Response of plants to water stress

Submitted by
Dr. Nitika Kapoor

Department of Botany
Hans Raj Mahila Maha Vidyalaya,
Jalandhar City-144008
Punjab

STRESS

External conditions that adversely affect growth, development or productivity of plant.

Types of stresses:

- **Abiotic Stresses**
- **Biotic Stresses**

Biotic Stresses: **Imposed by other organisms:**

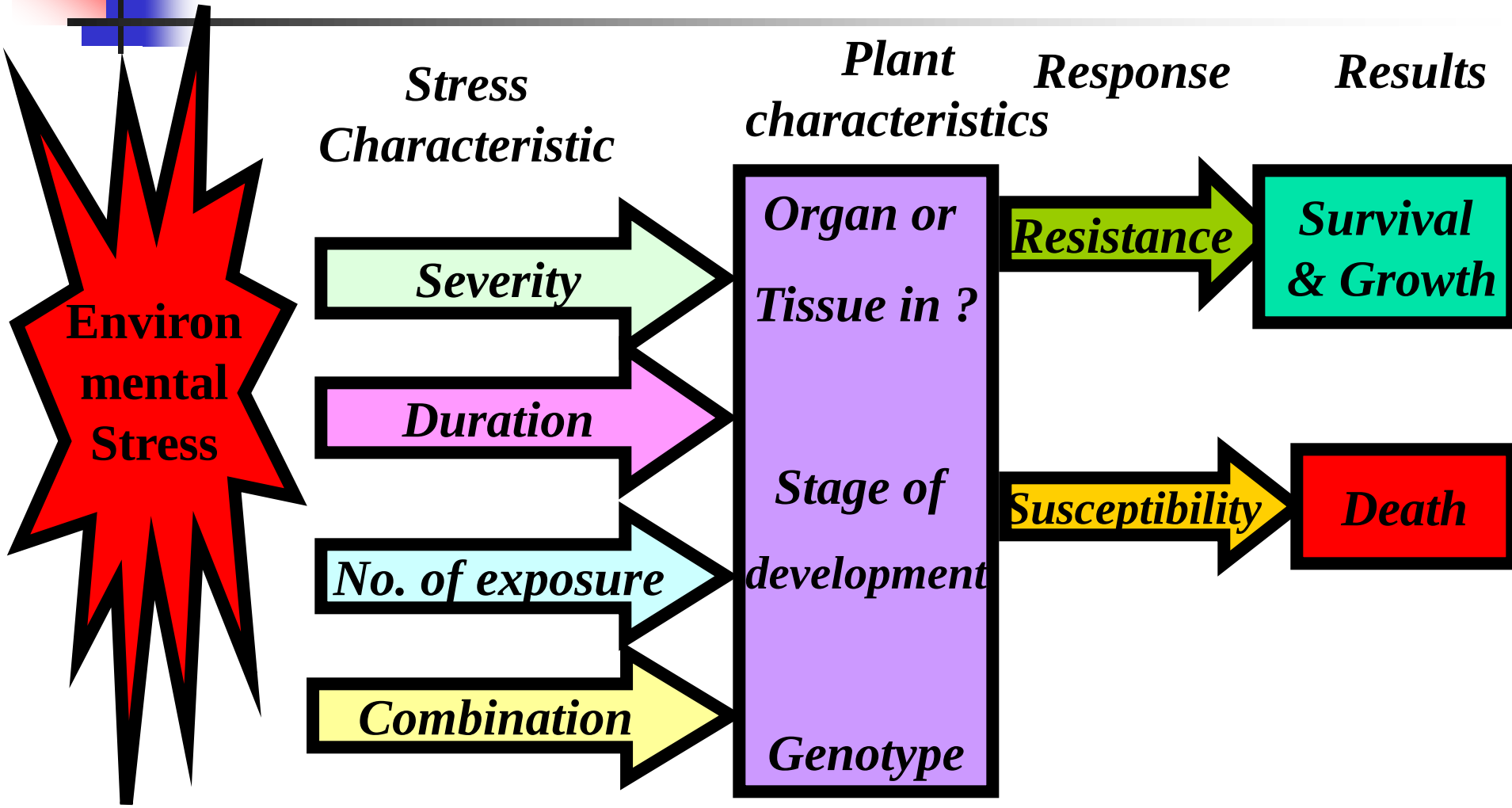
- **Bacteria**
- **Fungi**
- **Viruses**
- **Nematodes**

Abiotic Stresses

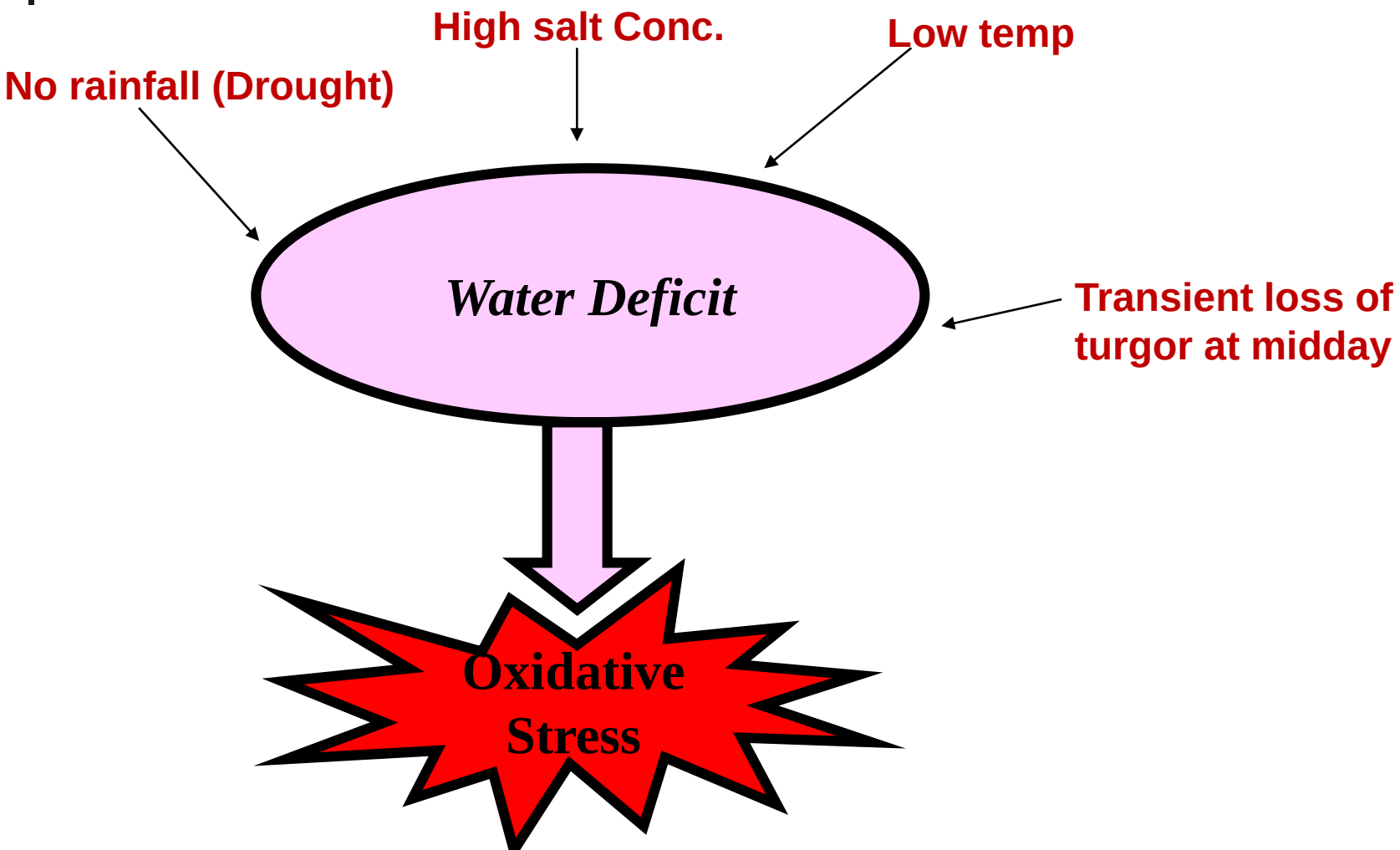
Arising from an excess or deficit in physiological or chemical environment.

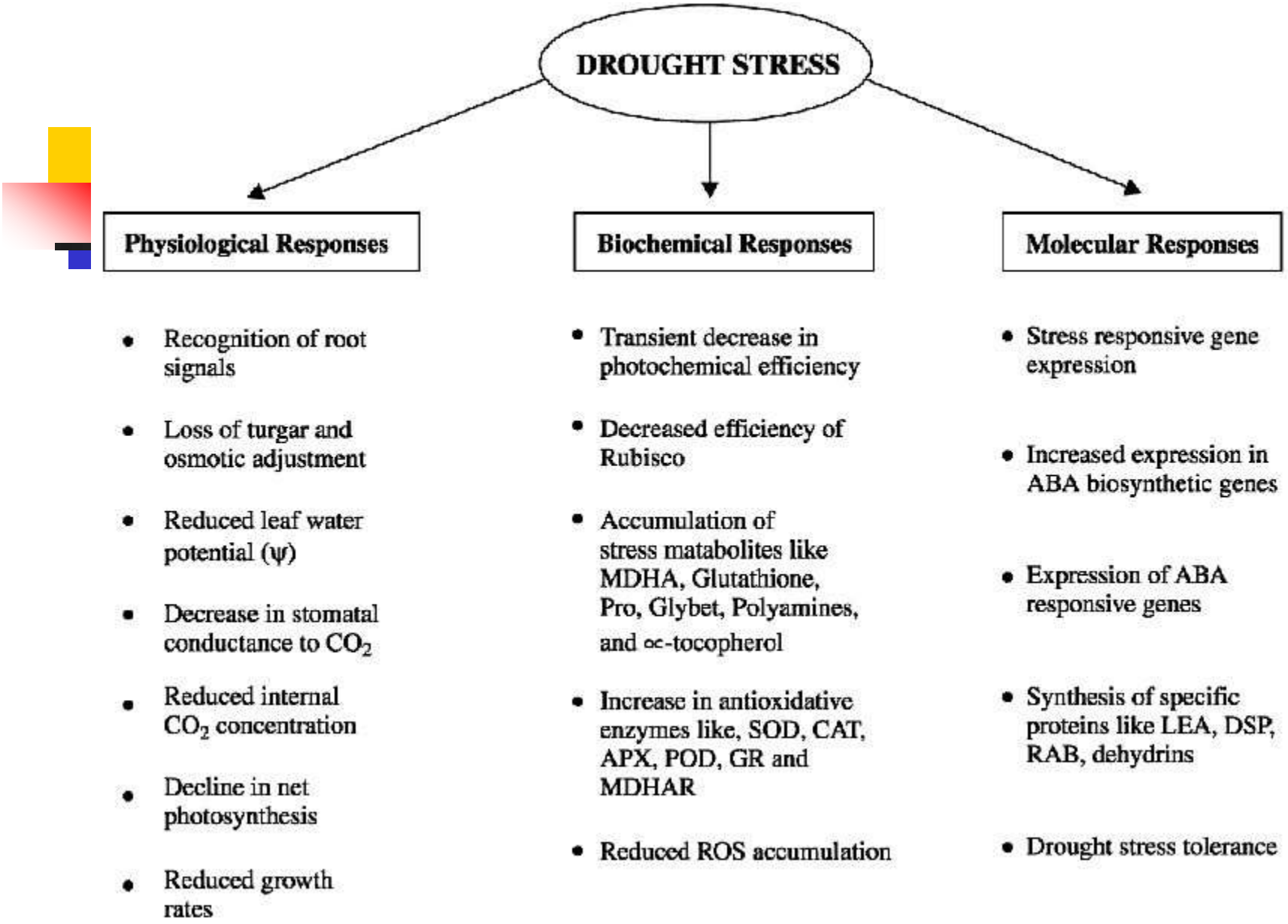
- **Water Logging**
- **Drought**
- **High or low temperatures**
- **Excessive soil salinity**
- **Chemicals (Pesticides, heavy metals and air pollutants)**
- **Radiation(Visible, ultraviolet)**

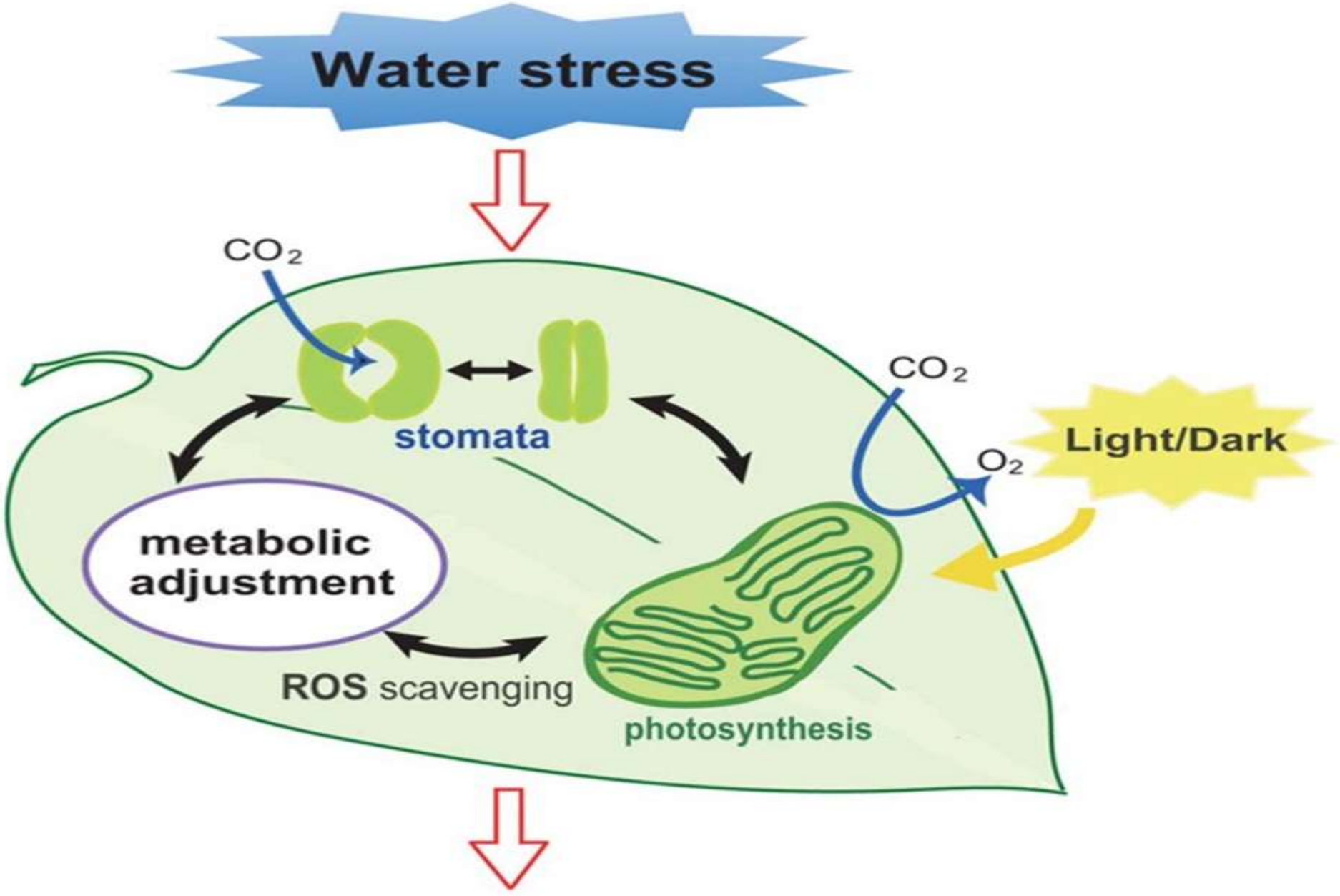
Response of plant to environmental stress



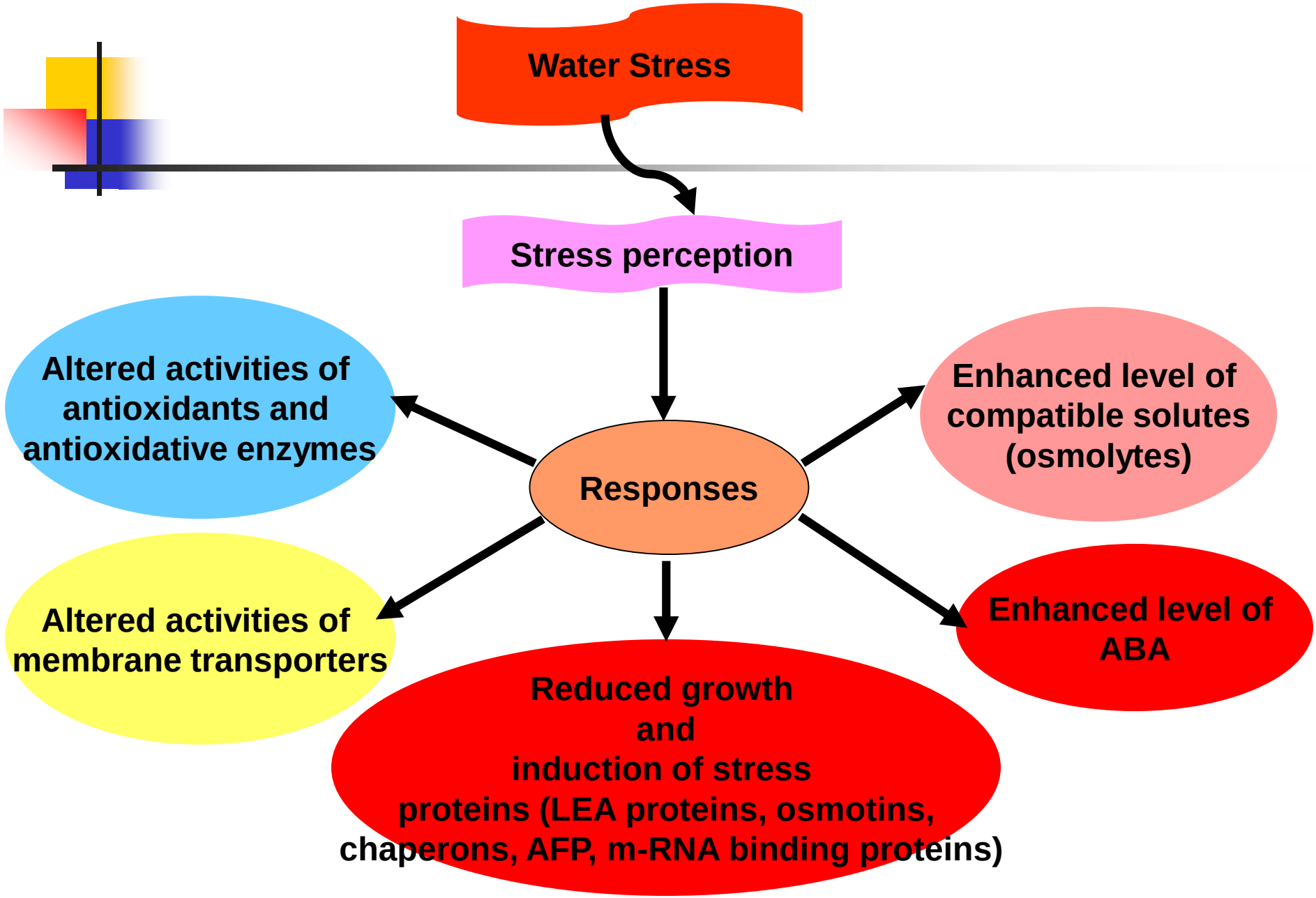
Environmental factors that induce water stress in plants




DROUGHT STRESS
Physiological Responses
Recognition of root signals
Loss of turgar and osmotic adjustment
Reduced leaf water potential (ψ)
Decrease in stomatal conductance to CO_2
Reduced internal CO_2 concentration
Decline in net photosynthesis
Reduced growth rates
Biochemical Responses
Transient decrease in photochemical efficiency
Decreased efficiency of Rubisco
Accumulation of stress matabolites like MDHA, Glutathione, Pro, Glybet, Polyamines, and ∝-tocopherol
Increase in antioxidative enzymes like, SOD, CAT, APX, POD, GR and MDHAR
Reduced ROS accumulation
Molecular Responses
Stress responsive gene expression
Increased expression in ABA biosynthetic genes
Expression of ABA responsive genes
Synthesis of specific proteins like LEA, DSP, RAB, dehydrins
Drought stress tolerance


Water stress
CO2
stomata
CO2
O2
Light/Dark
metabolic adjustment
ROS scavenging
photosynthesis
Growth adjustment and stress adaptation

Water Stress and plant responses

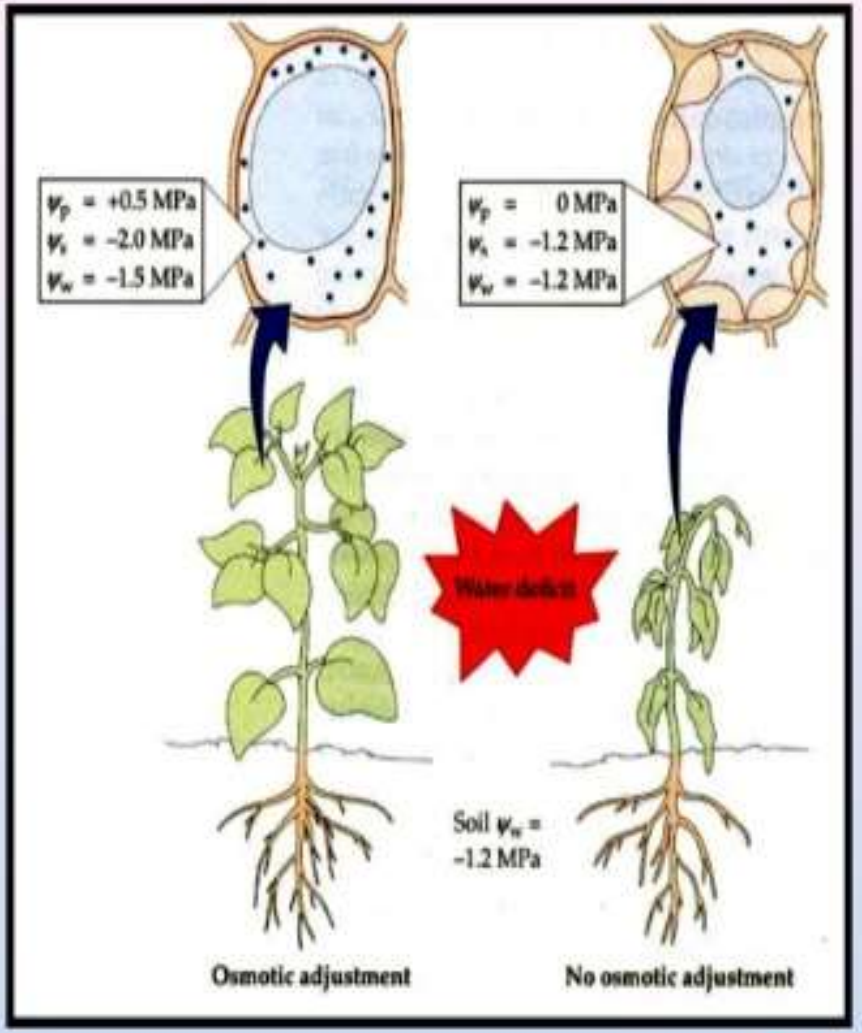


Role of osmolytes in water stress management

2. Osmotic adjustment

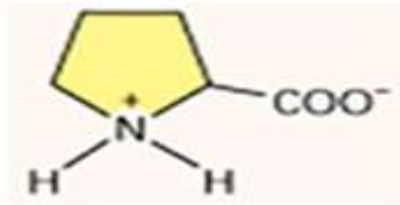
net increase in intercellular solutes in response to water stress, which allows turgor maintenance at lower water potential

Target : Gene encoding rate limiting enzymes in biosynthetic pathway of various osmolytes like Proline, mannitol etc



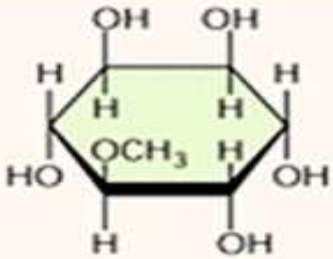
Osmolytes

Amino acid

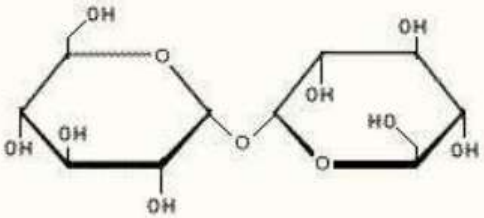


proline

Polyols

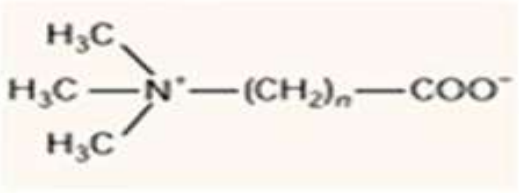


pinitol

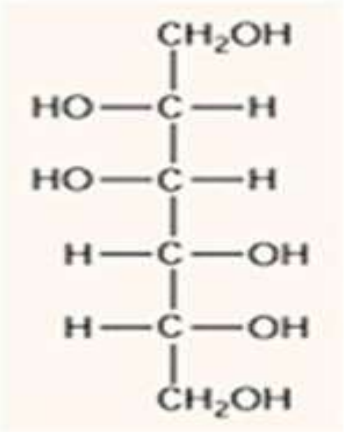


Trehalose

Quaternary ammonium compounds



n = 1. glycine betaine
n = 2. β-alanine betaine



mannitol

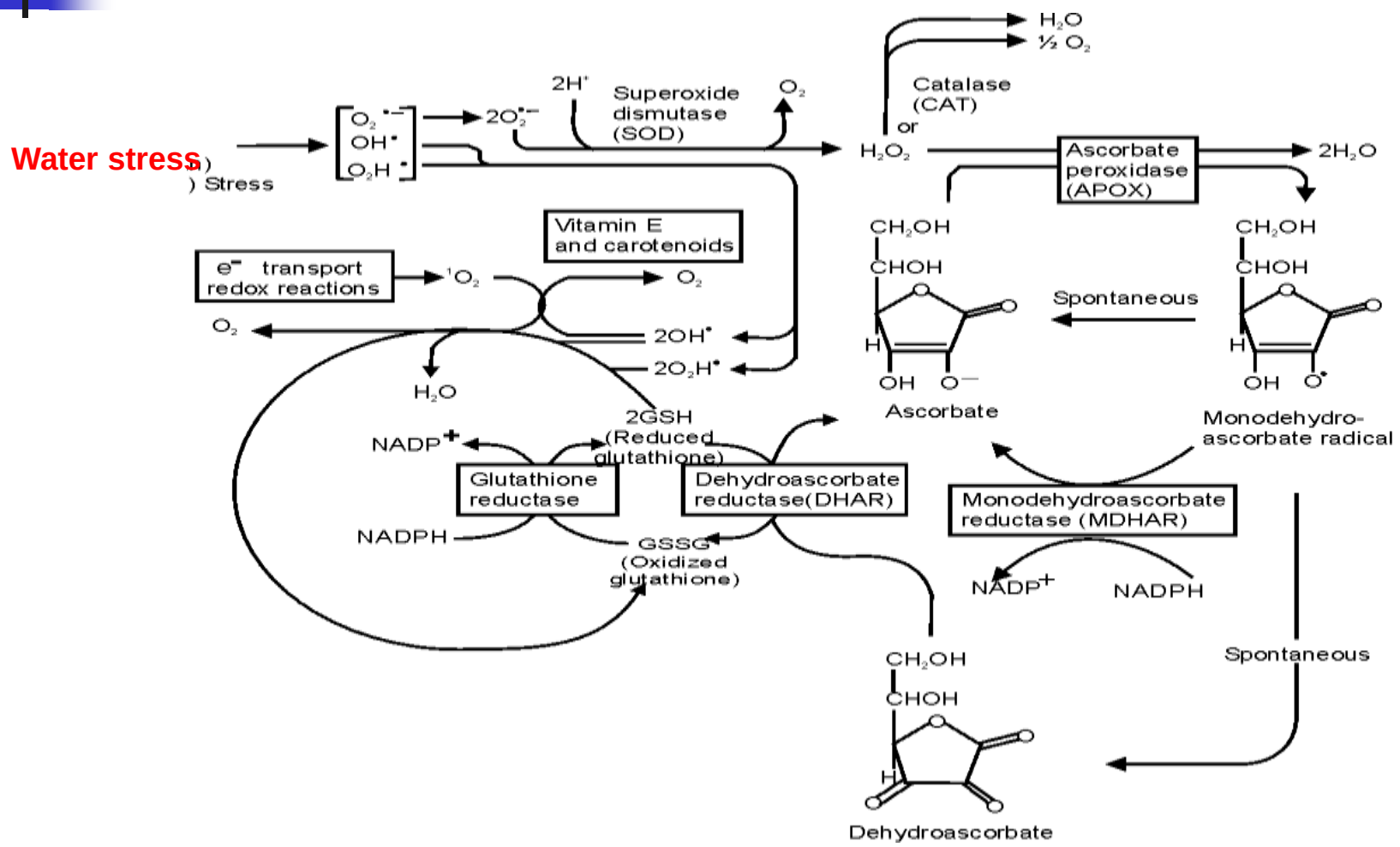
Role of Antioxidant system in water stress management

- Abiotic stress – drought, salt, chill- increases reactive O intermediates (ROI) in plants
- ROI- stress signal- due to altered metabolic functions of chloroplast, mitochondria

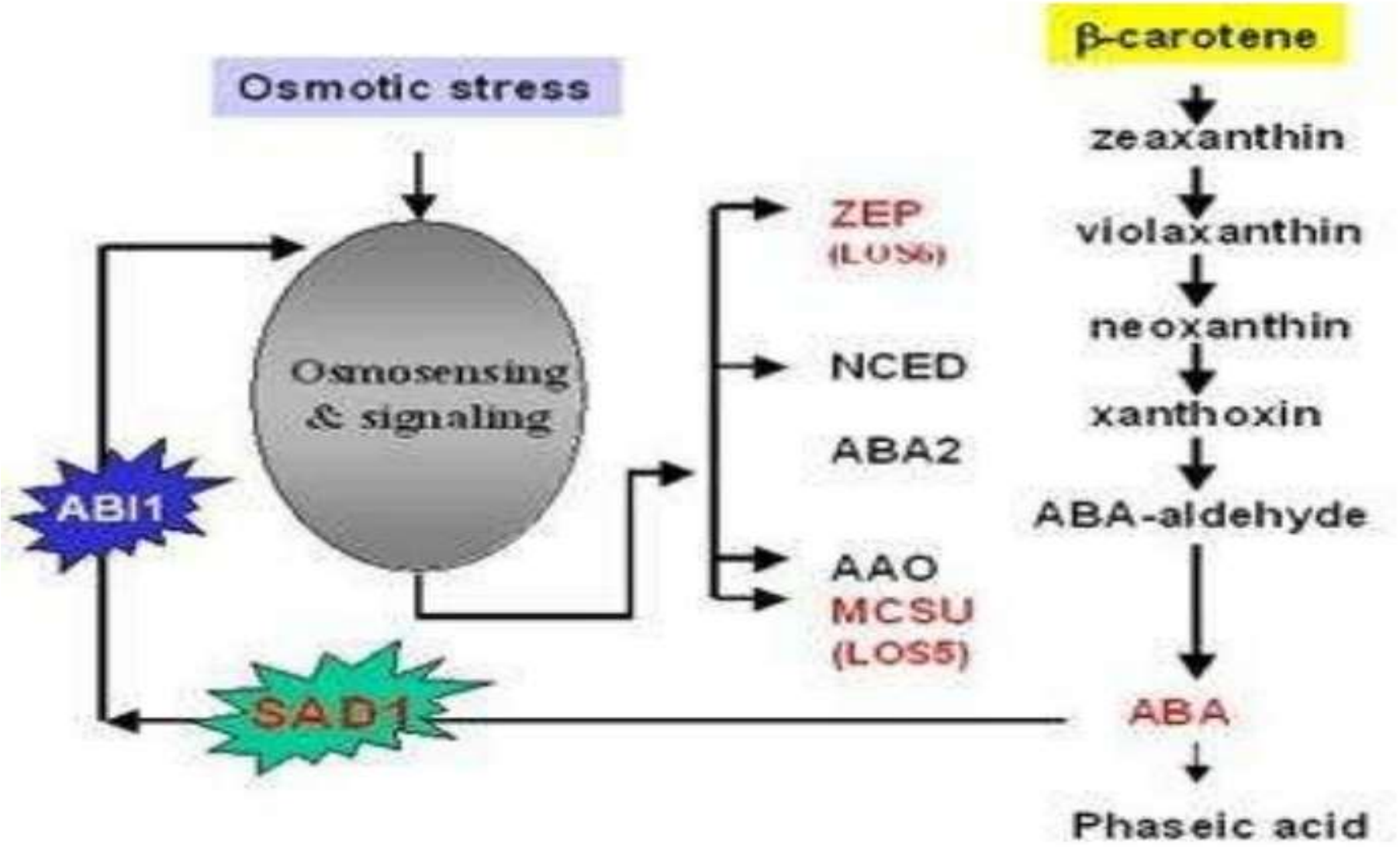
ROI SCAVENGING

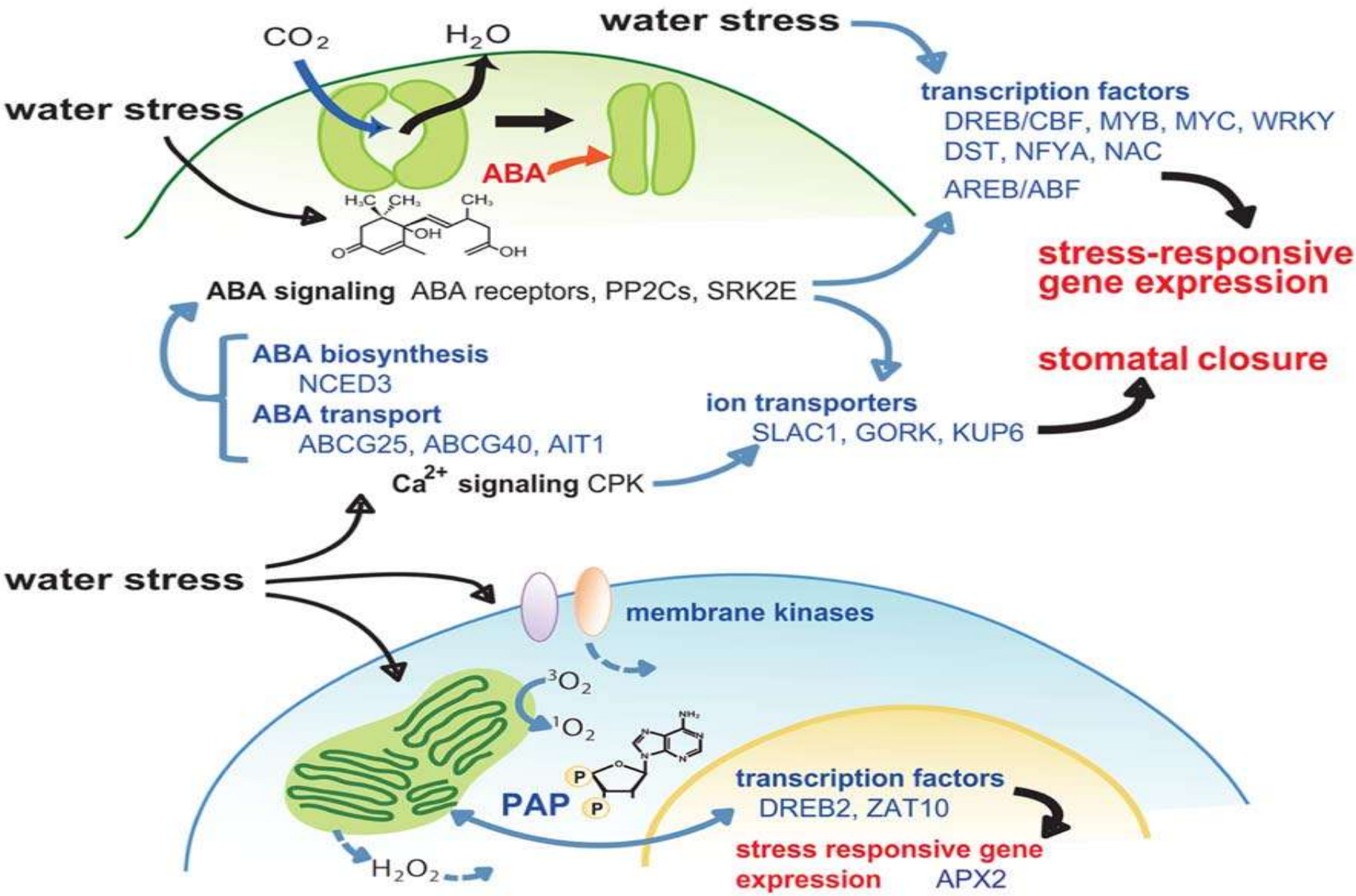
Antioxidant system contains a battery of enzymes that scavenge ROI- SOD, peroxidases, catalases, glutathione reductases

Asada - Halliwell pathway



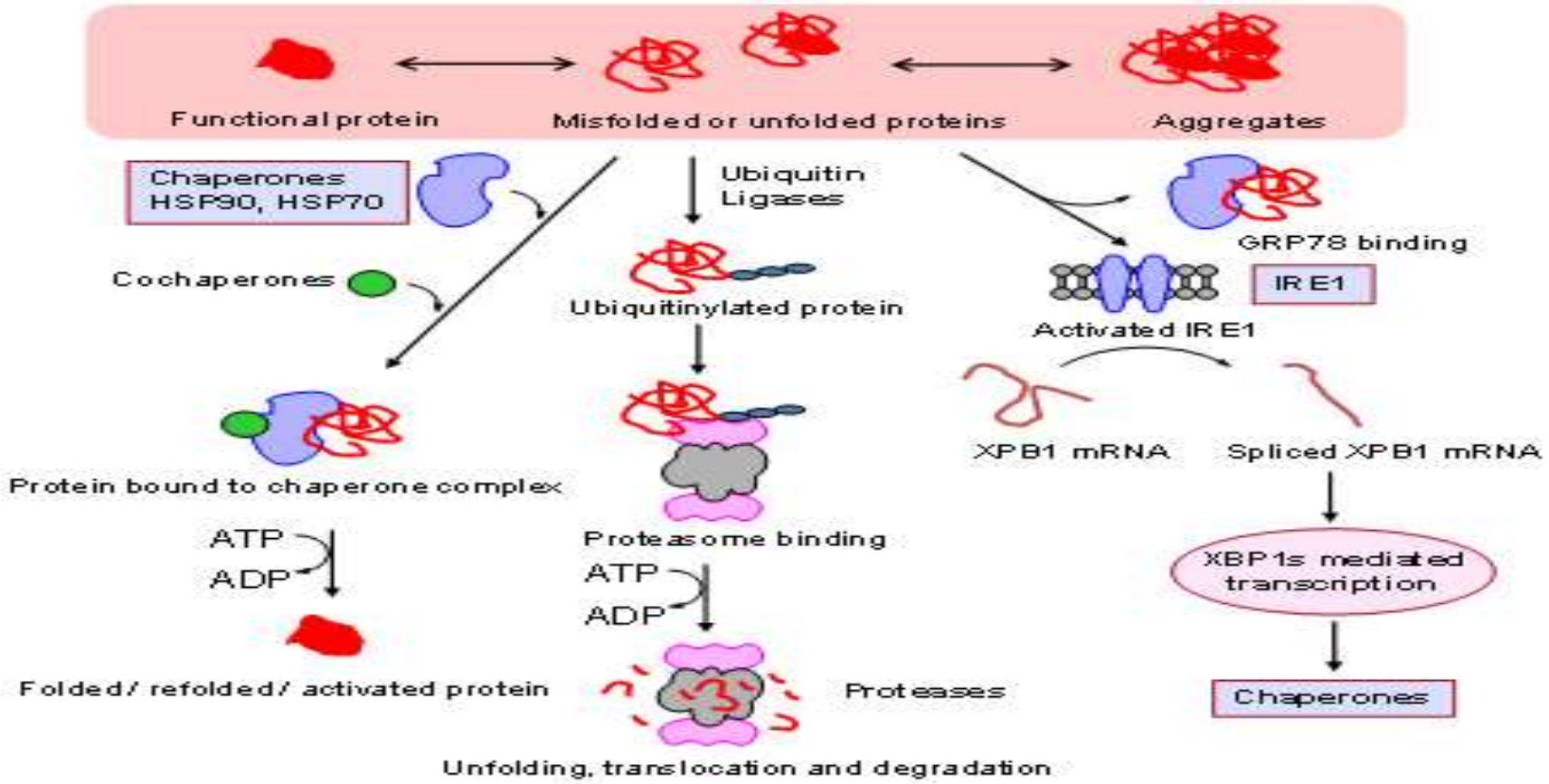
Role of ABA in water stress management





Source: Buttery *et al.*, 1993, Plant and Soil 149: 283-288

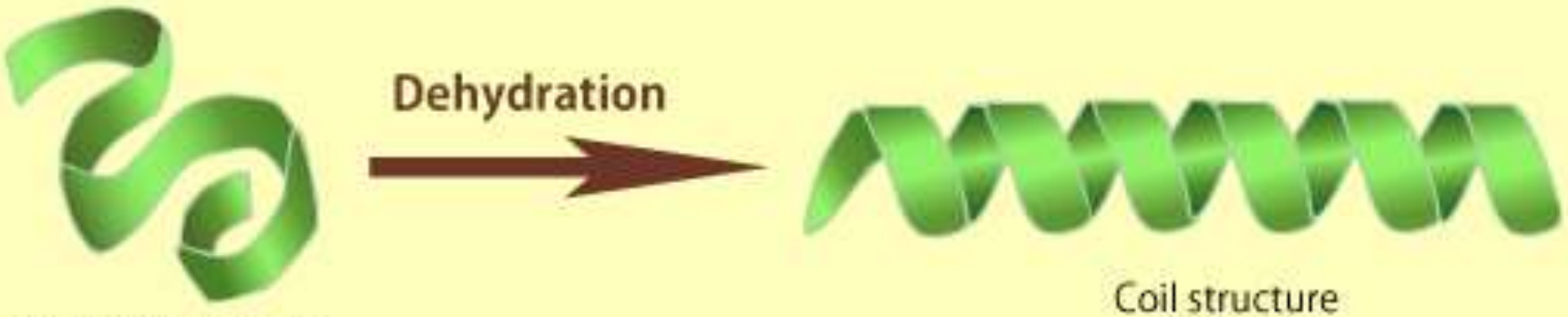
Role of Chaperones/ Heat shock proteins (HSP)



Role of Late embryogenesis abundant (LEA) proteins

The characteristics of LEA proteins

- Classifid in Groups 1~6 by primary structure and the differences of the expression pattern.
- Highly hydrophilic.
- Suppress the aggregation of proteins during dehydration and salt stress.
- In the prosess of dehydration, LEA proteins form the coil structure of α -helix.



Conclusion

- Water stress adversely impacts many aspects of the physiology of plants, especially photosynthetic capacity.
- An understanding of complex physiological and biochemical adaptations adopted by plants to ameliorate the impact of water stress on plant productivity will provide the information needed to improve plant stress tolerance using biotechnology, while maintaining the yield and quality of crops

REFERENCES

- Bohnert, H.J. and Jensen, R.G. (1996). Strategies for engineering water-stress tolerance in plants. Trends in Biotechnology. **14(3):** 89-97.
- Chen, T.H., and Murata, N. (2008). Glycinebetaine: an effective protectant against abiotic stress in plants. Trends in Plant Scinces. **13(9):** 499-505
- Buttery, B.R., Tan, C.S., Buzzell, R.I., Gaynor, J.D. and Mac Tavish, D.C. (1993). Stomatal numbers of soybean and response to water stress. Plant and Soil. **149:**283-288
- Osakabe, Y., Osakabe, K., Shinozaki, K. and Tran L.S. (2014) Response of plants to water stress. Frontiers in Plant Science. **5:** 86- 93


THANK YOU