CSIR NET Life Science Unit 2

Bacterial Stress Response

Stress condition is a biological and psychological response experienced due to non-optimal (unfavourable) external conditions.

A stressor that can induce a stress response in bacteria can be any condition outside of the ideal conditions for survival. The stressors that inflict harm to the cell are the ones that illicit the strongest responses.

- One such stressor is exposure to reactive oxygen species and reactive chlorine species chemicals that are used as disinfectants. Included in this category is sodium hypochlorite (NaOCl), or household bleach. These chemicals inflict extensive cellular damage to different systems such as the bacterial membrane, denaturation of proteins, and interference with biomolecules such as amino acids, nucleic acids, and lipids.
- Another type of stressor could be the absence of the favorable electron acceptor for cellular respiration. The shift from more favorable energy production to a less favorable one, such as nitrate, could change cell morphology and composition of the cellular membrane.
- Other types of stressors include oxidants, nutrient deprivation, hypo/hyper-osmolarity, extreme pH, extreme temperature, hypoxia (lack of oxygen), starvation or lack of nutrients, and antimicrobial substances.

Initial Stress Response

That system will likely go into effect against situations that are damaging to the bacterial cell is chaperones. Chaperones are proteins that are responsible for keeping other proteins in their proper conformations by binding to them. Without the chaperones as a first line of defense, other stress response systems would not be able to react quickly enough to stop proteins from denaturing in time. While a protein is denaturing, it will produce intermediate conformations of itself, and these intermediates are what activate chaperone proteins.

Another major stress response system is transcriptional regulation. Many transcriptional regulation systems are well defined, while others are less understood, but they can be activated by different pathways & stimuli and is a general response to most stimuli. What this involves is proteins binding to promoter regions of DNA to regulate which sections are transcribed into RNA. The concentration of different RNA transcripts is then altered to favor the production of those that will produce proteins that will mitigate the effects of

the stimulus. However, this system may be limited by the translational ability of the cell. The transcriptional changes can only be effective if the ribosomal speed to translate mRNA to protein is quick enough. This can be a bottleneck in the capability of bacteria to react to stressors quickly enough, and some stressors, such as oxidative stress, can inhibit the function of ribosomes.

General Stress Response

- A stress response that can occur under conditions that are non-advantageous, but also non-lethal, is the creation of a **biofilm**. In this response, bacterial cells can secrete extracellular polymeric substances to form a film that can provide support to the bacterial colony, such as by improving their ability to adhere to a surface.
- Another common stress response is **latency**. In a latent state, a cell will slow down its metabolism and become virtually dormant. This makes the cell much less affected by stressors such as antibacterial agents, starvation, hypoxia, and acidity. Some bacteria are able to enter a latent state and remain there for up to years before returning to an active state.
- A cell can also shift from the production of unsaturated fatty acids to saturated fatty acids to **decrease the fluidity of the cellular membrane**. If the stressor is a molecule, this will make it more difficult for it to get into the cell. A similar response can be observed in terms of a decrease in membrane fluidity in case of cold shock. Overall cellular morphology can also be changed in response to a stressor.

Heat Shock Response

Heat Shock Response helps to stop any damage to the cellular process in high-temperature conditions. It is also caused because the heat allows for the proteins to be transcriptionally upregulated which also helps to protect the bacteria from protein denaturation. Heat proteins are created by factors of heat-shock promoters. Some heat proteins that are created are chaperones and proteases. This means that the protein will be folded the correct way as well as position in the right portions of the cell. It also ensures that any protein that is not folded correctly will be destroyed properly to ensure that the bacteria remain to function properly.

Envelope Stress Response

The two-component signal transduction (2CST) system also allows the bacterial cell to be able to sense stress in the system. This is due to a histidine kinase that can be found in the cell's inner membrane, to detect the stress. It is able to detect stress because of autophosphorylation that happens when the stress

is detected. Once the stress is detected, the system moves to a cytoplasmic response regulator. This is due to the cell being in a phosphate group, but this new response regulator will start to act like a transcription factor. This means that it will start to change what is expressed when looking at the genes. This is especially true when looking at the **Cpx proteins** which help to prevent the protein from folding the wrong way or not at all. Cpx proteins also help to ensure that there will be no other damage when looking at other cellular processes.

Cold Shock Response

When bacteria are in an area of very low and cold temperature, they will have a five-hour-long phase that will cause them not to grow at all. The way the bacteria tries to adapt is by creating child shock proteins that will be transcription factors that will be upregulated during the five-hour phase. Once this five-hour period ends, the bacteria will start to grow again, but it will be at a very slow rate. These proteins will help the bacteria to continue to grow and survive at lower temperatures. A protein called CspA was originally found in *E. coli* and is known to be one of the first cold shock proteins discovered. This will ultimately help with transcription and translation.