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# Temperature & (extreme drying) Dessication Stress in Cyanobacteria

Stresses in nature occur simultaneously so, it is imperative that survival under stress means to sense stress & impart tolerance to it.

(Low precipitation (rainfall), prolonged drought & thermal (heat) stress (−20°C to +40°C) are the factors that create dessicated conditions.)

Another important factor is metric water potential. Water potential ($\Psi$) is the difference in the free energy between the system & pure water at the same temp.

## Effects of Dessication Stress Factors on

1.) **Nucleic Acids :**

a) Dessication leads to accumulation of mutations (damage) when there is no cell growth.

b) DNA damage due to chemical modification (alkylation & Oxidation), cross-linking, base removal by ionizing & non-ionizing radiation.

c) DNA undergoes single stranded breaks on dessication

d) Conformational change in DNA by base methylation in major groove of DNA occurs due to dessication.

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e.) Dessication may convert B form of DNA into A form.

f.) Alteration in DNA as a result of increased covalent cross-links between proteins & DNA that accumulate continously during dessication.

g.) Dessication ultimately causes loss of control mechanism that maintains low concentration of reactive oxygen species (ROS). ROS damages nucleic acid

h.) The $OH^-$ radical can attack & damage almost every molecule of living cell. In DNA it hydoxylates purines & pyrimidines (bases) & enhances mutation rates.

## Proteins :-

1.) As the cells dry up & get dessicated, the total turn over of proteins represented by $K_{cat}$ value have less meaning because the cells enter a period of dormancy (quiescence).

2.) Water is necessary for protein structure & folding. So after dessication when rehydration occurs, modified proteins form in majority.

3.) Damage of proteins is caused by ROS. It changes their configuration, mostly due to

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oxidation of free thiol residue of cystein to thiyl radicals, which may link thiyl radicals forming disulfide bonds.

4.) Loss of diffusion barrier to membrane impermeable markers cause cell lysis as a result of oxidative damage.

5.) Proteins become sensitive to proteolysis & show reduced activity or are inactivated.

6.) Proteins denature at low temperature.

**Stress Proteins**

| Water stress proteins (Wsp) | Heat Shock Proteins (HSP) |
|---|---|
| a.) 3 Wsp polypeptides accumulate in extracellular glycan. | → HSP are induced by heat shock & enhances expression level of Chaperones & Co-chaperones. |
| b.) | → HSp are located in plasma membrane or in Cytosol |
| c.) Wsp have structural role in cell stability due to their high content of serine, threonine & tyrosine (amino acids). | → Hsp of 4 sizes were induced when Synechocystis cells were subjected to HS. |
| d.) | → HSP 17 is thylakoid-associated during HS (heat Shock) |

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(Chaperones) → are proteins that help in folding of Proteins.
(in eukaryotes it is known as HSP).

Heat shock protein functions in folding of nascent proteins & re folding of denatured proteins.

## LIPID MEMBRANES :

1.) Under temperature stress, membrane without trehalose undergo vesical fusion, change in morphology & loss of Calcium transport activity.

2.) Damage by ROS (oxygen & Hydroxyl radical) initiates peroxidation.

3.) Lipid peroxidases decompose to give volatile hydrocarbons & aldehydes

## Mechanism Of Tolerance to Dessication Stress (ABIOTIC)

### Of Nucleic Acids :

1.) Multiple genome copies present per cell in Cyanobacteria present is mechanism of tolerance against DNA damage.

2.) Present of UV absorbing pigment

3.) Mechanism for retarding rate of depurination.

4.) Double helix structure & amount of bound water plays role in tolerance.

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5. Reduced water content influences photoproduct, thus tolerance.

6.) Special "Repair Ligases" are present for DNA repair. Single strand breaks are repaired by these Ligases.

7.) Trehalose protects Nucleic acids from dessication because of accumulation in membranes.

Stress tolerance (Defense mechanism) in PROTEINS due to abiotic Stress Dessication

1.) Bound water plays crucial role in protein folding & imparts stability during dessication.

2.) Uptake of glycerol proteins & sulphates. Phosphorylation of glycerol proteins & sulphates.

3.) Rapid cessation of nitrogenase activity in desiccated cell but its one component Fe-protein remains stable even after 10 years of drying.

4.) Catalase is another enzyme that maintains stability.

5.) Intracellular ATP pool & protein biosynthetic machinery remains undisturbed even after drying.

6.) RNA polymerase holoenzyme maintains

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stability of cell drying

7.) Role of Ubiquitin protein in increasing protein turn over.

8.) Cyanophycin appearance in cells during drying is from rapid protein turn over & their disappearance on rewetting of cells, contributes to protein stability.

9.) Wsp play role in modification of extracellular glycan which contains xylose.

10.) Trigger of HS protein formation. They are activated by accumulation of denatured proteins in cytoplasm. DNA K acts as temperature sensor. DNA K functions as molecular chaperone.

11.) Proteins have a structural role in cell stability due to their abundance & high content of hydroxylated amino acids (Serine, threonine & tyrosine)

Stress Tolerance Mechanism (Defense Mechanism) in Lipid membranes under abiotic stress Dessication.

1.) Dessication instigate trehalose

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accumulation. It stabilizes membranes lipid layer. Trehalose & Sucrose replace bound water & form aqueous glasses around dessicated cells

2.) Plasma membranes act as temperature sensors in cyanobacterial cells exposed to heat stress.

3.) Change in membrane fluidity is another defense mechanism to dessication stress. Desaturases insert double bonds in fatty acids (to make it unsaturated fat)

4.) Change in membrane fluidity through Histidine kinase enzyme

5.) ROS enzymes & Carotenoids prevent damage to membranes from ROS.