ter if one knew not only the influence of the chemical reagents employed by the histologist but also the "coagulation (clotting) phenomena of death, as well as . . . post mortem change" (p. 292) led Hardy to turn his attention to the phenomena of coagulation and especially to those molecules of the body that are most readily coagulated: the proteins. In 1899 the transition is made from histology to chemistry. The next fourteen papers, appearing over the period ending in 1912, are concerned largely with colloidal solutions, especially with proteins.

The first paper of this series "On the Coagulation of Proteid by Electricity" in 1899 is a classic. With clarity and insight Hardy correctly interpreted the scattered information in the literature regarding the charged condition of matter and correctly deduced the amphoteric properties of the proteins. He noted that "Under the influence of a constant current the particles of proteid in a boiled solution of egg-white move with the negative stream if the reaction of the fluid is alkaline; with the positive stream if the reaction is acid" (p. 307). All subsequent work upon this important class of molecules follows from this observation. The work started in 1899 led to several remarkable papers, two of which on globulins appeared in 1905, one in the *Journal of Physiology,* the other as the Croonian Lecture of the Royal Society of that year. "Globulins are a class of proteids which occur in both animal and vegetable tissues. They are peculiar in the complexity of their relations to electrolytes. Insoluble in water, they are soluble in low concentrations of acids, alkalis, or neutral salts. In presence of acids the globulin is electro-positive, in presence of alkalis it is electronegative, in presence of neutral salts it is electrically neutral. . . . The problem I propose to consider is their diversified relation to electrolytes" (p. 430).

These papers teem with incisive original observations which, however much they have been amplified in the last 30 years, have not in any important sense required reinterpretation. In them are to be found the concept of the isoelectric point and of the stoichiometric relations of proteins to acids and bases, deduced from measurements of conductivity, viscosity and electric transport of globulin ions, and the relations of the various ionic states of globulin, as well as of neutral globulin, to neutral salts.

The development of a theoretical understanding of the behavior of globulins in well-defined systems did not however replace his interest in the state of protein in nature. "The proteids of serum are electrically inactive. Neither the whole nor any fraction moves in a field. It is not possible to detect a trace of "ionic" proteid. Dialysis or dilution disturbs the equilibrium, and "ionic" globulin appears" (p. 418). "The probability of globulin being formed owing to the decomposition of a complex proteid present in serum is urged" (p. 426). However far from his morphological interests his studies of colloidal solutions seemed to take him, he was always concerned in his study of globulins with the problem of the state of matter in nature.

The study of the movement of proteins in an electric field led many biologists to investigate "the movement of free living cells suspended in a fluid through which an electric current is passing" (p. 490). The results reported on cells were as conflicting in 1911 as were those on molecules in 1899 and Hardy felt impelled to caution that "the movement of living cells, or indeed of any suspended particles, in films of liquid a millimeter or less in depth enclosed between glass plates is not open to simple interpretation" (p. 490). By 1911 Hardy's grasp of the chemical and physical problems as they related to the charged condition of matter had reached a point where he perceived the implications of the electrical density at interfaces and of the dimensions of molecules and surface layers.

In 1911 therefore, as in 1899, Hardy again changed the nature of his investigations. His work from this time on is for the most part concerned with the physical properties of matter at interfaces. Although his interest remains that of the biologist, as is attested by his papers on "Some Problems of Living Matter," "Living Matter" and "Molecular Orientation in Living Matter," he investigated such problems as "The Influence of Chemical Constitution upon Interfacial Tension," "The Spreading of Fluids on Glass," "Boundary Lubrication," "Chemistry at Interface" and "Problems of the Boundary State."

At each level of his understanding Hardy reverted to his primary interest, and the last of the collected papers is "To Remind: a Biological Essay." In this interesting lecture he warns against certain tendencies in modern science. His words have the wisdom always associated with him by his colleagues, but more important is the example he set by his scientific life. His collected writings, beautifully published under the auspices of the Colloid Committee of the Faraday Society, are a lasting memorial to him, and for us the detailed "history of a mind" such as is not likely often to appear in our times.

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VASCULAR PLANTS

Morphology of Vascular Plants; Lower Groups. By ARTHUR J. EAMES. McGraw-Hill. 1936. $4.00.

A NEW understanding of the comparative anatomy and morphology of vascular plants is one of the more recent developments in the progress of botany. Unlike the highest animal group, the vertebrates, in which the comparative body plan has been appreciated for hundreds if not thousands of years, in the highest plant group there has been no ready key to the comparative unity of structure.

In Professor Eames's book, we have an important contribution to the general understanding of the comparative anatomy and phylogeny of vascular plants. It sums up the findings and conclusions of anatomical and paleobotanical research, a considerable part of which has been contributed during the past thirty-odd years. Several basic conclusions are presented which, if finally validated, will displace general concepts of long standing. These may be noted as follows:

(1) Vascular plants are all grouped together in one phylum, the Tracheophyta. The current division into two phyla, Pteridophyta and Spermatophyta, goes the way of the earlier separation into Cryptogamia and Phanerogamia. The seed habit is recognized as having arisen independently in more than one line of vascular type.

(2) The phylum of tracheophytes is divided into four main groups, largely on the basis of stelar and foliar differences. E. C. Jeffrey was the first to propose a division on this basis, in 1901. He divided vascular plants into two main groups, the Lycopsida and the Pteropsida. The Pteropsida comprised all true ferns and the higher seed plants, all those with large leaves which leave a gap in the vascular cylinder at the point of origin.

In the Lycopsida, he grouped the remaining vascular plants, based on a simpler stelar structure and the absence of foliar gaps. Subsequent workers have split Jeffrey's Lycopsida into three groups; the Lycopsida proper, taking in Lycopodium, Selaginella and similar fossil types; the Sphenopsida, including modern Equisetum and the Paleozoic sphenophyls; and the Psilopsida, with living Psilotum and Tmesipteris and similar Paleozoic forms.

(3) The archetypal vascular plant body is not to be considered as consisting of the three parts, root, stem and leaf. Instead, based on some rather recent paleobotanical work which has reported the structure of Silurian fossils, it is concluded that the primitive, terrestrial, vascular plant had a dichotomously branching axis, partly hypogean, partly epigean, bearing sporangia, but without leaf or root differentiation. Psilotum and Tmesipteris are the modern representatives of this plant form. Psilophyton, Rhynia were among the earliest pre-Carboniferous types.

(4) The long-standing controversy regarding the homologous or antithetic origin of alternation of generations is considered settled in favor of the former principle. The vascular sporophyte has not been derived by the progressive sterilization of a diploid sporangium, but rather by the gradual modification of a thalloid branch system.

(5) Finally, as a corollary of the preceding point, leaves of tracheophytes are recognized as having had two different origins. Those of the lycopsid type are regarded as enations; those of the larger sort, which leave gaps in the stele, are considered to have come from branch systems, become lateral and secondary by sympodial development. The dichotomy of fern venation would represent the persistence of a primitive branch condition.

All these several conclusions sum up into one broader concept, *viz.*, that vascular plants were originally derived directly from some thallophyte ancestor, and not by way of an intermediate bryophyte stage. The latter would constitute a separate line of terrestrial development from the algae.

Not all botanists will be ready to accept these conclusions. Not only will there be delay, due to natural conservatism, and to the difficulty of effecting so radical a change in thought from what has come to be familiar and traditional. Some botanists will prefer the antithetic theory of alternation and possible liverwort ancestry for vascular plants, a view so long and ably upheld by Campbell and Bower. Thus, Brown, in a recent and excellent elementary text in botany (Ginn, 1936), reaches the conclusion that "the structure of the Psilophytales fits in very well with the long-accepted idea that the Pteridophyta are derived from the Bryophyta."

On the other hand, the newer point of view has found expression in the general texts of Torrey (1930) and Sinnott (1935). In Germany, Zimmerman's "Die Phylogenie der Pflanzen" is even more comprehensive than the Eames.

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ABSTRACTS OF PAPERS PRESENTED AT THE CHICAGO MEETING

A comparison of differential heats of dilution with the predictions of the theory of Debye and Hückel: T. F. YOUNG (introduced by W. D. Harkins). Differential heats of dilution to be used in combination with cryoscopic measurements for the evaluation of activity coefficients of sodium chloride, in aqueous solution, have recently been determined. Significant discrepancies were encountered when the new measurements were compared with published differential heat of dilution data derived from experiments with extremely dilute solutions. Those data were also in conflict with the Debye-Hückel theory which permits a theoretical calculation of