

place, viz., the root-hairs, where the water enters; the deeper tissues, the fibro-vascular bundles of root and stem, through which the water ascends; the veins of the leaf, along which it proceeds to the intercellular spaces, at the exit of which stand the guard cells of the stomata.

It was pointed out that sap is a dilute solution of food, partly of a mineral nature, taken from the soil, partly of an organic nature, derived from carbonic acid absorbed by the leaves from the atmosphere. The chief mineral constituents are phosphates, silicates and nitrates of potassium and calcium. The chief organic constituents are sugar, soluble proteids and organic acids, with sometimes coloring matters. These are conveyed or carried about in the water, which has the double function of dissolving and distributing this food material. An enormous amount of water takes part in these two processes. Besides the above uses of the water, it is itself food material, and also serves to render the plant turgid, thereby enabling succulent plants to stand erect. The proportion of water in plant tissues is very large, from 40% to 90%, but the amount of water so represented is very small compared with that which passes through the plant or tree and is lost by transportation. For every pound of dry matter stored up in the tissues between 300 and 400 pounds of water pass out into the atmosphere by the stomata.

The causes of the upward movement of sap were next dealt with. The water enters the root-hair from the soil by osmosis. This osmotic action may be experimentally illustrated by placing a strong sugar solution in a glass cylinder (lamp glass), one end of which is covered by a bladder, and suspending the cylinder in water. To eliminate purely hydrostatic action which might produce movement, have the level of water inside the bladder the same as that without. In a short time the level inside rises, showing that, if an interchange is taking place, more water is entering, than escaping from, the bladder. Some sugar makes its way to the outside liquid. Thus, on purely physical grounds, one may see how water enters the root-hairs of plants. Having entered, it filters through to the deeper cells, and, in the case of the higher plants, ascends chiefly by means of the Xylem elements of the fibro-vascular bundles. This ascent is aided by osmotic