the Edinburgh and Kew collections. It would appear probable that it is a peculiarity which may be induced, or at least its further development promoted, in certain species by particular conditions of culture: it is to be remembered, however, that it is not readily induced by moist culture in ordinary ferns, as I have shown by experiment[1], and in ferns at large it is certainly of rare occurrence. Since I know of no reference to this abnormality in systematic books, it would appear to be uncommon or even absent in the specimens of *Trichomanes* from their native habitat, upon which systematic writers will have based their descriptions.

In this, as in other cases of apospory, it is difficult to define the exact limit of the parts representing the two generations: examining them externally, the form and nature of the appendages (rhizoids, or sexual organs) and of the constituent cells have been used as diagnostic characters; it is possible, however, that the constitution of the nucleus may come to be recognized as a strict diagnostic character. If the generalization be correct, that the nuclei of the gametophyte on division show only half the number of chromosomes shown by those of the sporophyte, then clearly the cells in which the reduction takes place will be those which will define the limit between the generations; on this point detailed observations will be awaited with peculiar interest.

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Oct. 1894.

ON THE ASCENT OF SAP[2].—By Henry H. Dixon, B.A., Assistant to the Professor of Botany, Trinity College, Dublin, and J. Joly, M.A., Sc.D., F.R.S. Strasburger's experiments have eliminated the direct action of living protoplasm from the problem of the ascent of sap, and have left only the tracheal tissue, as an organized structure, and the transpiration-activity of the leaf wherein to seek an explanation of the phenomenon. The authors investigate the capability of the leaf to transpire against excessive atmospheric pressures. In these experiments the leaf was found able to bring forward its water meniscuses against the highest pressures attained and freely transpire. Whether the draught upon the sap established at the leaf during transpiration be regarded as purely capillary or not, these

[1] Annals of Botany, Vol. iv. p. 168.

[2] Abstract of a paper read before the Royal Society, November 15, 1894.

experiments lead the authors to believe that it alone is quite adequate to effect the elevation by direct tension of the sap in tall trees. Explanations of the lifting of the sap from other causes prove inadequate.

A reconsideration of the principal experiments of previous observers and some new experiments of the authors lead to the view that the ascent is principally in the lumen and not in the wall.

The explanation of how the tensile stress is transmitted in the ascending sap without rupture of the column of liquid is found in the stable condition of this liquid. The state of stability arises from two circumstances :—the internal stability of a liquid when mechanically stretched, whether containing dissolved gases or not, and the additional stability conferred by the minutely subdivided structure of the conducting tissue, which renders the stressed liquid stable even in the presence of free gas.

By direct experiments upon water containing large quantities of dissolved air, the state of internal stability is investigated. And, further, by sealing up in the vessels, in which the water to be put under tension is contained, chips of the wood of *Taxus baccata*, the authors find that their presence in no case gives rise to rupture of the stressed liquid, but that this occurs preferably anywhere else, and usually on the glass walls. The establishment of tensile stress is effected in the usual way, by cooling the completely filled vessel. A measurement possessing considerable accuracy afforded 7½ atmospheres as being attained in some of the experiments.

The second condition of stability arises directly from the property of the pit-membranes to oppose the passage of free gas, while they are freely permeable to the motion of a liquid. Hence a chance development of free gas is confined in effect to the minute dimensions of the compartment in which it is evolved, and this one lumen alone is rendered for the time being non-conducting. On the other hand, in the water-filled portion of the tracheal tissue, the closing membranes, occupying the median and least obstructive position, the motion of the stressed sap is freely allowed. The structure of the conducting tissue is, in fact, a configuration conferring stability on a stressed liquid in the presence (from various causes) of free gas. As neither free gas nor unwetted dust particles can ascend with the sap, the authors contend that the state of tensile stress necessary to their hypothesis is inevitably induced.

The energy relations of the leaf with its surroundings, on the assumption that evaporation at capillary water-surfaces is mainly responsible for the elevation of sap, may be illustrated by the well-known power of the water-filled porous pot to draw up mercury in a tube to which it is sealed. The authors describe an engine in which the energy entering in the form of heat at the capillary surfaces may be in part utilized to do mechanical work: a battery of twelve small porous pots, freely exposed to the air, keeping up the continuous rotation of a fly-wheel. Replacing the porous pots by a transpiring branch, this too maintains the wheel in rotation. This is, in fact, a vegetable engine. In short, the transpiration effects going on at the leaf are, in so far as they are the result of spontaneous evaporation and uninfluenced by other physiological phenomena, of the 'sorting demon' class, in which the evaporating surface plays the part of a sink of thermal energy.

If the tensile stress in the sap is transmitted to the root, the authors suggest that this will establish in the capillaries of the root-surface meniscuses competent to condense water rapidly from the surrounding soil. They show by experiment the power possessed even by a root injured by lifting from the soil, of condensing water vapour from a damp atmosphere. Such a state of things may be illustrated by a system (which the authors realised) consisting of two porous pots connected by a tube and all filled with water; one, the 'leaf,' exposed to the air gives out vapour, the other, the 'root,' buried in damp earth supplies the demand of the 'leaf,' and an upward current in the connecting tube is established.