الجامعة المستنصرية
كلية العلوم
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مادة بيئة الاحياء المجهرية/الدراسة المسائية والصباحية

Extreme Environments

An extreme environment is a habitat characterized by harsh environmental conditions, beyond the optimal range for the development of organisms, for example, pH 2 or 11, −20°C or 113°C, saturating salt concentrations, high radiation, high pressure, among others. Basically, these are all inhospitable conditions for life. By definition, the organisms that are able to live in extreme environments are known as extremophiles.

Types of Extreme Environments:

4- High Temperature Environments

There are many examples of environments with extreme temperature. Environments with high temperature (>70 °C) include terrestrial and submarine hot springs, some of which can reach temperature of 100 °C and hydrothermal vents, which can reach temperature in excess of 300 °C. Such high temperature are inhospitable for most forms of life except for certain bacteria and archaebacteria. Genera commonly found in these environments include Thermus, Methanobacterium, Sulfolobus, Pyrodictium, and Pyrococcus.

Another species of thermotolerant bacteria, namely *Thermus aquaticus* is an extreme thermophile able to grow between 40 and 79°C with an optimum temperature of 70°C is especially renowned because of its thermotolerant DNA polymerase which used for the polymerase chain reaction (PCR).

Many mechanisms allow microorganisms to survive at temperature that normally denaturation proteins, cell membranes, and even genetic material.

In terms of proteins: One general adaptive mechanism exhibited by thermophilic microorganisms is the production of chaperonins: which are specialized thermostable proteins that help refold and restore other proteins to their functional form following thermal denaturation. In addition there are microbespecific adaptations to increase protein stability at high temperature including these:

- An increased number of salt bridges (disulfide bridges)
- Increased interactions among aromatic peptides
- Increased hydrogen bonding among peptides

In terms of cell membranes: Thermophilic eubacteria have increased amounts of saturated fatty acids in their membranes that allow the membranes to remain stable at high temperatures.

In terms of nucleic acids(DNA): thermophiles contain special DNA binding proteins that arrange the DNA into globular particles ,that more resistant to melting .Another factor that is common to all (hyperthermophiles) produce a unique enzyme called DNA gyrase. This gyrase acts to induce positive supercoils in DNA, theoretically providing considerable heat stability.

There are numerous biotechnological applications for enzymes isolated from thermophilic microorganisms and the number of applications is growing rapidly, especially in commercial industry. One example is the thermostable DNA polymerase used in PCR. Other examples include proteases, lipases, amylases, and xylanases that are used in the agricultural, paper, pharmaceutical, water purification, bioremediation, mining, and petroleum recovery industries.

5- High Solute Environments

Halotolerant or High-salt-tolerant organisms require salt concentrations for growth that are substantially higher than that found in seawater.one of the best known examples of this type of environment is Utah's Great Salt Lake: another is the Dead Sea, *Halobacterium* and *Haloanaerobium* are two examples of halotolerant bacteria. In addition to bacteria, some algae and fungi are known to be halotolerant.

The main mechanism of salt tolerance displayed by bacteria is

- **First mechanism:** Internal sequestration of high concentration of a balancing solute to equal the salt concentration found external to the cell, examples of these balancing solutes include K^+.
- **Second mechanism:** involves proteins that are acidic and typically have low proportions of nonpolar amino acid. Thus for these proteins to be active, high salt concentrations are needed to balance their charge and acidity.

Because of these macromolecular modifications halotolerant bacteria are usually unable to survive in environments lacking high salt concentrations. Thus, many are considered obligate halophiles.

6- Low pH Environments

Acidic environments such as acid hot springs, the gastrointestinal tract, mining waste streams, acid mine wastewater and various mineral oxidizing environments, are populated by acidophiles bacteria such as *Thiobacillus*, other examples of acidophiles *clostridium acetobutylicum* and *sarcina ventriculi* which are obligate anaerobes that ferment sugars, in addition to bacteria, some fungi, algae and protozoa are also known to be acid tolerant.

Strategies used by microorganisms to deal with high or low pH values usually involves modifications of cell membranes

 The first modifications is to the structure of membrane components to allow them to be acid tolerant. This include the incorporation of very long chain dicarboxylic fatty acids (32-36 carbons), which make up more than 50% of the membrane fatty acids. These specialized fatty acids help inhibit acid hydrolysis of the membrane

 The second modification involves control of ion transport across the membrane. By controlling ion transport these organism can maintain an internal pH in the range between 5 and 7, even though the external environment can have a pH less than 2.

7- High Pressure Environments

Deep-sea environments are characterized by high pressure and cold temperature microbes that live in this environment are called barophiles. Barophiles have developed unique mechanisms that allow them to tolerant the high pressure of more than 1000 bars found in deep-sea (normal atmospheric pressure is 1 bar). Bacteria retrieved from depths greater than 2000 m actually grow better under high pressure than at normal atmospheric pressure .In addition to being pressure tolerant, barophiles are for the most part also psychrophilic meaning that they grow better at low temperatures ,finally these microbes are adapted to darkness.

Organisms that live under these deep ocean conditions have developed unique mechanisms for survival, **many of these mechanisms involves changes in macromolecular structure and function include**:

 Long-chain polyunsaturated fatty acids are found in high concentration in the membranes of barophiles , these modified fatty acids maintain the membranes in a fluid state under a pressure and that would otherwise tend to gel or crystallize them

8- No Nutrient Environments

Another extreme environment, which is of great importance in today's world is ultrapure or nutrient- free water. Ultrapure water is used in the semiconductor, medical and many other industries. Contamination of ultrapure water by microorganisms can be devastating to these industries.

For instance, microbial contamination of ultrapure water can cause flaws in crystal design of computer chips, lowering the efficiency of the chips. Because of no nutrients in ultrapure water, it is considered an extreme environment. Very few organisms are able to survive, also proliferation in ultrapure water, one of these is the bacterium *caulobacter* and another is *pseudomonas flurorescens*.

In distilled water, for instance, even the limited exchange of nutrients (CO_2) from the atmosphere provides enough nutrients to allow limited growth.