteria increase its chances for survival in hostile or changing environments. These responses allow the bacteria to deal with an adverse situation in an appropriate manner.

**Types of Stress Responses**

* **Heat-Shock Response**

Let’s look at one scenario: a bacterium needs to survive in an environment that is increasing in temperature. This temperature increase could cause damage to the bacteria since the bacteria is beginning to reach the upper edge of its growth range. The bacteria need to do something in order to survive. One way a bacterium may increase its survival chances may be through a heat-shock response. A **heat-shock response** will signal the bacterial cell to produce protective proteins in order to not be affected as much by the temperature. While this is not a permanent solution, this allows the bacteria to survive a little more time until the environment may cool down to a suitable temperature for the bacteria.

* **Osmotic Stress**

Another stress bacteria may experience is if the osmolarity of the environment becomes hypertonic or hypotonic. **Osmolarity** refers to the number of solute molecules that are present in a solution. In this example, the solution is the environment that the bacterial cell is in. A cell’s environment may become hypertonic or hypotonic. **Hypertonic** means that the osmolarity outside the cell is higher than the osmolarity inside the cell. With that, **hypotonic** would indicate that the osmolarity outside the cell is lower than that inside the cell. Both could result in the cell taking in or losing too much water, which could be detrimental. The hypertonic and hypotonic osmolarities would elicit a stress response from the bacterial cell.

The cell membranes of the bacteria allow water to move from the cell to the environment via water channels. In a hypertonic solution, these bacterial cells will try to protect the water that is already inside the cell. This will cause the channels to close, and the plasma membrane will prevent water in the cell from leaving. If the solution is hypotonic, the cells will try to expel the water outside of the cell. The pressure inside the cell will increase until the pressure-sensitive channels will allow the water to leak into the cell’s surroundings.

* **Acid Resistance**

Acid resistance, also referred to as **emergency global response system**, refers to the change in a bacteria’s physiology after it has undergone a type of molecular reprogramming. This reprogramming occurred in response to a stress caused by the bacteria is placed into high or low pH conditions, increasing or decreasing the hydrogen ions in the surroundings of the cell. This change in pH will result in the growth of the cell slowing down. These responses cause the cells to make more lipids and enhance its pH homeostasis. This allows the cell to better resist gaining or losing too many hydrogen ions.

* **Starvation**

A bacterial cell can sense the dangerous situation developing when nutrients in the environment are becoming scarce. The metabolism of a cell will start to slow down. This will signal the cell to begin making and storing glycogen, which can be used in the future as an internal emergency source. If time has passed and there has still not been an increase in nutrition availability, the bacterial cells may participate in a phenomenon referred to as programmed cell death. **Programmed cell death** is when some cells will sacrifice themselves for the benefit of its neighbors. The cells that are participating will release the nutrients that they had to the surrounding cells, thus increasing those cells’ chances at surviving for longer.

**Resistance**

These stress responses are all ways that bacterial cells participate in resistance to their changing environment. The bacteria’s goal is to survive. While there are some bacteria that we want to survive, like the ones in our digestive system, there are others that we don’t want to have great chances of survival. This refers to bacteria that could cause bacterial infections that may affect the health of an organism. Usually these bacterial infections can be cleared up through the use of antibiotics or other medications. However, bacteria can and are becoming more resistant to our efforts to wipe them out.

**Methods of Resistance**

* **Efflux Pumps**

One way that these bacteria are able to resist efforts to clear them is through the use of multidrug efflux pumps. **Multidrug efflux pumps** pump out hostile biocides, organic solvents, and detergents that entered the cell in an effort to exterminate it. The cell pumping out these substances reduces the efficiency of said substances because they are not in the cell to do their job. These pumps allow for low level resistance to occur.

* **Biofilms**

Cells may also use biofilms in an effort to resist against new hostile inhabitants. **Biofilms** are a congregation of cells that attach to a solid surface. These biofilms are held together by proteins and polysaccharides. These binding substances also bind to the hostile invaders, slowing down the substance’s penetration of the cell. This allows for a greater chance of cells further down in the biofilm to activate their own protective stress response systems.

* **Antibiotic Resistance**

One scary development that bacteria have achieved is the resistance to antibiotics. This can cause bacterial infections to be prolonged and/or prevent the treatment of the infection. Some bacterial cells can avoid being detected by an antibiotic by lacking a targeting molecule. This allows the bacteria to avoid me detected by the antibiotic, thus allowing the bacterial cell to survive. Some bacterial cells can also survive even if they are recognized. They achieve this by modifying the antibiotic itself. The cells will produce an enzyme that will attach a phosphate group upon the antibiotic’s entry into the cell. This causes the antibiotic to become ineffective.

**Conclusion**

A bacteria’s environment has a lot to do with how that bacteria is going to behave. If the bacteria anticipate incoming threats, the bacteria will induce stress responses to better its chances at survival. The stress responses a bacteria may use will depend on what type of threat it is encountering, just as we do. It turns out that bacteria are not so different from us after all.

Sources:

Foster, J., Slonczewski, J. Microbiology: An Evolving Science. *Chapter 5: Environmental Influences and Control of Microbial Growth.* 4th Edition, 2017.