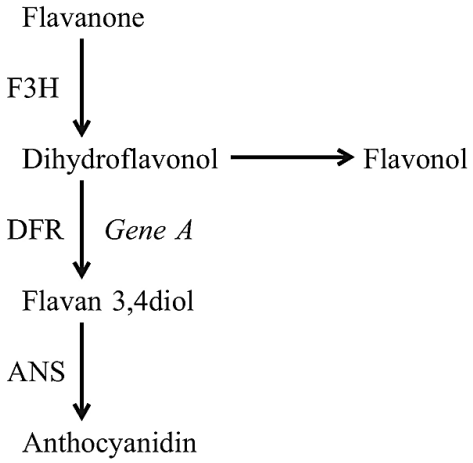
Moondust Carnations

- Rose, Chrysanthemum and carnations (*Dianthus caryophyllus*) are economically important flowers. Transgenic Technology has been used for protection of new varieties of ornamental plants and flowers moondust carnations are the first genetically modified flowers produced in the world and commercially sold. Traditional breeding techniques cannot produce flowers with colours which do not occur in nature.
- Pigments Specially flavonoids and carotenoids impart colour to flowers and fruits. flavonoids are responsible for bright yellow orange colour while flavonoids impart red pink and blue colours.
- Anthocyanin are the most important group of flavonoids which are responsible for imparting blue to violet colour to the flowers, fruits leaves.
- There are different kinds of anthocyanins example
  - cyanidin Is present in Apple, Cherry, fig
  - Delphinidin is present in pomegranate, eggplant
- Many ornamental plants like Petunia and Dianthus contain only one main type of anthocyanin in which is the delphinidin. It imparts purple, and blue colour to the flowers. flavonoid 3'5'- hydroxylase catalyzes the production of blue colored anthocyanin pigment delphinidin and its derivatives.
- This gene is absent in roses and carnations. Therefore blue colored roses and carnations cannot be produced by traditional breeding .
- A team from an Australian company Florigene isolated this gene F3'5'H (flavonoid 3'5"-hydroxylase) gene from Petunia in 1991.They first tried producing blue rose but somehow the gene didn't express in rose
- Then they over expressed the gene in carnation under control of constitutive promoter. In 1996, Florigene developed mauve-coloured carnation, FLORIGENE Moondust and it was the world's first genetically modified flower on sale. These had very marginal color change towards blue

- In 1997, developed second genetically-modified carnation, FLORIGENE Moonglow with a richer and true purple colour. To produce this, it was important to reduce competition between two endogenous enzymes of anthocyanin pathway ie. DFR pathway (dihydroflavonol-4-reductase) and flavonoid 3' hydroxylase (F3'H) gene



- Colorless carnation varieties were selected (which were deficient in DFR gene)
- 2 genes inserted

1. Petunia F 3'5' H gene under control of snapdragon CHS promoter
2. Petunia DFR gene under constitutive promoter

These two combined effect resulted in accumulation of delphinidin derivatives and deeper color in carnations. This variety was given trae name Moonglow

- Moondust are lilac (mauve) in color and moon glow in deeper shades of purple and blue
- These genetically modified ornamentals pose no threat to the environment as 1. they are not related to any weed species

2 Carnation varieties are infertile as seed setting doesn't take place.

3 Carnation pollen is heavy, sticky and is deep inside flowers so not spread by bees or wind

Abiotic stress resistant plants

Abiotic stress like drought, temperature, salinity and metal toxicity etc. adversely affect plant growth and productivity worldwide. They are also serious threats to agriculture resulting in deterioration of environment. They induce a series of biochemical, physiological, morphological and molecular changes in plants. When a plant is exposed to any abiotic stress a number of genes get activated, altering the level of proteins, some of which provide protection to these stresses.

Role of Biotechnology in Agriculture

Efforts have been made to produce stress tolerant transgenic crops using genes which can alter the specific biosynthetic pathways.

Different types of abiotic stresses.

- High Temperature (Heat)
- Low Temperature (Chilling and freezing)
- Excess water (Flooding and Anoxia)
- Salinity (Salt stress)
- Radiation (Visible, UV Radiation)
- Chemical (Pesticides, Heavy Metals and air pollutants)

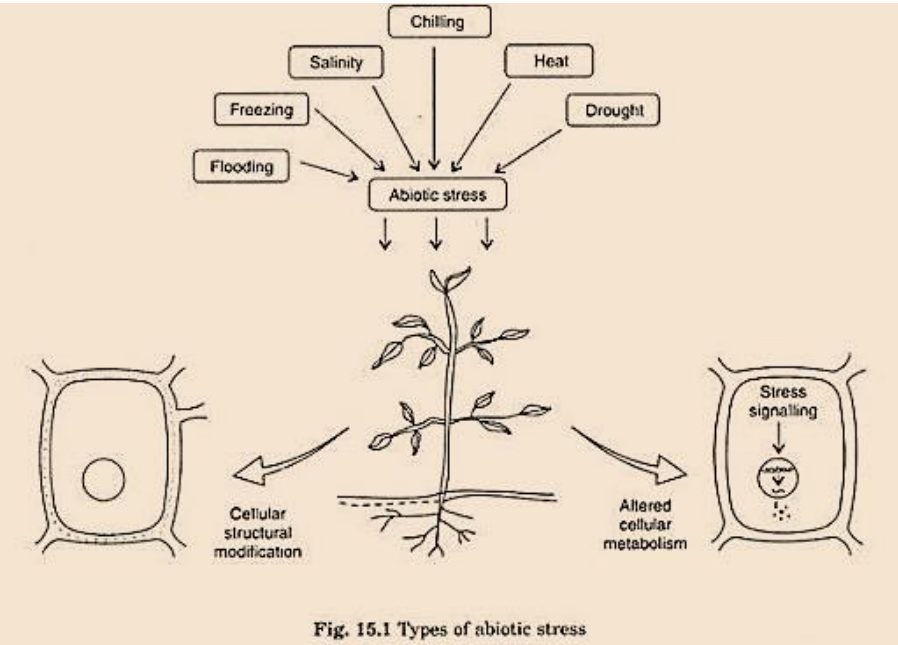


Fig. 15.1 Types of abiotic stress

A large number of genes provide resistance against abiotic stresses :

(i) Genes having enzymatic or structural functions

- Decreasing sensitivity to stress as in the case of salt tolerance through osmolyte protection and cold tolerance by polysaturated fatty acids.

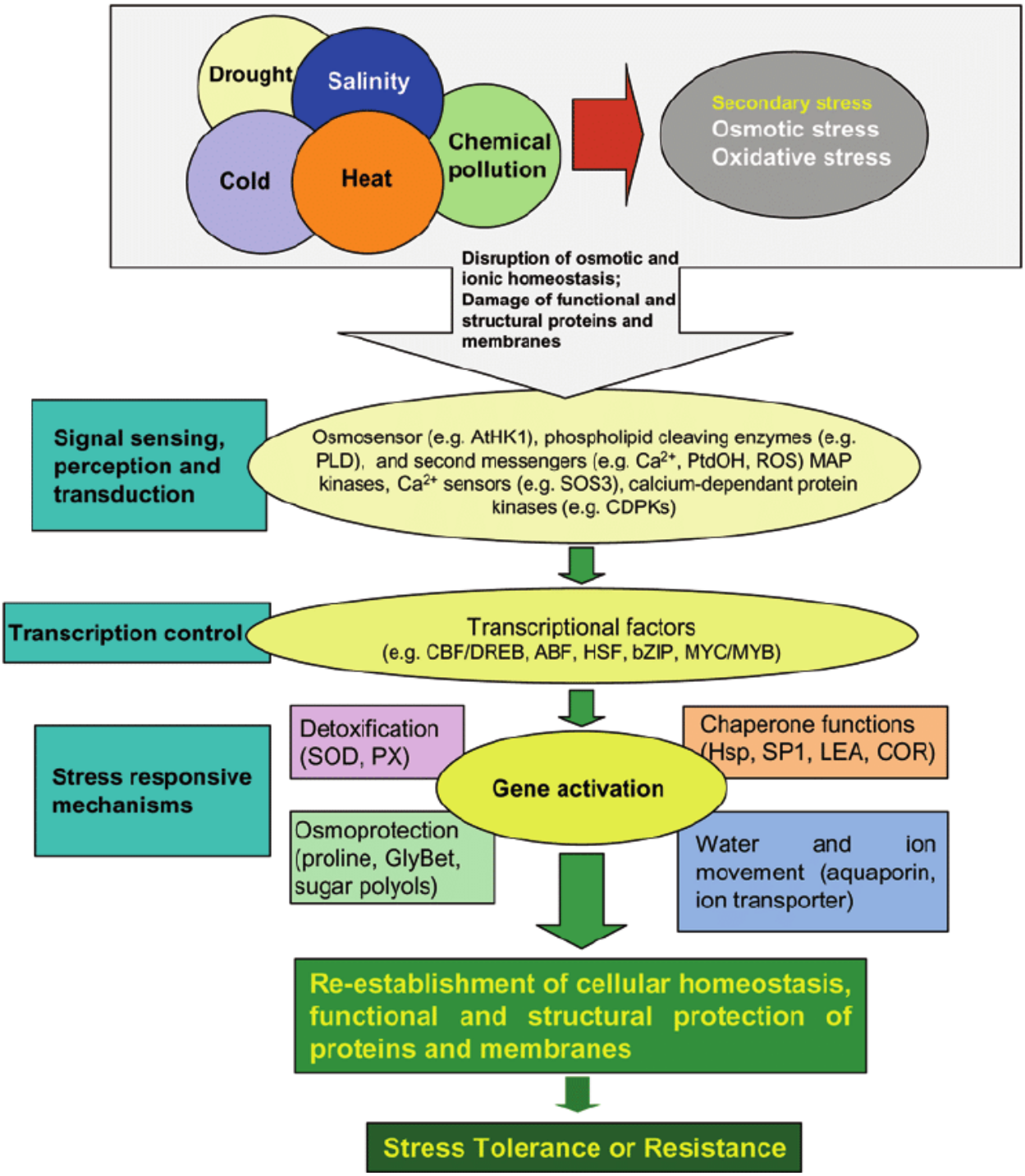
- The genes for production of osmoprotectants have been introduced by genetic engineering . These genes code for Osmoprotectants. These are a group of compounds which get accumulated in response to abiotic stresses and help in tolerance of abiotic stress eg these proline, glycine betaine and sugar alcohols. Accumulation of these molecules helps to Retain water within cells and protects cellular compartments from injury caused by dehydration, Maintains turgor pressure during water stress
- Protection from oxidative stress by superoxide dismutase (SOD): Scavenge reactive oxygen species

- Insertion of genes for Late embryogenesis abundant proteins (LEAs), antifreeze proteins, chaperones and detoxifying enzymes which protect cells from dehydration.
  - LEA proteins play a role in desiccation tolerance during seed development and in response to dehydration, salinity and cold stress by acting as chaperone.
  - Genetic Engineering of molecular Chaperones assist and maintain in correct folding and trafficking of cell proteins, to survive in abiotic stresses E.g: HSP70 family in Arabidopsis plants has been linked with thermotolerance

(ii) **Regulatory proteins:**

Stress inducible promoter or transcription factor, increasing tolerance for multiple stresses. For example, Dehydration response element (DRE) is a promoter element which regulates the gene expression in response totemperature, drought and salinity.

- By over expressing a single stress-inducible transcription factor (DREB1A), lead to plant tolerance to freezing, salinity and dehydration
- Arabidopsis transformation with DREB1A gene driven by a DRE- containing promoter resulted in a marked increase in tolerance to freezing,


Drought
Salinity
Cold
Heat
Chemical pollution
Secondary stress
Osmotic stress
Oxidative stress
Disruption of osmotic and ionic homeostasis; Damage of functional and structural proteins and membranes
Signal sensing, perception and transduction
Osmosensor (e.g. AtHK1), phospholipid cleaving enzymes (e.g. PLD), and second messengers (e.g. Ca2+, PtdOH, ROS) MAP kinases, Ca2+ sensors (e.g. SOS3), calcium-dependant protein kinases (e.g. CDPKs)
Transcription control
Transcriptional factors
(e.g. CBF/DREB, ABF, HSF, bZIP, MYC/MYB)
Stress responsive mechanisms
Detoxification (SOD, PX)
Chaperone functions (Hsp, SP1, LEA, COR)
Gene activation
Osmoprotection (proline, GlyBet, sugar polyols)
Water and ion movement (aquaporin, ion transporter)
Re-establishment of cellular homeostasis, functional and structural protection of proteins and membranes
Stress Tolerance or Resistance