**Chapter 20: Overview of Extremophiles**

**Recap of Unit 5: Life on Earth**

Planet Earth is home to a variety of living organisms. Recall from **Chapter 15** organisms are any living systems composed of one or more cells. From there the chapter discussed the four characteristics all living things- organization, metabolism, reproduction, and motion. The chapter also examined the structure from outside to inside of a basic cell. In **Chapter 16**, the Tree of Life and its three domains; Bacteria, Archaea, and Eukarya were explained, laying the foundation of classifying organisms. In **Chapter 17**,**18**, and **19** each domain was covered. In this chapter students will delve deeper into diversity of microorganisms by discussing extremophiles by what is an extremophile, examples of extremophiles, applications extremophiles.

**What is an Extremophile and Where Can One Be Found**

An extremophile is an organism that lives under extreme environmental conditions. Environmental conditions can include pressure, pH, salinity, and temperature. Most extremophiles are microorganisms of domains Bacteria and Archaea. Archaea have been best known for microorganisms living in habitats of high salt concentrations or high temperatures like some hot springs in Yellowstone National Park or the Great Salt. Organisms that live in hypersaline environments are called halophiles, and organisms that live in environments of high temperatures are called thermophiles.

Extremophiles have spent generations evolving to be adapted to such harsh environments. Furthermore, depending on which environment that microorganisms is in, it has acquired a specific trait (traits, heritable, and evolution were mentioned in **Unit 4** of the textbook) or traits that have given it that ability to survive. Depending on the extreme environment, extremophiles have adapted to survive by using modified cell walls, alternative molecular compounds, or cellular processes. Some extremophiles don’t require oxygen to survive, for some it can even be toxic. For example, microorganisms of genus *Sulfolobus* of the domain Archaea, can be found in some sulfuric hydrothermal areas (hot springs) in Yellowstone (“Thermophilic Archaea” 2018). It has the ability to take in sulfur compounds (instead of oxygen), which are of high concentration in said environment and convert them into other molecular compounds (like energy) needed for cellular processes. It also has a modified cell wall to withstand the high temperatures of the hot springs. Thermophiles have the ability to withstand denaturing of proteins by having a high concentration of cytosine and guanine nucleotides (nucleotides and proteins were discussed in **Unit 4**). Denaturing is the process of disrupting the structure of a protein by uncoiling it into a random shape that can no longer be used in cellular process. It usually occurs in high temperature environments.

Extremophiles don’t necessarily have to live in environments of high temperatures, they can also survive in the frigid temperatures of Antarctica or the Dead Sea. Organisms that are found in the extremely cold temperatures (psychrophilic) of Antarctica make proteins called cold-shock proteins. Cold shock proteins are meant to help in translation. The fungus *Eurotium rubrum* is a halophilic (salt-loving) organism found in the Dead Sea (“Salt Needed: Tolerance Lessons from a Dead Sea Fungus” 2014), an environment of high salt content. The fungus has adapted to survive in such a salty environment by maintaining its osmotic balance (refer to **Chapter 15** for more information about osmotic balance) by producing compatible solutes to help keep the salt out. Extremophiles can also be found living at the bottom of the ocean near hydrothermal vents. They can not only withstand the high temperatures the vent releases, but the pressure at that depth of the ocean. Organisms that love to live in environments of high pressures are called piezophiles. The bacteria *Deinococcus radiodurans* is an extremophile much different from the above examples. This particular bacterium has adapted to survive in environments of extremely high radiation, it is considered a radioresistant extremophile. *Deinococcus* can survive up to five million rad, 100 rad is deadly to humans (Willey et al. 2014). Extremophiles are taxonomically and functionally diverse.

**Applications and Importance of Extremophiles**

Since extremophiles have adaptations to survive in extreme environments, they have created a field of their own in the biotechnology and biomedical industries. Their specialized proteins that they create can be used in each industry to create new medicines or new technologies. For instance, there has been promising results in using organic solutes produced by extremophilic microorganisms to help with protein misfolding diseases (refer to **Unit 4** for protein misfolding), like Parkinson’s and Alzheimer’s disease (Jorge et al. 2016). The modeled thermophiles under heat stress, produces organic solutes that can be used against denaturing of proteins and can be used as chaperones in proper refolding (Jorge et al. 2016). The biomedical field hopes to include the defensive mechanisms produced by radioresistant extremophiles in anticancer drugs and sunscreens (Gabani and Singh 2013). In the biotechnology industry, biocatalysts (enzymes; see **Unit 4** for more information) of extremophiles can be used to convert waste into biofuels (Raddadi et al. 2015). Extremophiles help to pave the way to understanding how biological mechanisms and adaptation coincide. They could possibly be the key to cancer and a bio-based economy. A bio-based economy is the production of renewable resources and the conversion of them into valued products. For more information on bio-based economy see webpage <http://www.biobasedeconomy.eu/> (“What is BBE”).

**References**

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