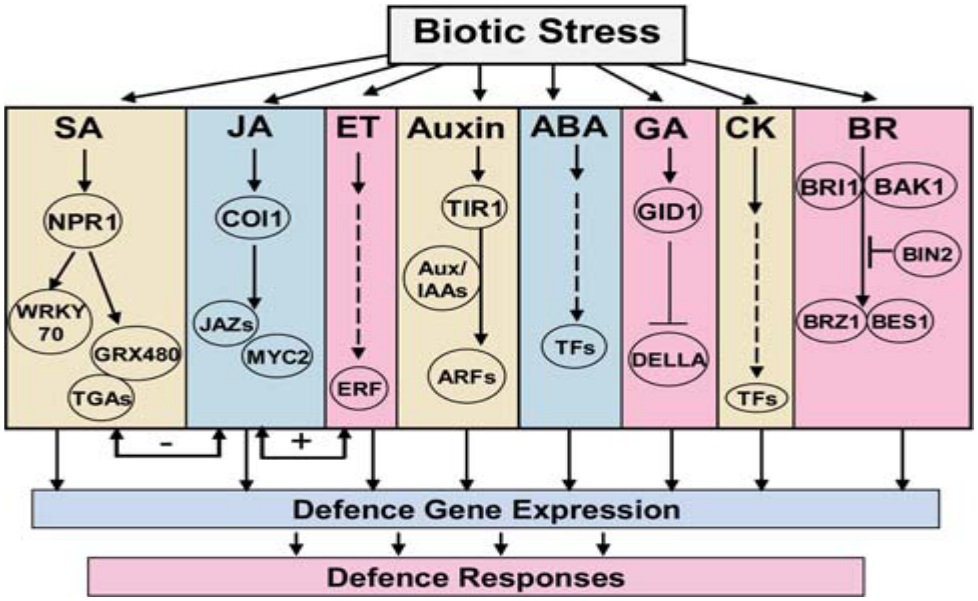
Brassinosteroids mediated stress responses in plants

Presented by
Dr. Nitika Kapoor

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

Hormones involved in plant defence responses

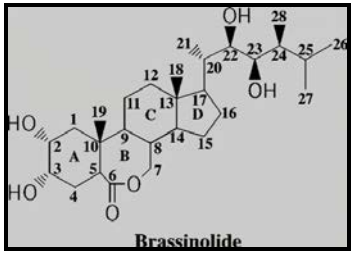
- Phytohormones play important role in diverse growth and developmental processes as well as biotic and abiotic stress responses.
- These hormones include:
- Auxin
- Gibberellins
- Abscisic acid
- Cytokinins
- Salicylic acid
- Ethylene
- Jasmonates
- **Brassinosteroids**



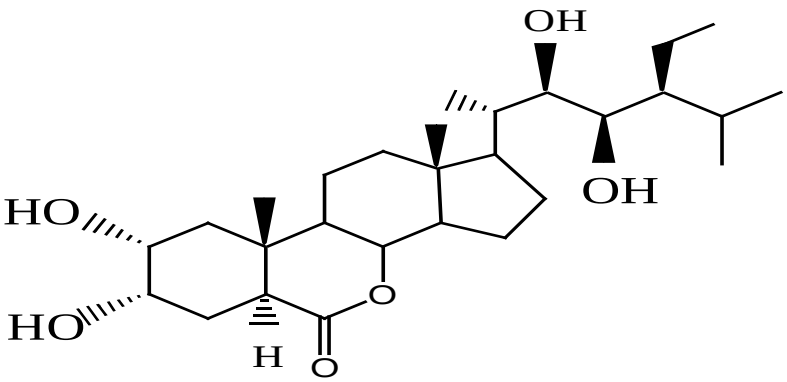
Gomez-Roldan *et al.* 2008

Umehara *et al.* 2008

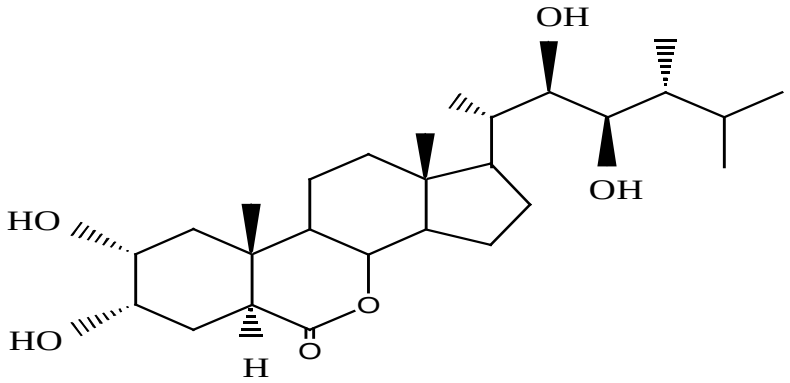
Brassinosteroids



- **Brassinosteroids (BRs) are hydroxylated derivatives of cholestane, which play an essential role in plant growth and development by influencing various physiological responses in plants (Bajguz and Tretyn, 2003).**



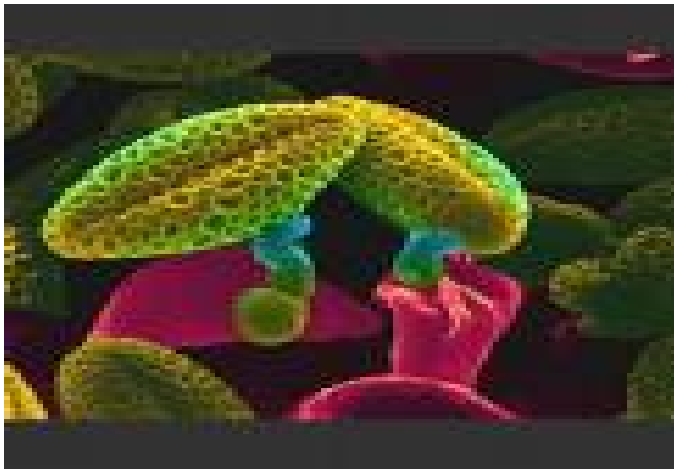
28-homobrassinolide (28-homoBL)



24-epibrassinolide (24-epiBL)

History

- Oily extract from pollen of rape caused extreme elongation of the internodes of pinto beans. (Mitchell *et al*., 1970)
- active compounds were called *Brassins.*
- 227kg of rape pollen was extracted, fractionated with activity tests at each step.
- 4mg of crystals was obtained from the 40kg of pollen and the active compound was identified as Brassinolide (Grove *et al*., 1979)
- First plant hormonal steroid discovered.



Distribution of BRs

- BRs are regarded as ubiquitous in plant kingdom.
- About 70 BR have been isolated from 60 plants species i.e.

  - 51 angiosperms
  - 6 gymnosperms
  - 1 pteridophyte
  - 1 bryophyte
  - 1 algae.

Distribution of brassinosteroids in the plant kingdom

Plant part	Plant species
Pollen	*Helianthus annuus*, *Alnus glutinosa*, *Brassica napus*, *Robinia pseudo-acacia*, *Vicia faba*, *Fagopyrum esculentum*, *Citrus unshiu*, *Citrus sinensis*, *Cupresus arizonica*, *Pinus thunbergii*, *Cryptimeria japonica*
Seed	*Gypsophili perfoliata*, *Beta vulgaris*, *Pharbitis purpurea*, *Brassica campestris*, *Raphanus sativus*, *Cassia tora*, *Lablab purpreus*, *Orinthopus sativus*, *Phaseolus vulgaris*, *Pisum sativum*, *Vicia faba*, *Cannabinus sativa*, *Apium graveolens*
Shoot	*Arabidopsis thaliana*, *Ornithopus sativus*, *Pisum sativum*, *Lycopersicon esculentum*
Leaf	*Castanea crenata*, *Distylium recemosus*, *Thea sinensis*
Others	
Cultured cell	*Catharanthus roseus*
Panicle	*Rheum rhabarum*
Cambial region	*Cryptomeria japonica*
Gall	*Castanea crenata*
Strobilus	*Equisetum arvense*
Thallus	*Hydrodictyon reticulatum*

Rao *et al.* (2002) Current Science. 82(10)1239-1245

Physiological effects of Brassinosteroids in plants

At Whole Plant Level:

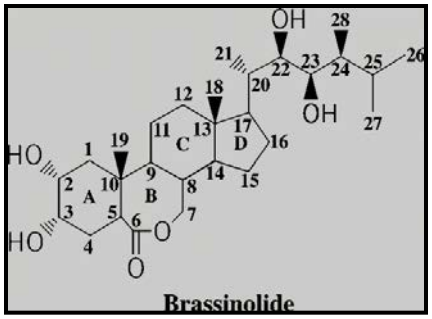
- Growth promotion
- Increase in success of fertilization
- Shortening the period of vegetative growth
- Effect on content of nutritive components and fruit quality improvement
- Crop yield increase
- Increased resistance to unfavorable environmental factors, stress and diseases

At cellular level:

- Stimulation of elongation and fission.
- Effect on hormonal balance.
- Effect on enzyme activity.
- Activation of protein and nucleic acid synthesis.
- Effect on fatty acid composition and on the properties of membranes.
- Enhancement of photosynthetic capacity and translocation of products.

Khripach *et al.* (2000) *Annals of Botany* 86: 441- 447

Brassinosteroids and stress management



One of the most important role of BRs is their ability to confer resistance to plants against various abiotic/biotic stresses like:

- **Water stress (Kagale *et al.*, 2007; Upreti & Murti,2004)**
- **Thermal stress (Dhaubhadel *et al.*, 2002)**
- **Salt stress (Ozdemir *et al.*, 2004; Arora *et al.*,*2008*)**
- **Heavy metal stress (Bajguz, 2002; Sharma and Bhardwaj, 2007; Arora *et al.*, 2008)**
- **Pesticide stress (Xia *et al.*, 2006)**
- **Pathogen attack such as fungi, bacteria, viruses etc. (Nakashita *et al.*, 2003; Wachsman *et al.*, 2004; Michelini *et al.*, 2008)**

STRESS

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

Types of stresses:

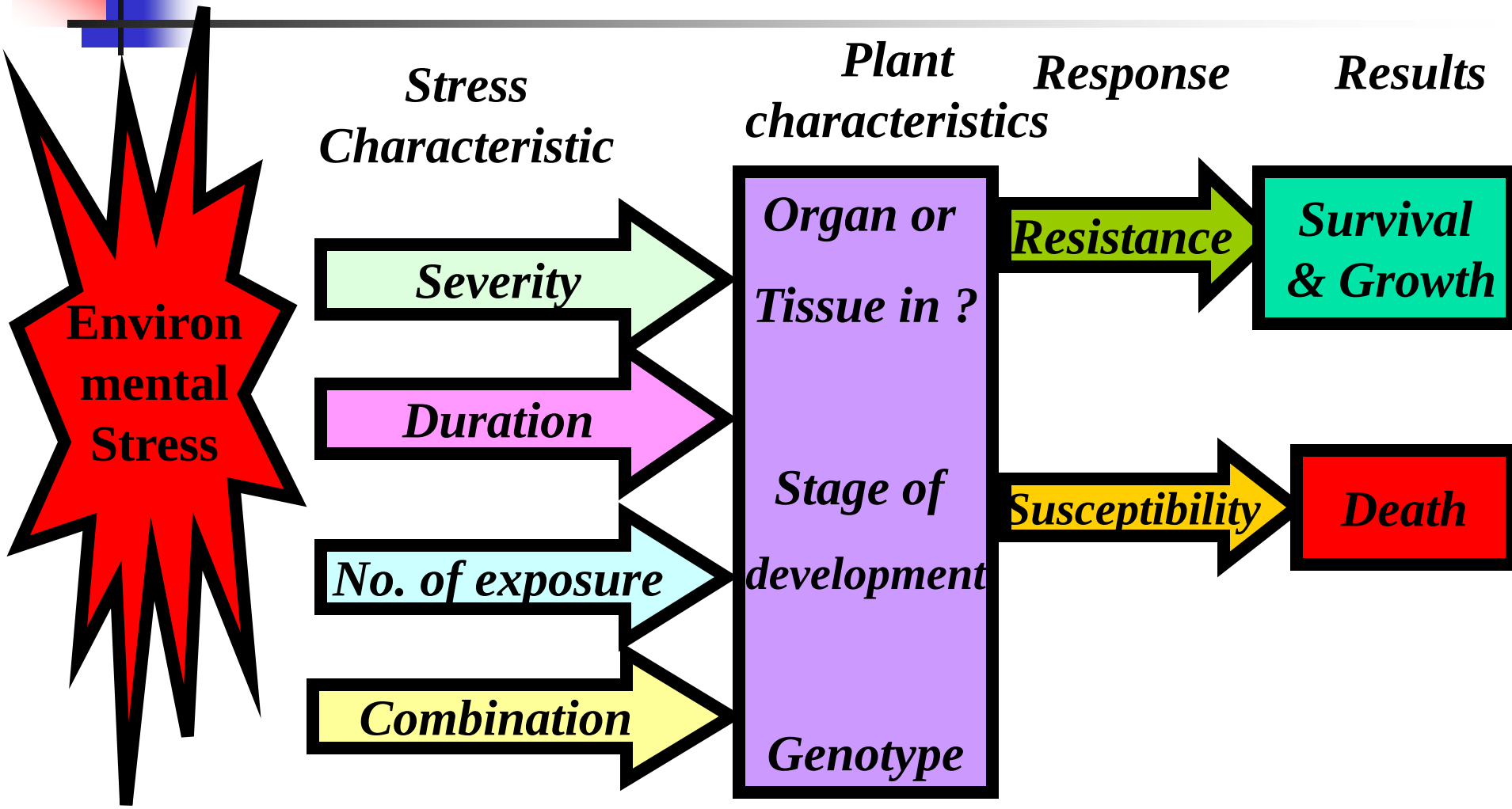
- **Abiotic Stresses**
- **Biotic Stresses**

Types of stresses

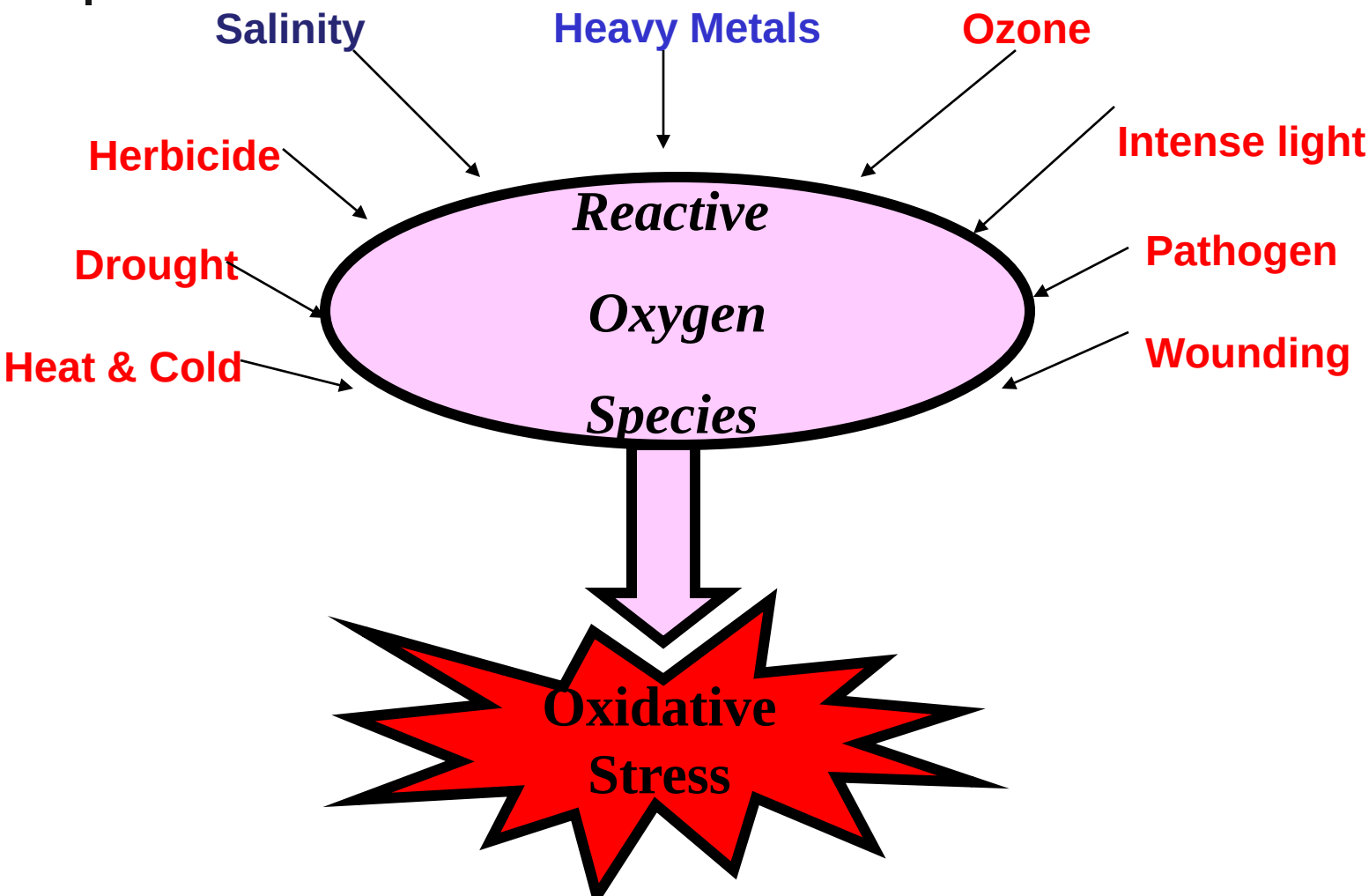
Abiotic Stresses: Arising from an excess or deficit in physiological or chemical environment.

- 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 increase the Production of ROS in plant cells



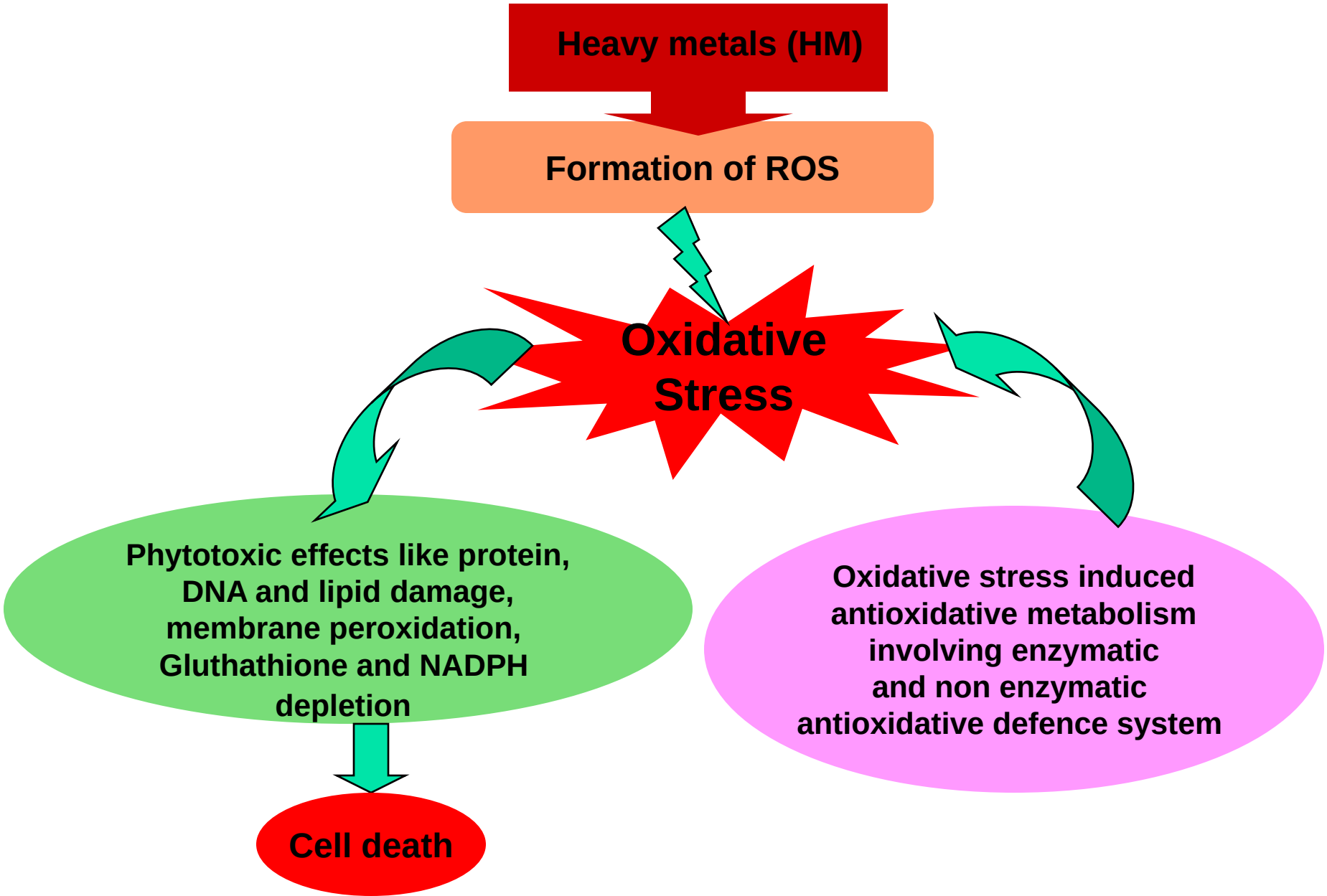
Heavy metal Stress

- **Heavy metals are those which have density more than 5 g cm^{-3}.**
- **Zn – 7.1 g cm^{-3}**
- **Cr – 7.2 g cm^{-3}**
- **Ni – 8.7g cm^{-3}**
- **Cu – 8.9 g cm^{-3}**
- **essential as micronutrients for plants**
- **but toxic at higher concentration**

Heavy Metal Stress

- **affect growth , development and metabolism**
- **induction of oxidative damage due to the production of reactive oxygen species (ROS)**
- **ROS ($O_2^{\cdot -}$,H_2O_2,$OH^{\cdot}$ and $RO^{\cdot}$)**
  - **initiate lipid peroxidation**
  - **degrade proteins, lipids and nucleic acids**

Heavy metal induced oxidative stress and related cellular damage in plants

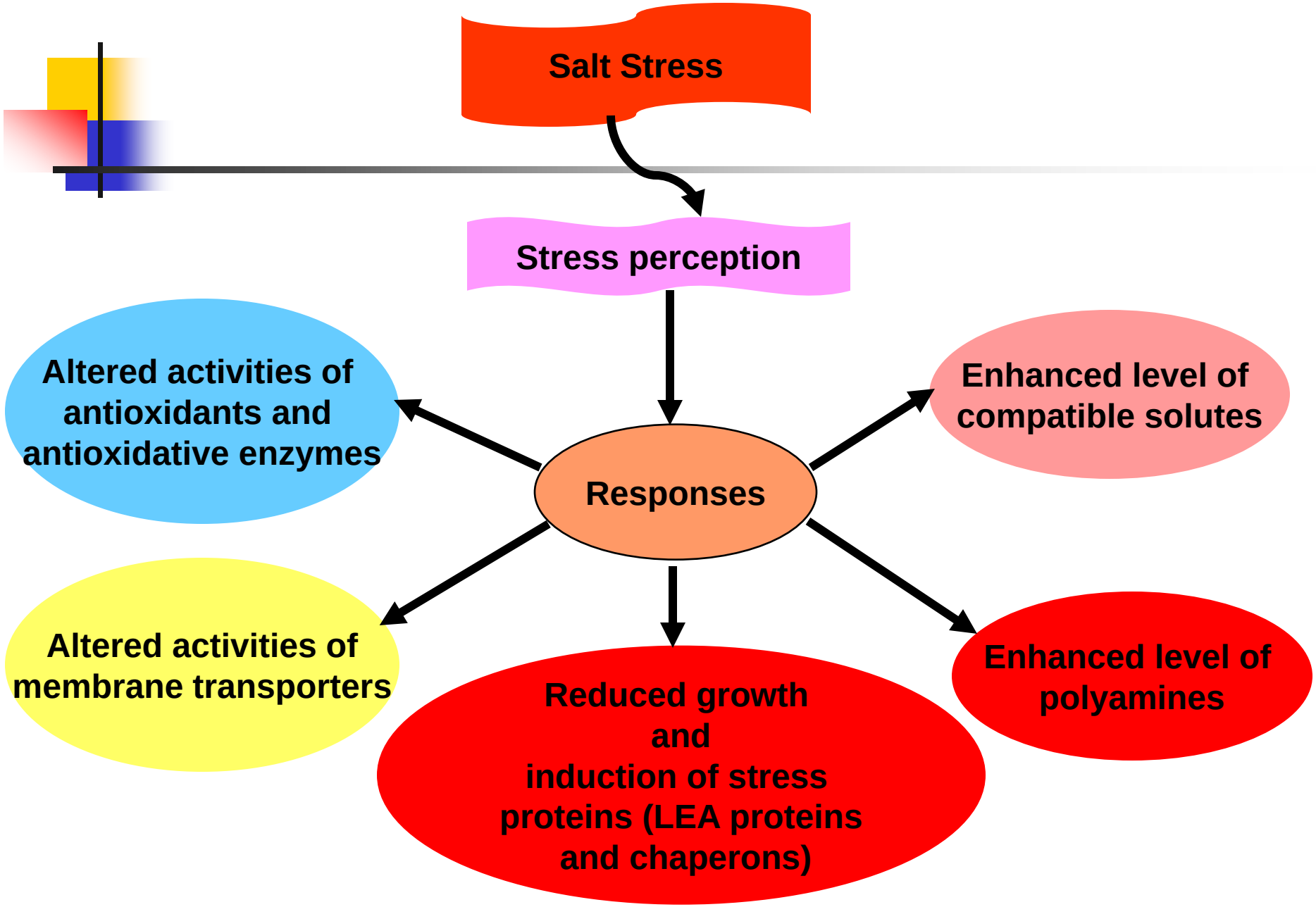


Salt Stress

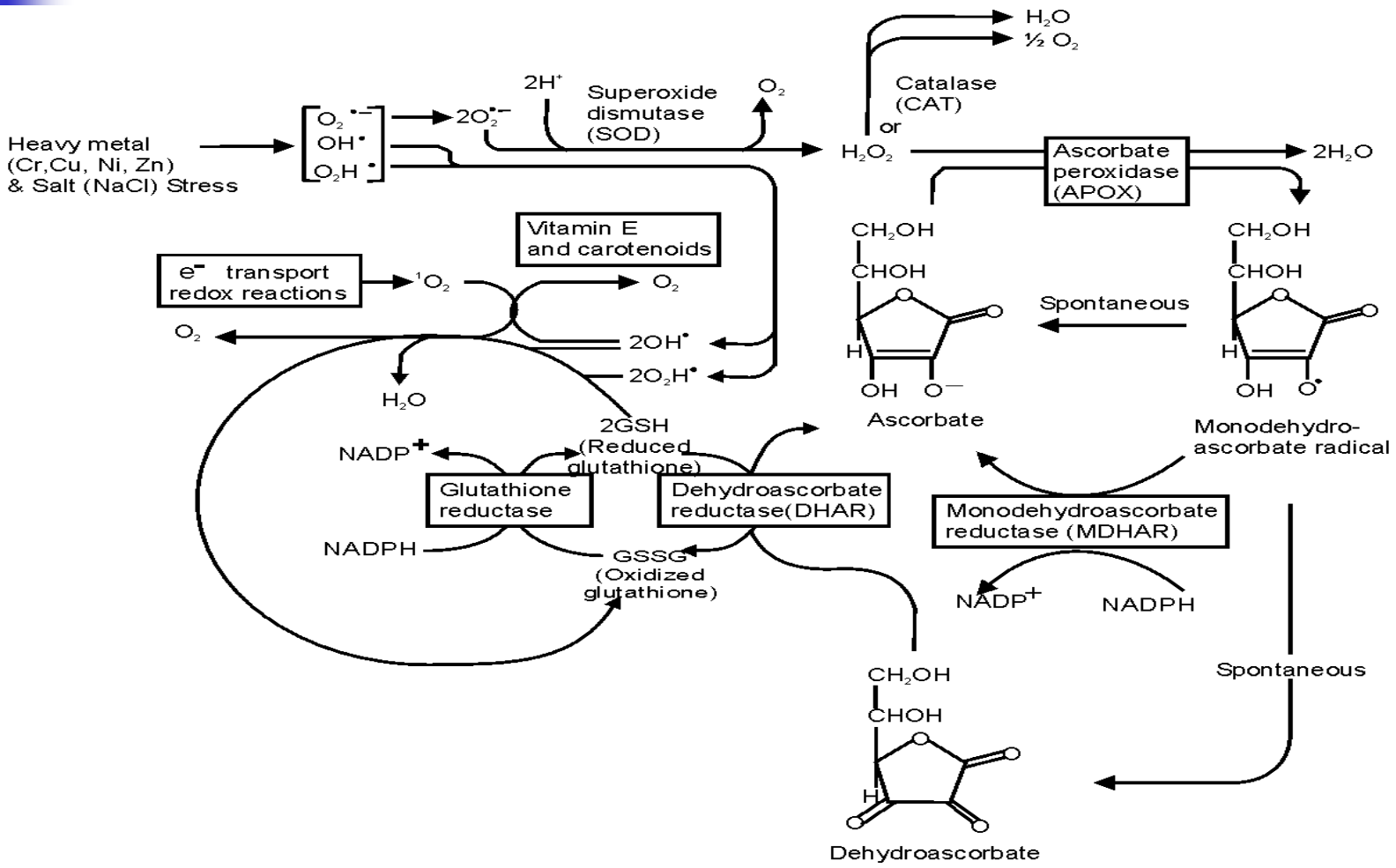
- **Major abiotic stress to plants**
- **Adversely affects various physiological parameters**
- **Reduces plant productivity**
- **Cause inhibition in plant growth by affecting water absorption, biochemical processes**
- **Increases energy loses for salt exclusion mechanisms there by resulting decreased nutrient uptake**
- **Exerts oxidative stress due to the production of reactive oxygen species (ROS)**

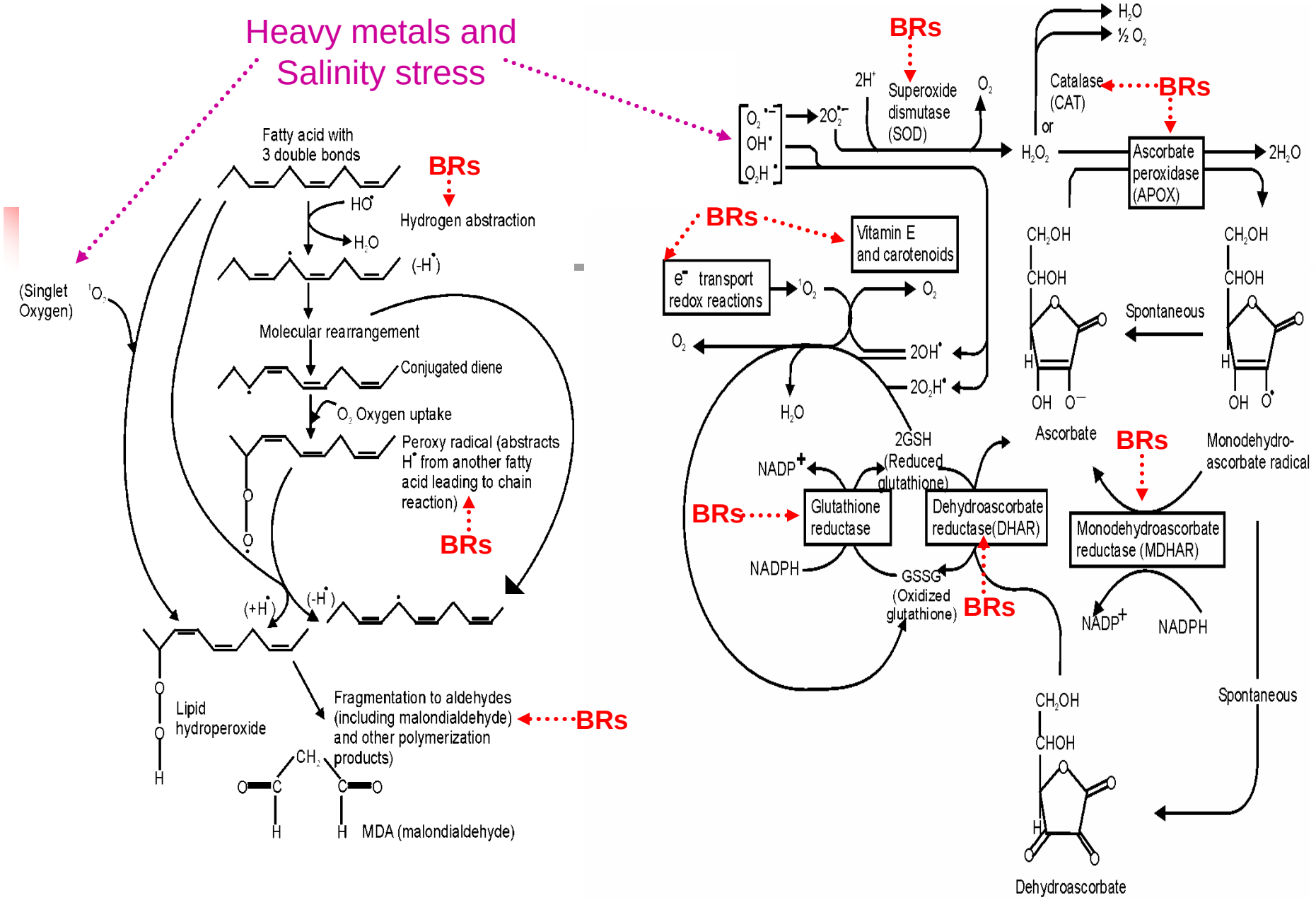
  (Sairam and Tyagi, 2004; Manchanda and Garg, 2008)

Salinity Stress and plant responses



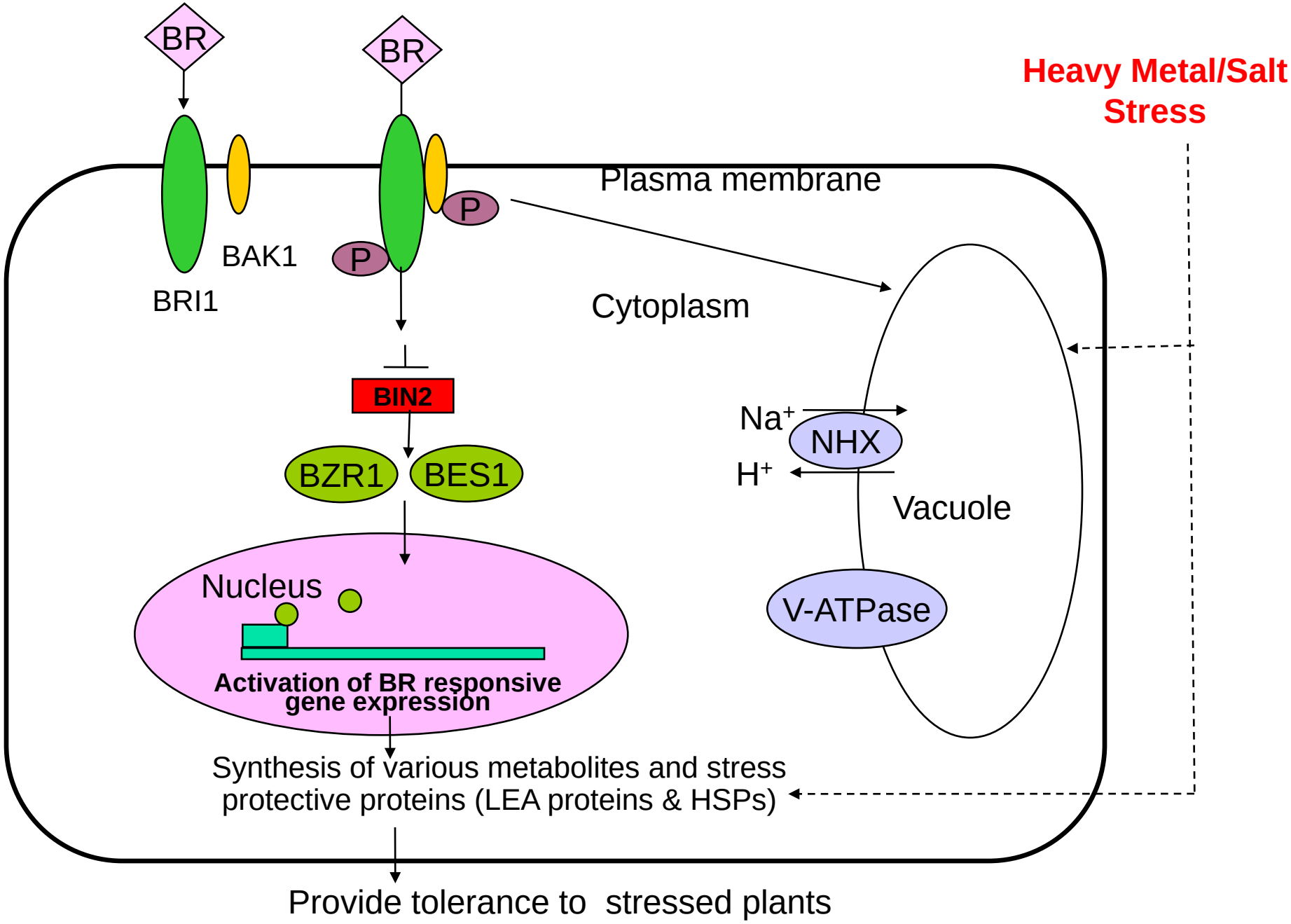
Asada - Halliwell pathway





BRs regulated lipid peroxidation and Asada Halliwell pathway

Possible mode of action of BRs under stressed conditions in plants



Conclusion

- **BRs have potential to act stress protectant when applied at appropriate dose and at correct stage of plant development.**
- **The stress protective action of BRs is the result of a complex sequence of biochemical shifts such as activation or suppression of key enzymatic reactions, induction of protein synthesis and production of various defence related compounds**
- **So these stress protective properties of BRs are promising from practical point of view. They provide new insights for plant protection, based on the employment of very small amounts of eco-friendly natural substances.**

THANK YOU