

## **PLANT STRESS PHYSIOLOGY**

HEAVY METAL STRESS

# HEAVY METALS

- **Definition**

Elements (other than alkalis and alkaline earths) with an atomic number greater than 20 are referred to as heavy metals.

Most representative are: lead, mercury, zinc, copper, nickel, cadmium, chromium, selenium, etc.

- **How do they enter the plant body?**

Despite the selectivity of plant absorption mechanisms of the root system, the predominance of high concentrations of heavy metals in the soil results in their inevitable entry into the cells.

# HEAVY METALS

- **Heavy metals accumulate**

Heavy metals not only have the ability to accumulate in organisms and enter the food chain, but remain in toxic concentrations in the soil for long periods of time.

- **Their extent in space intensifies over time**

High concentrations of heavy metals are limited to certain areas only. However, the widespread accumulation of heavy metals in cultivated and non-cultivated soils is now a significant side effect of industrial activity due to waste from mines, various industries and precipitations of gaseous pollutants.

# HEAVY METALS

- **Using plants as biomarkers**

Some biomarkers plants can be used to detect the presence of heavy metals in the soil.

- **Some plants show significant tolerance**

These are metalophytes that choose the strategy of resistance. They absorb high concentrations of heavy metals but are equipped with efficient isolation mechanisms.

# HEAVY METALS

plant organ	zinc intercellular distribution (%)		
	vacuole, cytoplasm	cellular organelles	cell wall
	<i>Cardaminopsis halleri</i>		
leaf	82	6	12
root	38	5	57
	<i>Sillene vulgaris</i>		
leaf	64	10	26
root	18	10	72
	<i>Minuartia verna</i>		
leaf	46	8	46
root	20	8	72

# HEAVY METALS

- **Heavy metals cause metabolic disorders in plants**
  1. Transport perturbations such as those of calcium, magnesium, nitrate and potassium ions through membranes
  2. Inhibition of electron transfer during photosynthesis and respiration
  3. Irreversible inhibition of enzyme function

## TWO STRATEGIES CAN BE DISTINGUISHED

- **Avoidance**

Plants that have chosen the avoidance strategy have appropriate mechanisms to exclude heavy metals in the external environment.

One mechanism is the excretion of chelating agents from the root cells to the rhizosphere.

Alternatively, some plants have high selectivity membranes in the root cells to prevent the entry of heavy metals.

Finally, in some plants, the minerals are trapped in the cell walls of the root tissues (mainly in the pectin fraction).

## TWO STRATEGIES CAN BE DISTINGUISHED

- **Resistance**

Plants that have chosen the strategy of resistance absorb high concentrations of heavy metals in their cells.

The tolerance of plant-accumulators consists in mechanisms of binding and neutralization of toxic metals by specialized cell molecules.

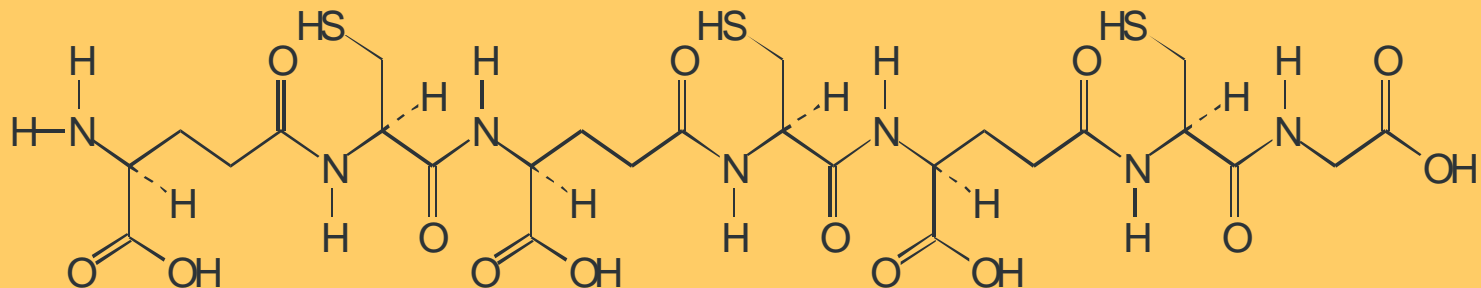
a. Some plants bind heavy metals in the form of complexes with low molecular weight organic molecules such as organic acids, amino acids or phenolic components. These complexes are isolated in the vacuole.



# TWO STRATEGIES CAN BE DISTINGUISHED

- **Resistance**

b. Some plants carry heavy metals to the vacuole in the form of complexes with phytochelatin (unusual sulfur-rich peptides, most likely glutathione derivatives). Phytochelatin is produced from phytochelatin synthase and has the general formula  $(\gamma\text{-glutamine-cysteine})_n\text{-glycine}$  with  $n = 2-8$ .



## TWO STRATEGIES CAN BE DISTINGUISHED

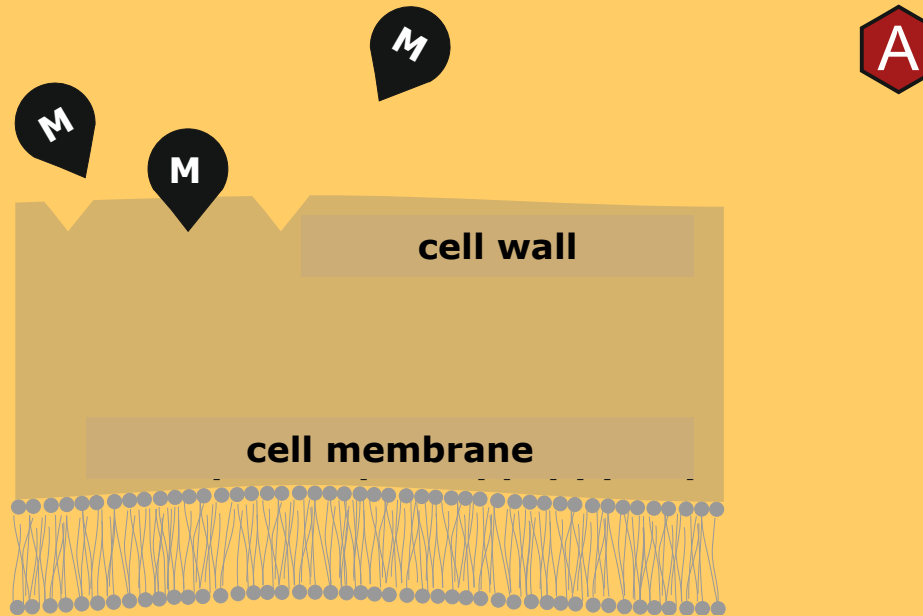
- **Resistance**

Phytochelatins are detected in tissues only in the presence of toxic levels of heavy metals. Therefore their presence is a result of acclimation.

c. In some plants there is an active transport of ions from the cytoplasm to the apoplastic space.

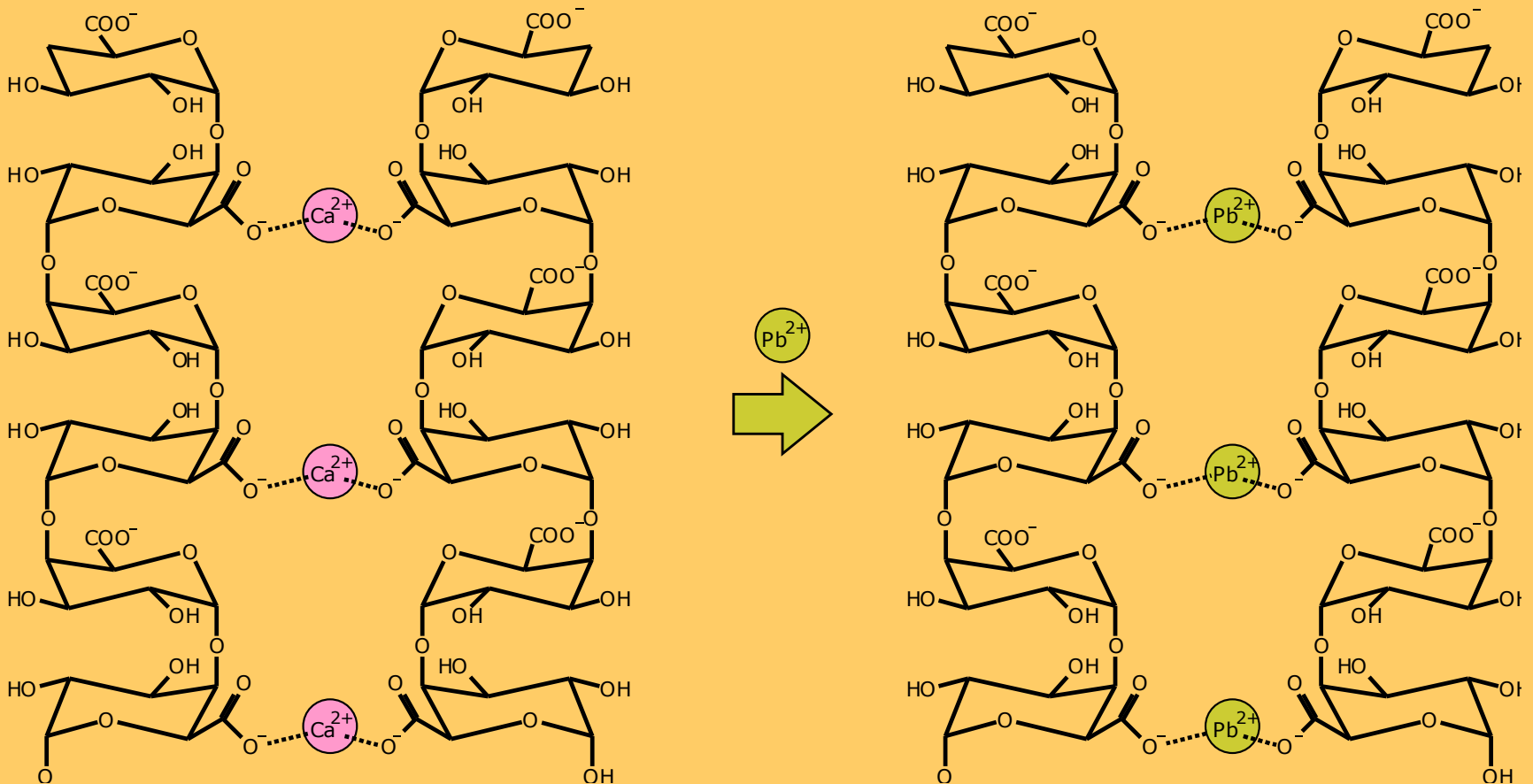
# HEAVY METALS

- Review of avoidance and resistance mechanisms



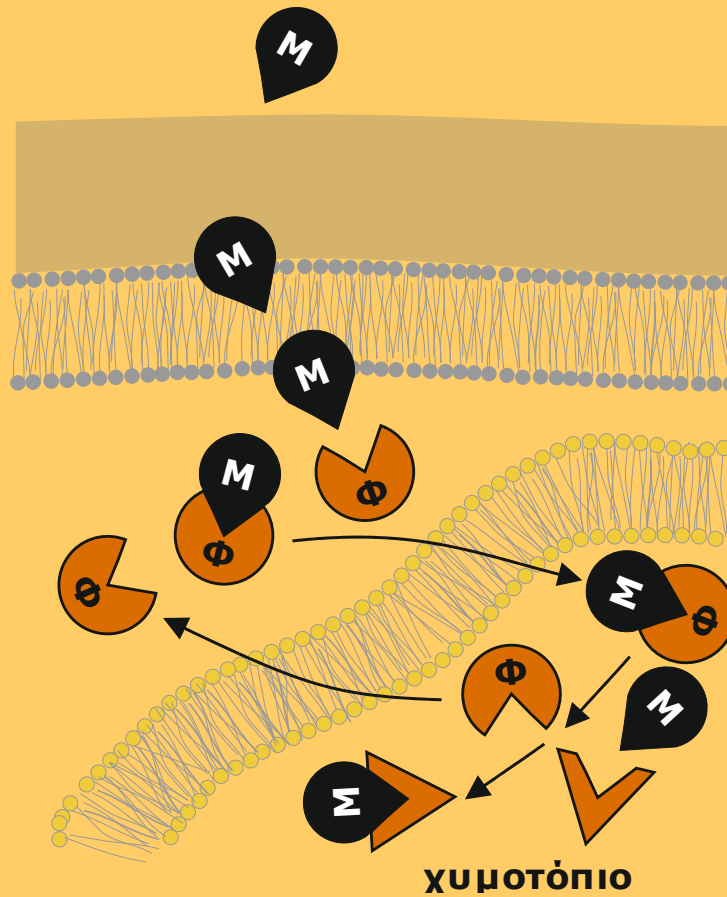
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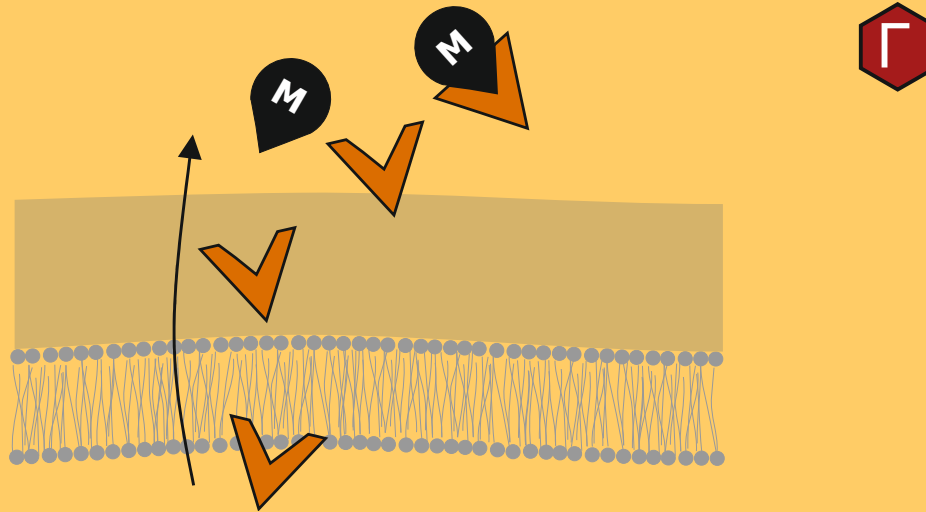
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