One way to understand the different levels of organization (cells, tissues, organs, and systems) work together is to follow the path of water through a plant. Most plants need a large supply of water. Plants require water to make sugars in the process of photosynthesis. Plants obtain water from the soil. If you examine the structure of a root system, you will see that its growing tips are covered with fine root hairs. These “hairs” are, in fact, extensions of single epidermal cells. When the concentration of water in the soil is greater than the concentration of water in the root cells, water enters these root hairs by osmosis. The process of water uptake is therefore a function of the first level of organization: the cells.

From root hair, water passes from cell to cell by osmosis until it reaches the xylem tissue. The tube-shaped cells making up xylem tissue have thick walls with holes in their ends. Stacked end to end they form bundles of hollow vessels similar to drinking straws. Water can flow easily through these vessels. As more water enters the root hairs, it creates pressure that pushes water up the plant through the xylem tissue- the second level of organization. Water is transported by xylem tissue into the stems and leaves. Leaves are the plant’s food-producing organs – the third level of organization. Remember that photosynthesis manufactures sugars from water, carbon dioxide, and sunlight. Most photosynthesis takes place in a layer of cells in the leaf that are filled with chloroplasts. These cells are called palisade cells. Why are so many leaves typically flat and thin? This shape provides a large surface area to absorb sunlight, and it makes it easy for gases to diffuse into the leaf cells. There are tiny openings on the underside of the leaf. These openings are called stomata (stomata is the singular of stoma). They allow air to enter the leaf, supply the oxygen the cells need for respiration and the carbon dioxide they need for photosynthesis. Spaces between leaf cells allow the air to flow around each cell. Surrounding each stoma are guard cells, which can expand to close off the stoma. Why do the stomata in a leaf open and close? To answer this question, recall that water first enters a plant through its root system. Then it moves into its shoot system. There are two of the plant’s organ systems – the fourth level of organization. What happens next? The water does not continually circulate like the blood in our bodies. It does not go back into the root system. Instead it exits the plant- through the open stomata in the leaves.

This loss of water from a plant through evaporation is called transpiration. The loss of water is not a problem as long as it is replaced by more water that enters the plant through the roots. In periods of drought and in deserts, however, water loss from a plant can be a serious problem.

If all the tissues of a plant were to magically disappear, leaving only the water in them behind, you would see a ghostly outline of the plant in a web-like network of water. There is no break in this water system. Fine columns of water connect every cell, from the leaves to the roots. The network extends even beyond the root hairs – it connects root hairs to channels of water in the soil.

According to the particle theory, individual water particles are held together by bonds of attraction, which make the plant’s water network behave as a single unit. Water drawn into the root hairs by osmosis pushes slender water columns up the plant. At the same time, water lost from the leaves by transpiration pulls water up the xylem tissues all the way from the roots. Both these actions – pushing and pulling – are necessary to raise the water up to the top of very tall trees. In this way, trees can transport water without having a pumping organ similar to the human heart.

Organ Adaptations in Plants

Like animals, plants have adaptations that help them grow and survive in different environments. You can see some of these adaptations in the structure of roots, stems, and leaves. For example, many plants growing in deserts have small, fleshy leaves with a heavy wax coating that helps reduce water loss. Cactus spines are, in fact, narrow, waxy leaves. To compensate for their reduced lead area, cacti carry out photosynthesis in their stems. The leaves of coniferous (cone-bearing) trees, such as pines and other evergreens, are also adapted to dry conditions. The needlelike shape of the leaf reduces evaporation from the surface of the leaf.

Plants that grow in water, such as water lilies, could have a problem obtaining the air they need to survive. To ensure their underwater roots obtain the oxygen they need for cell respiration, the root tissues of these plants have large air spaces in them. Still other plants have roots in the air! Orchids grow high above the ground on the branches of trees in tropical forests. Their root tissues are specially adapted to absorb moisture from the warm humid air.