cells next below the actual epidermis. This feature occurs in many recent roots.

It is shown incidentally that the doubts expressed by Messrs. Hick and Cash as to the identification of their "*Myriophylloides*" with "*Astromyelon*" are unfounded. A section of the type-specimen of "*Myriophylloides*" has been re-examined, and its structure is shown to be identical with that of the other specimens of "*Astromyelon.*"

The numerous minute rootlets, associated with the larger roots, have been carefully examined. Many of these rootlets are without any pith, but they are in other respects identical with the typical specimens, with which they are connected by an unbroken series of intermediate forms. There are also instances in which rootlets are found inserted upon the medullate roots.

The conclusions at which the authors arrive are the following:—

1. The fossils hitherto described under the name of *Astromyelon Williamsonis* are the adventitious roots of *Calamites*.

2. Their structure is in all respects that characteristic of roots, as is proved by the centripetal primary wood, the alternating strands of primary wood and phloëm, the endogenous mode of branching, and the absence of nodes.

3. The smallest specimens, with little or no medulla, represent the finest branches of the same roots, of which the large medullate forms are the relatively main axes.

The paper is illustrated by micro-photographs from the actual specimens, and also by *camera-lucida* drawings.

II. "On the Ascent of Sap." 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. Received October 16, 1894.

(Abstract.)

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 organised 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 experiments lead the authors to believe that it alone is quite adequate to effect the eleva-

tion 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 onducting 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 $7\frac{1}{2}$ 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 utilised 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.

III. "The Pigments of the Pieridæ. A Contribution to the Study of Excretory Substances which function in Ornament." By F. GOWLAND HOPKINS, Demonstrator of Physiology and Chemistry at Guy's Hospital, London. Communicated by Professor E. RAY LANKESTER, F.R.S. Received October 5. 1894.

(Abstract.)

The paper deals with the chemistry of the wing pigments of that group of butterflies known as the Pieridæ, and demonstrates the excretory nature of these pigments. The following are the salient facts dealt with, most of the statements being based on original observations described in the paper:—

1. The wing scales of the white Pieridæ are shown to contain *uric acid*, this substance bearing the same relation to the scale as do the pigments in the coloured Pieridæ, and therefore functioning practically as a white pigment.

2. The yellow pigment which is so widely distributed in the Pieridæ (being found in the majority of the genera) is shown to be a derivative of uric acid.

3. The properties of this yellow pigment are described, and the results of its analysis are given. The pigments of various yellow-coloured genera are shown to be identical.

4. It is shown that this yellow pigment may be artificially produced by heating uric acid with water in sealed tubes at high tem-