Plant Solutions for climate change

Lecture 3

Bibliography

How do plants sense and communicate water deficit? In “Burning questions for a warming and changing world: 15 unknowns in plant abiotic stress, Plant Cell, 2023

Zhu et al., Cell 2016
Yuan et al., 2014

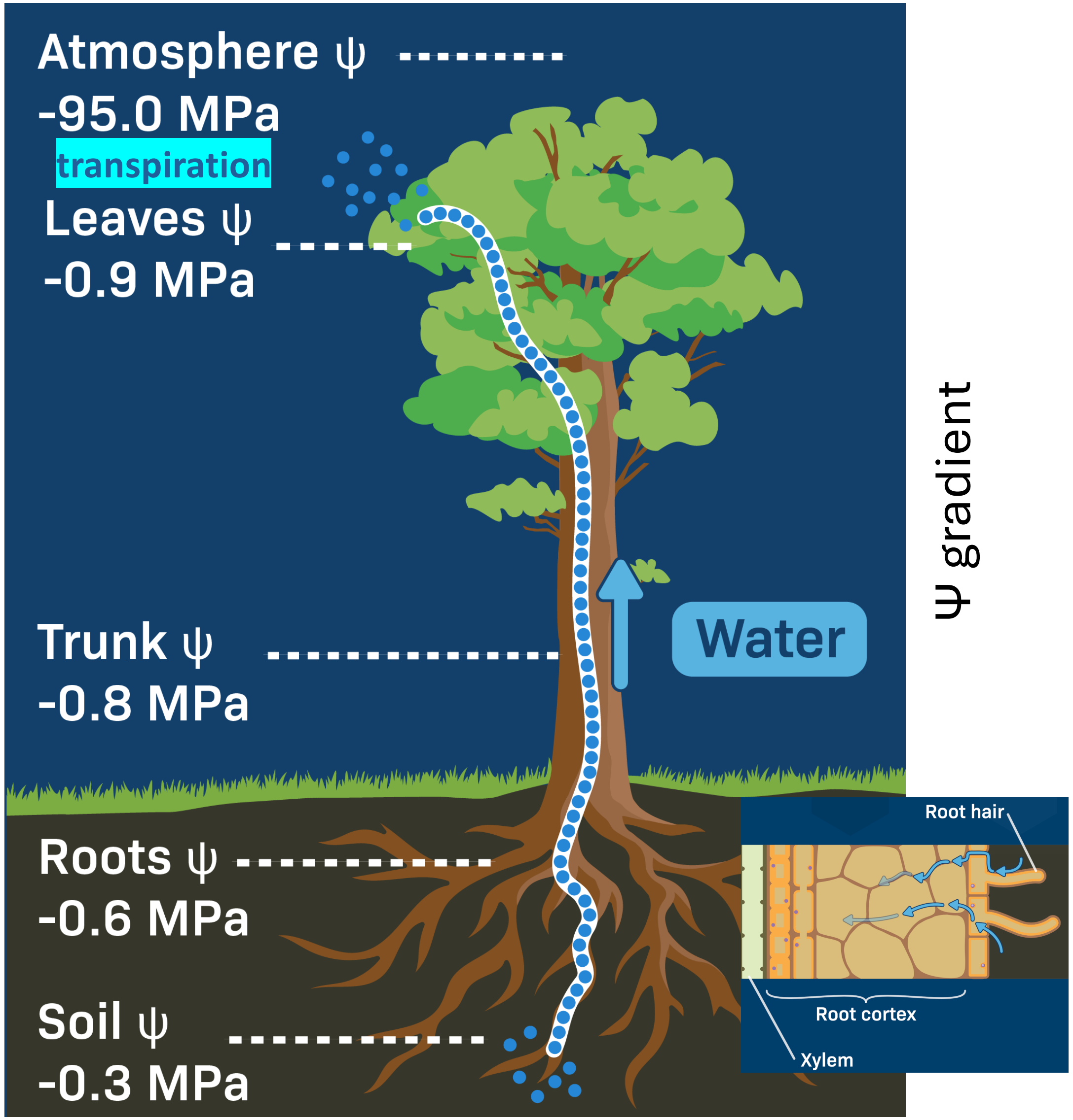
water flows from high Ψ (soli ->roots) to low Ψ (leaves-> atmosphere)

The string of water molecules is pulled upwards and out of the leaves because of a difference in water potential between the leaves (-0.9 MPa) and the atmosphere (-95.0 MPa).

The leaves have an even lower water potential (-0.9 MPa) than the tree trunk (-0.8 MPa), so water molecules move from the tree trunk into the leaves.

The water molecules move upwards in the xylem since the tree trunk has a lower water potential (-0.8 MPa) than the roots (-0.6 MPa).

Root hair cells have a high solute concentration compared to the surrounding soil, generating a water potential gradient. The soil has a higher water potential than the root hair cells. Water molecules move from the soil into the root hair cells by osmosis. Root hair cells do not actively pump water in. Once they pump in the solutes, the water passively follows.

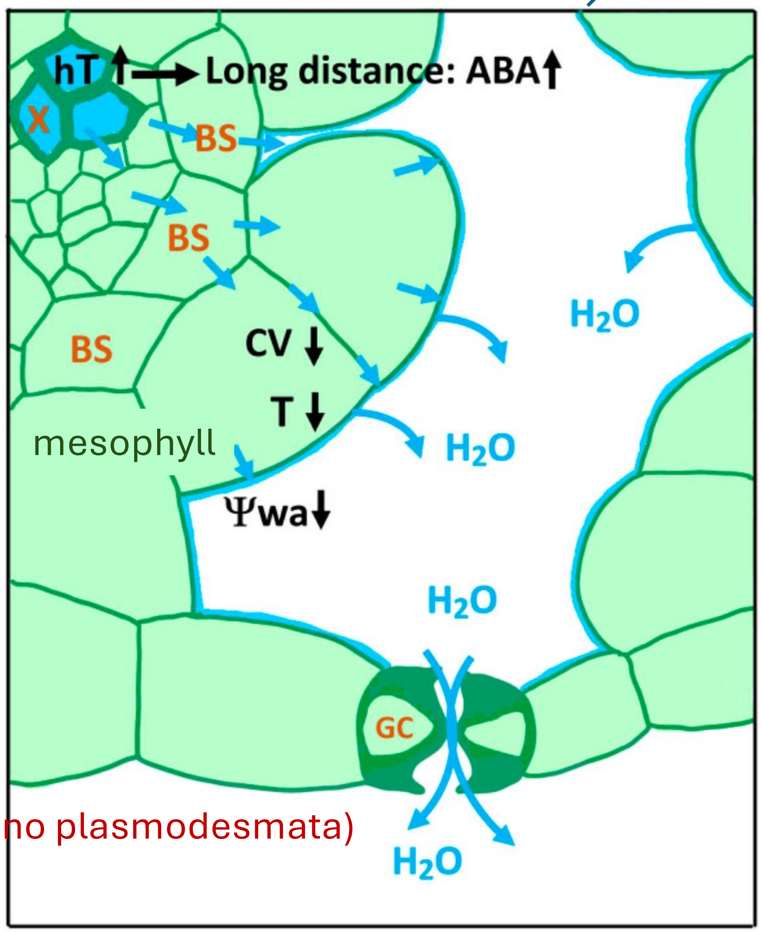


What happens in case of a negative water balance (i.e. water uptake lower than its release by transpiration) ?

Water transported through the xylem of a small leaf vein passes through bundle sheath (**BS**) cells to mesophyll and epidermal cells, which surround guard cells, the sites of transpiration.

If transpiration exceeds water replenishing form the xylem, Ψ_{wa} decreases causing:

- Reduction of turgor (**T**) and cell volume (**CV**) within the mesophyll
- increase in the hydraulic tension (**hT**) within the vasculature
- The change in hT serves as fast long-distance signal (40cm min^{-1}) similar to mechanical sensing and relay of touch and wounding.
- This hydraulic signal is converted into the chemical signal ABA
- Reduction of stomatal aperture by ABA signaling readjusts the water balance by lowering transpiration.
- Improved water uptake via increases in root hydraulic conductance and osmotic adjustment recover leaf gas exchange at the expense of increasingly negative Ψ w.



Primary versus secondary drought (and salt) responses

- Primary stress»: osmotic (triggers ABA productio)
- Secondary stress: oxidative stress; damage to cellular components such as membrane lipids, proteins, and nucleic acids; and metabolic dysfunction

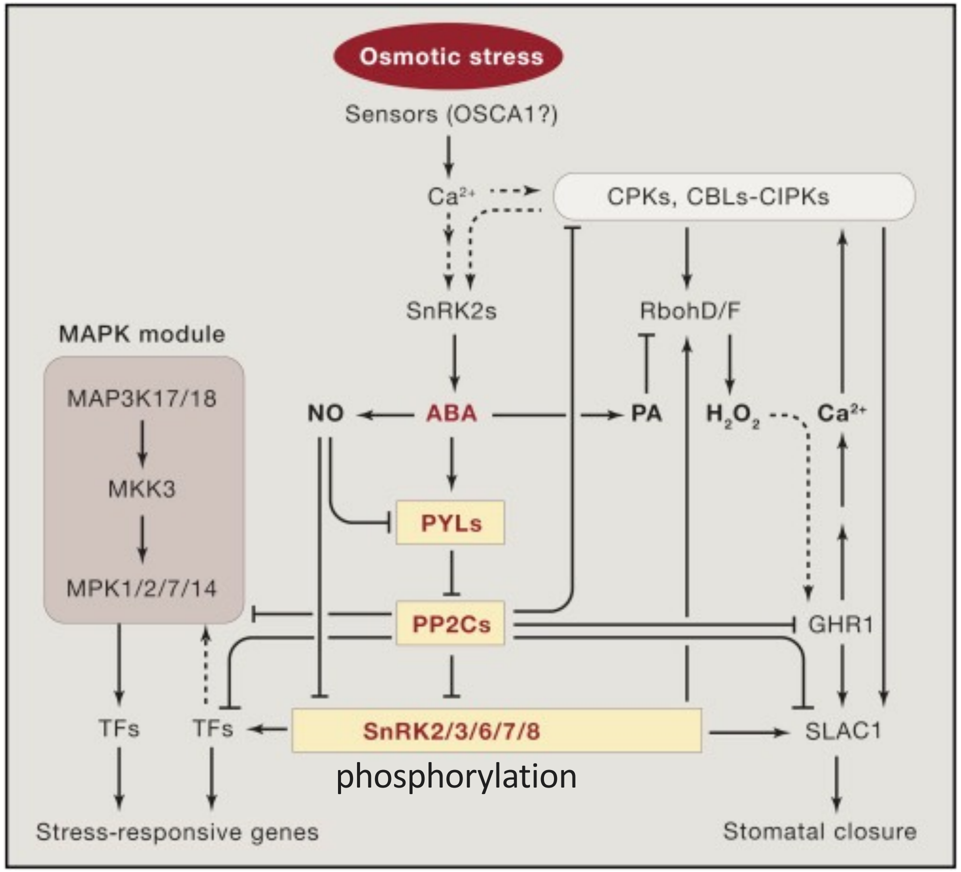
How to identify a receptor

- Genetic screens under hyperosmotic stress in wild- type or plants expressing an ABA-responsive reporter expression
- Arabidopsis natural variation in low ww-induced ABA ac- cumulation
- Candidate gene/pathway approach (force-sensing Ca++ signaling; mechanoreceptors; similar pathways from other organisms; cell integrity monitoring mechanism)

Why it is so difficult to identify osmotic receptors?

- Redundancy
- Essentiality (-> no knock out mutants)
- Technically very challenging

Osmotic Stress and ABA Sensing and Signaling



all 10 SnRK2s except SnRK2.9 are activated by osmotic stress . The decuple *snrk2* mutant plants are impaired in osmotic stress regulation . how osmotic stress activates SnRK2 kinases is not known.

second messengers:
NO (nitric oxide)
PA (phosphatidic acid)
Ca^{++}

SnRK2.2/3/6/7/8 are also activated by ABA

(Zhu et al., 2016, Cell)