## THE IMPORTANCE OF INVESTIGATIONS OF SEEDLING STAGES.[1]

The selection of the title, 'The Importance of Investigations of Seedling Stages,' for presentation before the Section of Vegetable Morphology of the International Congress carries with it the suggestion that it is the intention of the writer to epitomize the recent attempts made to solve the problem of the phylogeny of Monocotyledons by reference to the anatomy of seedlings. The importance of these investigations is beyond question and the unexploited nature of the field has never been better expressed than by Miss Sargent, whose name occupies the most important place in these discussions, when she remarked that while theoretically the embryo should offer characteristics of unusual taxonomic importance, the only character so far of recognized value seems to be that employed in the separation of the two great divisions of the Angiosperms.

But this work has already been brought to the attention of botanists by foreign and American writers and I speak of it only incidentally in passing to the consideration of some other, though related, points, omitting, of necessity, many interesting and suggestive illustrations which would require far too much space for their adequate discussion.

The recent revival and defense of the conception of the cotyledon as homologous with the nursing foot of the lower forms rather than with foliar organs has suggested many problems which will require a broad comparative study of all embryonic stages for solution.

The functions performed by the cotyledons are various, the protection of younger embryonic regions, the deeper planting of the young seedling, and above all, elaboration, storage and absorption of food material, or in other cases the cotyledons are merely vestigial structures. If it be maintained that the cotyledon is homologous with a more primitive nursing foot and that the Dicotyledons are derived from the Monocotyledons by a bifurcation of an originally simple member, the whole series of adaptive modifications of the cotyledon must be studied and arranged in series in agreement with their origin.

This presents problems of no mean magnitude, physiological and morphological, the solution of which demands the accumulation of a vast series of comparative data. Not only do the differing degrees of physiological specialization and morphological modification of the cotyledon among Monocotyledons offer problems of interest and importance, but the evolution of epigean and hypogean cotyledons in the dicotyledons must be more satisfactorily traced. If the close resemblance of many cotyledons to foliar organs is merely similar structural adaptation to the same physiological function, the problem is not *solved,* but the point of view is simply changed, since the origin of such adaptations offers a group of knotty problems which will require painstaking research for their solution. If the cotyledons of many Onagraceæ are the homologues of haustorial organs, what is the nature and action of the 'correlation' which demands that the portion of the cotyledonary lamina interpolated after exposure to the light shall have a structure and venation in close agreement with that of the true leaves which follow rather than with the simple form and tissue of many other cotyledons which are photosynthetically active for a long time.

If, on the other hand, the old and generally accepted view is considered the correct one and cotyledons are regarded as foliar in nature, the series of forms is almost as puzzling and as much in need of broad and comparative investigation and arrangement.

The morphology of the cotyledon has been called into question through a consideration of the relationship of Monocotyledons and Dicotyledons. Apparent transitions from one great group to the other have been discovered. These apparent transition stages have been used to support two antagonistic views of the relationship of the two great groups. It is apparent that the special data so far secured are very meager and, if it exists, the connection between the two great groups must be

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established by the discovery of a more complete series of transition stages. If, on the other hand, the forms to which so much significance has been attached are merely adaptations to peculiar life conditions, assumed by a plant at an exceedingly plastic stage of its development, the problem of the relationship of the two great groups seems to be farther than ever from a satisfactory solution.

The value of seedling characters for the tracing of phylogenetic development in families and lower systematic groups and an understanding of past changes both in the race and in its environmental conditions, has been emphasized by several writers. The most satisfactory results in this field are those obtained by Ganong and Cockyane, who have both worked principally with xerophytic forms which offer especially promising material for such researches, though here extreme caution must be exercised in deciding whether distinctive characters of the adult are not merely an expression of the direct influence of the environment upon a plastic organism, while the juvenile stages, owing to the different conditions of growth, are not subjected to these influences, and consequently all the potentialities of their primordia may be realized instead of intercepted and diverted or modified by powerful environmental influences. It scarcely need be suggested that here experimental morphology and ecology have before them material for a series of very interesting monographs.

A field in which results of especial interest may be expected is the comparative investigation of the later developmental stages within the same systematic group. For families Ganong has presented a masterly treatment of the Cactaceæ and Willis has accumulated some data for, and suggested the importance of, such work in the Podostemaceæ, while Miss Sargent's work on the Liliaceæ, when it appears, will doubtless represent the most extensive study of the kind ever undertaken. In other families there is a large store of details waiting for supplementary researches and correlation. The results so far obtained show beyond question the interest, ecological, morphological and phylogenetic, attached to the study of these groups. While I would not discourage the investigations of these larger groups, it must be admitted that in the present state of our knowledge there are many uncertainties connected with the generalizations concerning their phylogeny, and for the present especial importance should be attached to the investigation of the minor groups, particularly the genera. We have little right to assume the monophyletic origin of the most of the families, while with the genus this is more justifiable, though even here the greatest caution must be used. The embryonic stages, especially the later ones, should be of the greatest value in just this connection, for theoretically they ought to furnish us with an indication of form prevailing prior to the assumption of the more specialized adaptive characters.

But before we may draw conclusions as to the phylogeny of a group or conclude whether monophyletic or polyphyletic in its origin, from characters offered by the later embryonic stages of its members, we must first understand thoroughly the seedling and its reaction to all the factors influencing it. This is a field not for comparative work alone, but for physiological, ecological and experimental morphological investigations as well. Comparative studies are of the highest importance, but in this case they must be carried out upon material of systematically homogeneous nature. Until the appearance of Professor de Vries's epoch-making work no one has had available for study a series of forms unquestionably descended from the same ancestor. It is highly desirable that some one take up such types as the new elementary species of Professor de Vries for the purpose of ascertaining in how far there is a relation of ancestral characters and to what extent there is in the seedling a working back into the embryo of the characters of the adult. While the new species of *Œnothera* described by Professor de Vries are the simplest systematic units, there are some very suggestive points to be found in his descriptions. The relative stages of development at which the differential

characteristics of the new species make their appearance seem not without significance. In some there is an immediate and complete obliteration of the *Lamarckiana* characters, while in others, as in the 'atavism' of *O. nanella,* the new characters replace those of the old only at a later period of development. Such cases as that of *Trifolium,* in which there was a working back into the embryo of the divided condition of the leaf as the number of leaflets characteristic of the mature plants increased offer suggestion for an important phase of statistical investigation. Investigations of the seedlings of some of the teratological 'varieties' may be expected to yield results of great interest, especially when taken up from the experimental and historical point of view.

The chief object of the study of seedling stages, phylogeny, is dependent for its realization upon the validity of the recapitulation theory. In many cases this seems to hold, but, as pointed out above, a broad, comparative investigation of minor groups is imperative. Results of importance are assured. Developmental stages in the same group will generally show either a close similarity or present a series of perplexing differences. The conclusion in the one case will be that community of descent or identical environmental conditions are responsible. In the other case —and of this a considerable number of striking illustrations might be cited—polyphyletic origin of groups hitherto supposed to be monophyletic must be assumed, or the differences must be accounted for on the ground of adaptation or mutation and the importance of ontogeny as a key to phylogeny greatly restricted. With reference to seedling stages the statement that ontogeny recapitulates phylogeny must be made with great reserve. Doubtless it has here an evolutionary significance, but its application is a matter of serious import. It seems to me that in vast numbers of cases, the sweeping back of later developed characters in the nature of adaptations to environment or otherwise has obliterated ancestral features, especially the superficial ones, to such an extent that an attempt to reconstruct the phylogenetic tree is quite out of the question.

In the examination of seedling stages, experimental morphology may find, as we have already suggested above, a fertile field for research in the determination of the degree of plasticity of juvenile and adult types. Some structures seem to be merely the result of the direct environmental influence, but others can not be modified by the changing of conditions. Some characters seem to be well fixed, while others are apparently merely the product of immediate influences of the environment. While phylogeny is the chief end, experimental morphology may find in seedling stages material of value for use in the formulation and solution of some of its fundamental problems.

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## *Current Notes on Meteorology.*

### Cyclonic and Anticyclonic Temperatures.

A very useful summary of 'Various Researches on the Temperature in Cyclones and Anticyclones in Temperate Latitudes' has been prepared by H. Helm Clayton, of Blue Hill Observatory, and is published in *Beiträge zur Physik der freien Atmosphäre,* Vol. I., No. 3, 1905. It is probably known to men of science generally that one of the most interesting of present-day problems in meteorology concerns the origin of the cyclones and anticyclones which are such characteristic phenomena of the prevailing westerly wind belts, and constantly impress themselves upon us by reason of their control of our weather changes. Mr. Clayton presents an outline of the work of Hann, Dechevrens, Berson, Teisserenc de Bort, Rotch and others, including his own important results; points out the contradiction which exists between the conclusions of those who believe that cyclones are colder than anticyclones and those who find them to be warmer, and gives it as his opinion that both sets of investigators may be partly right. The author calls attention to the fact that those who have found the cyclone colder have considered the temperature in relation