or yellow, I think I should have become conscious of the fact. It seemed to be followed by a faint line of light about half as long as its own body. From a point about 20 degrees southwest of the zenith it fell rather swiftly in a direction that would have brought it to the horizon at a point very nearly northwest (magnetic) of my position. I was unable, however, to follow it all the way to the horizon on account of the trees between my house and your cottage behind which it disappeared without having lost either its shape or its brightness. The time occupied by its fall was not more, I think, than three seconds. If you will hold the accompanying diagram above your head like a celestial chart and look up at it, facing the west, you will get an approximate idea of of the meteor's course as it appeared to me. The sun was shining brightly, but it did not overcome the brilliancy of the aerolite.

Sincerely yours,

GEORGE KENNAN.

BRETON COTTAGE, BADDECK, C. B.,
NOVA SCOTIA, June 26, 1897.

SCIENTIFIC LITERATURE.

WHAT ARE STIPULES?

'THE Nature and Origin of Stipules,' by A. A. Tyler, A. M. Presented to the Faculty of Pure Science of Columbia University in partial requirement for the degree of Doctor of Philosophy. Annals of the New York Academy of Sciences, Vol. X., New York, 1897, pp. 1–49, pl. i.–iii. Also separate: Contributions from the Department of Botany of Columbia University, No. 119.

This is, without doubt, the most considerable contribution that has been made to the vexed question of the nature of stipules; at least it is safe to say that it comes much nearer to a solution of that question than anything that has hitherto been brought forward. Although assuredly not the last word that will be said on the subject, nevertheless the light that had already been shed upon it by a long train of previous investigations placed the author in a position to treat it from an advanced standpoint.

Nearly half the paper, and that the first half, is devoted to summing up, in chronological order, the views that have been expressed and the conclusions that have been reached; but the paper is by no means a mere literary effort. It is itself the result of a series of special researches on the part of the author. Indeed, it may be looked upon as a new departure, since his investigations have proceeded from an almost entirely different standpoint from those of previous authors. He has made use of their labors and failures rather as a means of warning than as guides to his work.

Probably the most suggestive results that had been reached were those which, within the past decade, have been furnished by paleontology, and while he has singularly omitted to mention the researches of Saporta and Marion,* he has not left out of account those that have been made in America.† It is not too much to say that these paleontological discoveries have added more to our acquaintance with the true nature of stipules than the combined morphological studies of previous authors. If I do not mistake, it was from attention to paleontological considerations as thus brought out, that Mr. Tyler was led to adopt the method of his thesis, a method which had been wholly neglected hitherto, and yet the only one that seems to promise ultimate success in the solution of the problem.

The earliest of the above mentioned papers called attention to certain remarkable basilar expansions that occur in leaves of *Platanus basilobata*, a fossil species from the Fort Union

*Evolution du Règne Végétal, Pt. II., Phanérogames. Paris, 1885. See especially Vol. I., pp. 201–223; Vol. II., pp. 9-44.

†The Paleontologic History of the Genus Platanus by Lester F. Ward; Proc. U. S. Nat. Mus., Vol. XI., 1888, pp. 39–42, pl. xvii.–xxii. Origin of the Plane-Trees, by Lester F. Ward; Am. Nat., Vol. XXIV., September, 1890, pp. 797–810, pl. xxviii. Flora of the Dakota Group, by Leo Lesquereux; Monogr. U. S. Geol. Surv., Vol. XVII., pp. 65, 231, 232, 254. Wing-like Appendages on the Petioles of *Liriophyllum populoides* Lesq. and *Liriodendron alatum* Newb., with Descriptions of the Latter, by Arthur Hollick; Bull. Torr. Bot. Club, Vol. XXI., No. 11, November 24, 1894, pp. 467–471, pl. ccxx., ccxxi. Appendages to the Petioles of Liriodendra, by Arthur Hollick; Bull. Torr. Bot. Club, Vol. XXIII., No. 6, June, 1896, pp. 249–250, pl. cclxix., cclxx.

group, which was compared with another fossil species, *P. appendiculata* of Lesquereux, in which somewhat similar basilar expansions occur, but in this case separate from the main blade. The latter species comes from the Auriferous gravels of California, a much later formation, and it was argued that these two cases indicate a gradual separation of these lobes from the blade as having taken place in the progress of development. It was further shown that the living American species, *P. occidentalis*, sometimes has a small expansion at the base, through which the petiole passes, and that other cases may be found on young shoots in which these lobes are distinct from the blade.

The second paper cited, though chiefly a criticism of a memoir by Jankó, on the leaves of Platanus, discusses the subject of basilar expansions with additional illustrations.

Dr. Hollick's papers deal with an almost similar condition of things in the fossil species of Liriodendron. Both of these genera belong to what are known as waning types, and their present foliage has reached its highest state of development.

These and other facts that have been from time to time coming to light had begun to imbue botanists who had given attention to the subject with the general idea that stipules are morphologically portions of the leaf that have been gradually separated from the existing leaf blade through a process of development going on under the influence of the great principle of advantage in biology, which relegates to the domain of vestiges or obsolescent organs everything that has ceased to benefit the organism, a process which has as its ultimate result the complete extinction of such organs, and there is no doubt that in many cases modern exstipulate leaves have once had stipules and lost them, although it is also true, as Mr. Tyler shows, that in other cases, especially those of sessile leaves, no stipules have ever existed.

In 1894 Mr. Morong, in treating the genus Smilax,* said: "Most of the species climb upon other shrubs and trees by means of a pair of tendrils which grow at the summit of a stipular wing on each side of the petiole, often not developing till the stem is several years of age;" to which he adds in a footnote: "De Candolle regards this appendage as more in the nature of a modified leaf segment or leaflet than a stipule, but it seems to me that a stipule is nothing else than a leaflet at the base of a petiole." Mr. Tyler does not note this statement of Mr. Morong in his bibliographic summary, but it is characteristic both of Mr. Morong's keen insight into such matters and also of the general drift of botanical thought on the subject.

* Bull. Torr. Bot. Club, Vol. XXI., No. 9, September 29, 1894, p. 420.

In the paper before us there are brought out into clear light at least three distinct and highly important facts. The first relates to method. It had long been felt that the great need in botany was the study of plants from the embryological standpoint in some such way as animals have been studied with such remarkable results. The two great sources of our knowledge of development in both kingdoms are, first, paleontology, and second, embryology. Both of these had been almost totally neglected by botanists until within recent years. Something, it is true, had been done along the more general lines of plant development from the paleontological side, but scarcely anything in connection with the transformation that leaves undergo, and the few papers above quoted constitute practically all that has been done in this line. A number of attempts have, however, been made to approach the vegetable kingdom from the embryological point of view. But the seed being regarded in a certain sense as the homologue of the egg, most of these attempts have been devoted to the study of the seed and of seedlings, the great work of Sir John Lubbock constituting the most exhaustive of these efforts.

Mr. Tyler has shown in the present paper that the study of plant embryology should not proceed from a consideration of seeds and their development, but of buds, and that while botanists have been mainly seeking for light in the difficult study of seed embryos, the true source of such knowledge is the much more accessible phenomena of bud development. The figures that he has given abundantly demonstrate this truth, and henceforth there can be no doubt that botanists generally will proceed according to this method and that the

natural history of the leaf will soon be fully known.

The second lesson which Mr. Tyler's paper enforces is the one which paleontology, as we have seen, had already taught. What the leaf struggles to secure is the maximum amount of light and air. In this effort it constantly tends to stretch out as far a possible from the stem. The proximal portion, which is most shaded, is then sacrificed to the distal portion, and the leaf is differentiated into petiole and blade. But in this process various stages occur. Those parts which are of any advantage to the plant are in part retained, and the parts sacrificed are selected in the exact measure of their failure to benefit the plant.

Some may regard the principle of adaptation for securing the maximum light and air as inadequate to explain these modifications of the leaf, but it is this principle that determines not only the form but also the arrangement of leaves, and when we remember that opposite leaves are also decussate, that in whorled leaves those of one whorl stand over the intervals between those of the next whorl below, and that even in plants with alternate leaves the phyllotaxy is so adjusted as to secure the longest interval between one leaf and the next one that must stand directly over it, we not only see with what rigorous exactness this principle works, but also what apparently trifling differences in advantageousness are seized upon and made to count in producing manifest effects.

The least useful portion of a leaf is not that at the very base, but that which is some distance from the base, and even this may be partially retained as a wing to strengthen the leaf-stalk. The portion at the base is often preserved in one form or another, and we have seen, in the fossil and living species considered, how this may vary in the process of evolution, but in the most highly developed of our living flora, where it is retained at all, it is usually in the form of stipules, which have all conceivable shapes and differ in all degrees in their permanence, some being appropriated to other uses according to the law of vicarious function. Others are persistent as small organs of different forms. Still others are deciduous at varying stages in the growth of the leaf, some, as Mr. Tyler shows, never being seen except on dissecting the bud. The last stage in this process is their complete atrophy and the resultant wholly exstipulate leaf.

The third lesson that we learn from Mr. Tyler's studies is that monocotyledonous plants constitute an early stage in the process of leaf development. This is what would have been naturally supposed, but there has been a tendency of late to cast doubts upon the position of the monocotyledons and to maintain that they are as highly developed and that they have been as late in their appearance in geologic time as the dicotyledonous angiosperms. It must be admitted that the paleobotanists have been the ones who have chiefly taken this view. This has been due to the exceedingly meager representation which the monocotyledons have in the fossil floras of the globe, and especially to the natural doubts which have arisen as to the botanical character of most of the fossil forms that have been regarded as monocotyledons by certain authors. The Yuccites of Schimper, from the Lower Trias, as also his genus *Æthophyllum*, which he did not himself refer to that class, but which others have naturally regarded as a monocotyledonous plant, cannot certainly be claimed as ancestral monocotyledons, although the proof to the contrary is equally wanting. Scarcely anything that has been discovered in the great Jurassic floras of the world has even been called monocotyledonous, and very little that is certainly such occurs even in the Cretaceous. It is, therefore, been held by some that this class of plants first made its appearance with the palms of the Eocene, but so rich and varied is this Eocene palm flora that it presents a case analogous to that which until recently was offered by the dicotyledonous floras of the Middle Cretaceous, and requires the violent assumption that a great group of plants suddenly burst in upon the world and attained all at once a high state of development in widely separated regions. This assumption is now thoroughly disproved in regard to the dicotyledons by the discovery of early embryonic types at a much earlier age, naturally leading up to the higher types referred to.

The monocotyledons, from their very nature, are the least adapted of all forms of vegetable

life to be preserved in the fossil state, representing, as Saporta and Marion show, and as Mr. Tyler's researches fully bear out, the primitive form of leaf development, which consists simply in setting apart a portion of the growing plant to serve the purposes of leaves, consisting of more or less broad and elongated blades, usually embracing the stem and tapering gradually to a point, with the leaf bundles continued in straight lines parallel to each other throughout their entire length. They are, therefore, broadest at the base and least adapted to securing the ultimate purpose of leaves already mentioned, viz., the maximum amount of light and air. The process of leaf development began with this condition, and many of the forms in which the cotyledon is still single have acquired a blade, as, for example, many species of *Potamogeton*, *Smilax*, *Dioscorea*, etc. In *Smilax* and some other genera true stipules have been developed, along with the tendency towards their differentiation into tendrils and other useful organs.

An important obstacle to the preservation of monocotyledonous leaves in the fossil state is the absence in them of any definite joint or natural point of separation of the leaf from the stem, which is one of the earliest results in the process of leaf evolution, also involving the principle of the renewal of leaves at annual or other fixed periods, which has practically resulted in the indefinite multiplication of the leaves produced, increasing the chances of their preservation by the whole number of such renewals. The only chance for an ordinary monocotyledonous plant to become entombed and preserved in the fossil state is that the locality in which it grows shall become somewhat rapidly covered up, burying the entire plant so quickly that it cannot decay during the process. This, as anyone can see, must be an exceedingly rare occurrence. Still, there is no doubt that a large amount of monocotyledonous vegetation growing in bogs and marshes in estuarine regions that are slowly subsiding under the weight of materials brought down the streams, and which also aid in covering them up, has been, in fact, preserved in a very imperfect way, and many vague and puzzling objects occur in all collections made from such localities. They are found throughout the Mesozoic, in the form of short culm-like segments and imperfect bits of leaves so badly macerated that they are neglected by those who determine such collections. It is rarely possible to say what form of plant they really represent, and yet it is often clear that these remains belong to certain glumaceous forms, grasses, sedges, rushes, etc. Saporta, in his work on the Mesozoic of Portugal, described and figured, under the name of Poactites, quite a number of these forms from the Neo-Jurassic to the Albian, or through the Upper Jurassic and entire Lower Cretaceous. Others have been called Cyperites, Zosterites, Bambusium, etc. Numerous small seeds are also constantly occurring, which are for the most part unnamed or given such names as do not indicate their botanical affinities. Many of these probably belong to monocotyledonous plants.

Mr. Tyler's paper, with all its excellencies, conveys the impression of an unfinished production. One would say that in his hurry to use it as a thesis he had been obliged to close it up abruptly. Its most serious defect is the want of careful descriptions of the plates and figures explained in their numerical order for the convenient use of the reader. This condition of the paper suggests the probability that the writer has much additional material, and inspires the hope that he may have entered upon a much more extended and exhaustive series of observations along these suggestive lines.

LESTER F. WARD.

On the Genera of Rodents: An Attempt to bring up to Date the current Arrangement of the Order. By OLDFIELD THOMAS, F.Z.S. Proc. Zool. Soc., London, 1896, pp. 1012–1028. Issued April, 1897.

The order Rodentia offers peculiar difficulties to the student, both on account of the number of its species and the great variety of forms which it includes. The satisfactory arrangement of the thousand or more species now known is no easy matter, as shown by the attempts of several authors, notably Waterhouse in 1839–48, Gervais in 1848–53, Brandt in 1855, Lilljeborg in 1866, Gill in 1872, and Alston in 1876. During the last ten years more progress has been made in the study of mammals than