1) *Discuss the role of stomata in transpiration (7)*
2) *What is meant by Transpiration Stream? (3)*
3) *Describe the factors affecting the rate of transpiration (10)*

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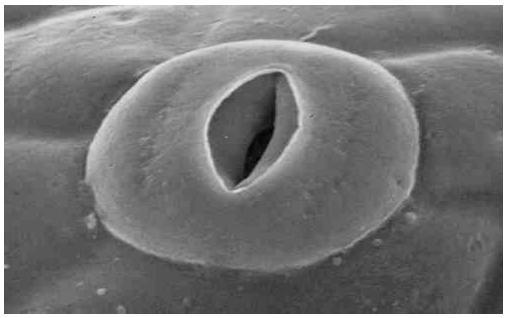
1) Leaves are the primary photosynthetic organs of most plants. Leaf surfaces are equipped with small openings or pores called stomata, which allow carbon dioxide to enter the leaf and oxygen to escape to facilitate photosynthesis. In addition, water is lost through stomata during a process called transpiration. It is estimated that appro ximately 99% of the water absorbed by the roots of the plant is lost by the leaves in transpiration.

Plants must exchange gasses through their leaves in order to conduct photosynthesis and respiration; they also must permit evaporation / transpiration in order to assist in the movement of water from the ground to leaves, where it is needed to build carbohydrates. Yet, if transpiration is uncontrolled, a plant may become dehydrated and die.



The stoma is a pore formed by a pair of guard cells. The guard cells are located in both epidermal layers of the leaf, with a higher concentration on the underside (this is a strategy to reduce water loss). Plants contain a range of 10,000 - 100,000 stomata per cm^2. Stomatal opening is regulated by turgor in the guard cells. The inner walls of the stomata are fused at both ends, and, as the cells fill wi th water, the fused walls stay the same length, while the outer walls stretch, causing the cells to curve and opening the pore between them wider. As to differ from this process, when guard cells lose turgidity, they loose their curvy structure, closing th e pore. This stretching is limited by the strength of lignin fibres surrounding the cells. Water enters and leaves guard cells in response to changes in solute concentrations. Potassium is actively pumped into the guard cells from surrounding cells. This in turn increases solute concentration; as a result, water potential decreases and water enters the guard cell against a pressure gradient.

2) Water is absorbed from the root and is transported to all areas of the plant; this passage of water is called the transpiration stream. Water is absorbed by the roots of a plant, which possess many root hairs with large surface areas for high

absorption of water. Osmosis occurs across a concentration gradient, and this is the case here, when water is required and the concentration of water in the roots is low, water is absorbed from the higher concentration of water found in the ground. This same process happens for the concentration difference between cells, as the root cells rich in water allow osmosis to occur up the plant until there is an equal concentration throughout the organism. As this water evaporates through the now open (high concentration of water in guard cells of stomata), more water is required so as to continue to satisfy the metabolic needs of the plant, and so more water is taken up by the roots and the entire process is repeated. This is why it is called the transpiration 'stream'.

3) There are numerous factors affecting the rate of transpiration of a plant. These factors majorly influence the closing or opening of stomata within the leaves. The following are the major examples of factors (both environmental/external and internal) affecting any plant's rate of transpiration:

- *<u>Temperature</u>: A high temperature increases the rate of transpiration within a plant, and a low temperature decreases. This is due to the fact that evaporation is stimulated by heat, so as to provide cooling down of the plant. The more water evaporates, the more is needed to replace it, keeping the needed amount of water within the plant needed for all of its metabolic processes, and therefore more water is taken up from the soil by the roots of the plant, and the transpiration rate is therefore increased.*
- *<u>Humidity</u>: A high humidity of the air surrounding a plant would account for a decrease in the rate of transpiration of the plant, and vice versa. This is because, once the air in the environment surrounding the plant is moist, there is no high difference in the osmotic potentials of the plant and the air, and no steep diffusion gradient is present to influence diffusion of water molecules out of the leaf. Since no water is being passed out, no water needs to be taken in, and therefore the rate of transpiration has decreased.*
- *<u>Wind (air movements)</u>: Strong and high wind speeds cause water to be evaporated from the leaf at a faster rate, increasing the transpiration rate. In more detail, this wind sweeps with it the moist air molecules secreted into the atmosphere by the leaf and brings along more 'dry' air, which needs to be 'moisturized' by the water exerted by the plant's leaves through diffusion. Water constantly needs to be taken up when winds as such occur, and this means that the transpiration rate is higher than before.*
- *<u>Sunlight</u>; Sunlight results in photosynthesis, and photosynthesis requires water. This water is provided for photosynthesis after being taken up by the root intensively, from the soil. The fact that water is being taken up from the soil activates the transpiration stream and increases the transpiration rate of the plant.*
- *<u>Dryness of Soil</u>: If the soil the plant it planted in is dry, the plant cells will become flaccid (this is seen through wilting plants), and so will the stomata cells. These cells therefore close when the soil is dry, disallowing the release of water from the leaves of the plant. Also, the water potential in the soil is low, and therefore no water can be passed up the plant passively due to a diffusion gradient. All this means the transpiration rate is now much lower.*

- *<u>Surface Area of Leaf</u>: The higher the surface area of the leaf, the higher the transpiration rate of the plant, and vice versa. An example which could explain why this is so is that more of the leaf is exposed to sunlight, increasing the amount of photosynthesis going on in the plant, and therefore increasing the plants water needs. The roots take up enough water to fulfill these needs, and in doing so, they increased the transpiration rate of the plant.*
- *<u>Cuticle Thickness</u>: The thicker the cuticle, the more the rate of transpiration is reduced. This is so because the cuticle makes exchange of materials between the outside environment and the inside of the plant very restrict ed. So therefore, one of the materials which can now with more difficulty leave the plant leafs is water. As this water stays within the plant, there is no need to take up more from the soil, and so the transpiration rate is automatically decreased.*
- *<u>Stomatal Density</u>: The higher the number of stomata per unit area of a leaf, the higher the rate of transpiration. This is due to the fact that more stomata are exposed to factors such as wind or sunlight (which increase transpiration). It is also clear that for instance, in the case of a very moist soil, all the stomata will open, allowing water vapor out, again, in creasing the transpiration rate of the plant.*