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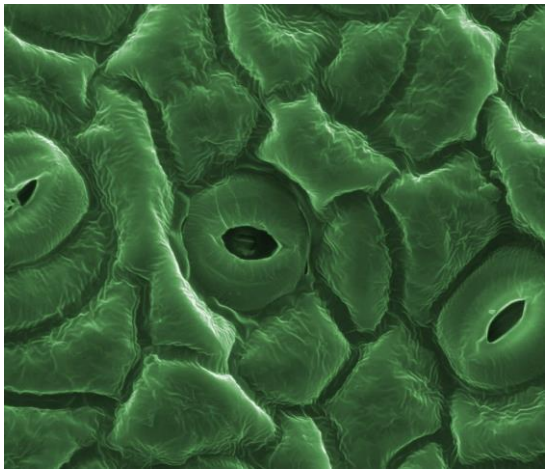
THE IMPORTANCE OF STOMATA

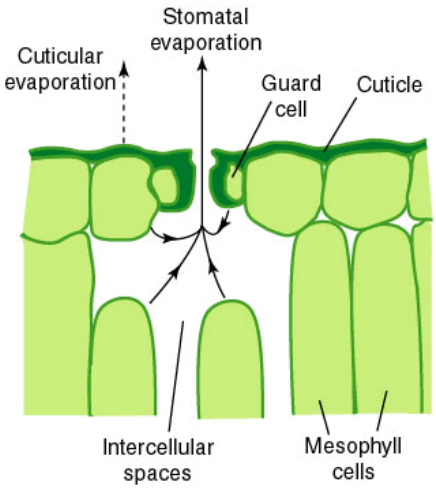
Plants may have a simple structure externally, consisting mainly of the stem, leaves, flowers and the roots. However, internally there is a whole world of complex mechanisms working together to carry out the different physiological activities. The main force driving plant growth is water. It is the main component of the plant, constituting up to 95% of its structure in some species. How can water be responsible for plant growth?

Simply put, it is the medium in which all the complex chemical reactions occur, also being in charge of nutrient absorption and translocation. Water enters the plant mainly through the roots and is then transported to the different organs, distributing nutrients and hormones throughout the plant. Since we have established the importance of water for plant growth, it is important to state the importance of stomata, the pores that drive plant growth. So, what are stomata?



Source: Dr. Willem Van Cotthem, University of Ghent (Belgium)

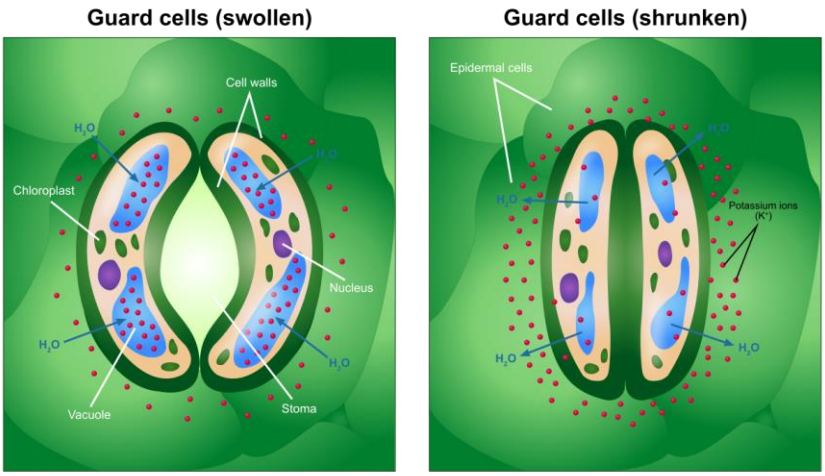
Simply put, they are openings in the surface of plants, found mainly on the leaves, but also on stems and other organs. They are **pores surrounded by specialized parenchymatic cells, called guard cells**. Stomata have **two main functions**, namely they allow for **gas exchange** acting as an **entryway for carbon dioxide (CO_2) and releasing the Oxygen (O_2)** that we breath. The other main function is **regulating water movement through transpiration**. Stomata vary in shape and size, being able to change to adapt to the different environmental factors, thus ensuring optimum conditions for photosynthesis.



Just as animals breath, plants do so too through the stomata. The gaseous exchange that they are responsible for, facilitate photosynthesis by letting in the essential CO_2. Carbon dioxide is used as the fuel to drive photosynthesis, which generates oxygen as a byproduct, which is then released to the atmosphere. Now, how can stomata facilitate photosynthesis? They can do so by playing an important role in transpiration. Transpiration is defined as the absorption of water into the plant, its distribution within it and its final release to the atmosphere from the areal parts. Transpiration through stomata, creates a water potential within the plant, which in turn, favors the passive water absorption in the roots, which will then be transported throughout the plant by the Xylem. To perform photosynthesis, plants need six molecules of water and six molecules of CO_2 to produce sugar and oxygen. Therefore, as mentioned, stomata play an integral part in water and CO_2, entry to the plant, thus having facilitating photosynthesis.

Stomata regulate transpiration and CO_2 intake by changing its size depending on the environmental signals. In optimum conditions, stomata are wide open, allowing gaseous exchange with the atmosphere. **Guard cells are responsible for changing pore size**, they do so by expanding or contracting themselves effectively opening and closing stomata. For stomata opening, water is rushed into the guard cells due to osmosis, which is dependent on potassium concentration in the cells. Potassium enters and leaves the cells through active transport, depending on environmental triggers. Such triggers include ion exchange, temperature, light, hormone signaling, CO_2 concentration etc.

For **stomata to open**, **potassium** is actively **transported to the vacuoles**, which increases its concentration in the cells, thus **driving water entry due to osmosis**, **increasing cell turgency** and size, **exposing the pores**. The **opposite occurs** for **stomata closure, potassium is transported out the cells**, which **attracts the water out** to the exterior, **collapsing** the cells **on the pore**, effectively **closing it**.



Stoma opening | Stoma closing

Stress is the main reason for stomata closure, as plant produces abscisic acid (ABA), a plant hormone well known to regulate many key processes involved in plant development and adaptation to biotic and abiotic stresses. In the case of water stress caused by drought or salinity, the plant copes with the stress by avoiding unnecessary water loss through stomata. Physiologically speaking, the plant produces **abscisic acid (ABA),** which signals stomata closure by **binding to protein receptors in the guard cells** plasma membrane which then activate second messengers such as ROS, Nitric Oxide, Ca^{2+} triggering ion channels which ultimately causes water to leave the guard cells, thus shrinking their size and collapsing on the pore, effectively closing it.
This way the plant can conserve water, avoiding any unnecessary losses, until the stress signal is reduced, therefore lowering the concentration of ABA and its effect on stomata closure. Similarly, it has been observed that **the plant can produce ABA as a response to pathogen attack such as *Pseudomonas syringae***, which can enter the plant through stomata. The plant synthesizes **ABA** which **induces stomatal closure, avoiding any further pathogen invasion.**

Stress negatively affects growth through **stomata closure**, which in turn **disrupts photosynthesis as well as water and hormonal movement within the plant**, bringing on a **hormonal imbalance** which **will lead to stunted growth**. This is widely observed in the field, causing immense agronomical losses, both in yields and fruit quality. Therefore, controlling stress at a physiological level is important to avoid stomata closure and the subsequent production losses. With ever changing weather conditions, alongside resource scarcity, products specialized in combating plant stress are playing a more important in role in effectively alleviating production losses.

In summary, stomata play a vital role in plant development, by regulating gas exchange with the atmosphere and controlling transpiration. Different factors can affect its shape and size, effectively regulating water uptake, transport and the distribution of nutrients and hormonal signals in the different organs of plants, thus controlling growth.

Maintaining the plant stress-free is essential for avoiding production losses, which could be a direct effect of stomata condition.

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