SCIENCE

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THE NEW BOTANY.

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THIS is an age of new sciences; at least we have a new chemistry, a new astronomy, and a new geology. May we not have a new botany? The real science of botany is what we know of the origin and nature of plants. All other knowledge about plants is preparatory to this. Not only is this true of descriptive botany, which is merely taking off the slabs, as it were, but it is true of structural botany, even where this becomes histological. What has been the object of all the thorough and profound investigations of the German botanists? To show how the existing vegetation has become what it is and how the various kinds of plants are related to one another from the standpoint of real kinship. In a word, it is the development of plant life that constitutes the true science of botany. And think of the enormous labor and research that it has required to arrive at this through the study of the existing plants alone! Whether we consider the working-out of the anatomical structure of all the various types of vegetation in order to conclude from the different grades of tissue along what lines development has taken place, or whether it be the reproductive organs that engage attention, from the relationships of which the course of botanical evolution may be inferred, the task in either and in any case is immense and has properly engrossed the attention and absorbed the energies of the foremost students of that noble science. And it is proper that the great universities should have prominent chairs of botany to push on the solution of the still unsolved problems of the vegetable world.

But there are two routes that lead to these important results. There are two methods by which the development of plant life may be studied. The one I have outlined is what Huxley has so happily called "the method of Zadig."[1] The past is seen through the present and ancestral forms are inferred from the marks they have stamped upon their posterity. It is a true scientific method, usually the best that nature affords, and it has led us to the greater part of the knowledge we possess with respect to the evolution of world systems, of our own planet's history, and of the development of organic beings.

But far better than this method of "retrospective prophecy" or rational inference, wherever it can be applied, is the method of direct comparison. No one claims that the nature of a form can be reasoned out from no matter how complete a series of facts with the same certainty that it can be learned if it can be actually brought forward for direct observation. Yet this latter is the method of paleontology in all the departments of life to which it can be applied. In the animal kingdom this great resource is freely drawn upon, but in the study of plants it is almost entirely neglected. In all Europe I can only name one chair of botany, that of the University of Strasburg, which is occupied by one who has paid special attention to the paleontological side. In America there is none, and yet we have several able students of botanical evolution from the morphological side, who are doing excellent work. I will not be deemed invidious if I mention the thorough and successful researches of Professor Douglas H. Campbell of the Leland Stanford, Jr., University.

Why have we not equally competent men at work upon the ancient forms? It can no longer be said that the material is wanting. It exists in vast quantities and excellent quality. There have been already collected and not yet at all studied fossil plants enough to furnish employment for a corps of investigators during the balance of the present century. But what exists is nothing to what may be easily obtained. I could direct any one to hundreds of localities where a little labor would certainly be rewarded by abundant results. In nearly all the geological formations of the United States, from the Devonian to the Pleistocene, there exist rich beds of vegetable remains, as yet only slightly explored, which, if thoroughly developed and studied, would, with scarcely any doubt, throw more light on the evolution of our American floras than any amount of histological investigation of those floras themselves as we now find them could be expected to do.

Without going into details, and omitting entirely the Paleozoic floras, which, as every one knows, are very rich in America and have been chiefly studied, a glance at the Mesozoic and Cenozoic series may be of interest. It begins, so far as we now know the plant-bearing horizons, with the Upper Trias, but this, as I have shown,[2] is found in nine of the States and Territories of the Union, and has already yielded 119 species of fossil plants, sufficient to fix with great accuracy the geological position of the beds and show the general character of the vegetation that flourished on this continent at that remote period. We also know that extensive Permian deposits occur in the West, and there is hope that the interval between these and the plant-bearing Trias may yet be bridged over by the discovery of Lower Triassic forms.

We as yet know nothing of the Jurassic flora of America, unless the Trinity beds of Texas, the supposed Kootanie deposits of Montana, and the lowest Potomac strata of Virginia prove to reach downward into that system. But in these and the great series of clays that overlie them and seem to occupy the entire interval to the Laminated Sands of New Jersey, placed in the Upper Cretaceous, we have an immense period represented by successive plant-bearing horizons, and by scarcely any other remains of life, from which, at this writing, nearly a thousand different plant forms are known, with large collections still awaiting study. If to this we add the great Dakota formation of Kansas and Nebraska, we nearly double these figures, and have a Lower and Middle Cretaceous flora that compares favorably in its number and extent with that of the same areas at the present day.

Between this and the rich Laramie flora of the extreme Upper Cretaceous there is a newly-discovered plant-bearing horizon in the Montana formation, probably the equivalent of the Belly River series of the Canadian geologists, the flora of which is as yet very little known.[3] Of the Laramie flora I need scarcely speak[4] further than to say that all that has thus far been done is merely preliminary to the elaboration of the extensive collections that I have myself made in this vast store-house of facts bearing upon the history and nature of plant life on this continent.

Overlying the Laramie, or perhaps forming an upper member of it, and occupying wide areas west of the great plains, are other plant-bearing deposits, some of them now known as the Denver formation, others of more doubtful age embracing the Carbon and Evanston coal-fields of Wyoming, others farther north long known as the Fort Union group, and all taken together nearly or quite filling the interval from the recognized Laramie to the Green River group, about whose Tertiary age there has never been any question; and this last itself has entombed along with its beautiful fishes and with insects a great number of vegetable remains in an admirable state of preservation.

In Montana, about the sources of both the Upper Missouri and the Yellowstone Rivers, especially in the Bozeman coal mines

[1] Nineteenth Century for June, 1880, vol. vii., p. 929.

[2] Bulletin of the Geological Society of America, Proceedings, vol. iii., 1891, pp. 23-31.

[3] See the American Journal of Science for April, 1884, 3d Series, vol. xxvii., pp. 292-303.

[4] See my Synopsis of the Flora of the Laramie Group. Sixth Annual Report of the U. S. Geological Survey, 1884-85, pp. 399-557, pl. xxxi.-lxv.; also, Types of the Laramie Flora. Bulletin of the U. S. Geological Survey, No. 37.

and on the flanks of the Amethyst Mountain in the National Yellowstone Park, the series, probably beginning as early as Laramie age, is represented by an almost unbroken succession of plant-yielding deposits, extending upward into the Volcanic Tertiary, where the ruins of vast Sequoian forests mantle the slopes with their erect and prostrate trunks, among whose still persisting roots of stone lie buried in great profusion the more delicate parts, branches, leaves, fruits, and even flowers, of a rich and varied flora. Thousands of beautifully preserved impressions of these have been collected by Professor Knowlton and myself in two field seasons' operations, besides a most extensive series of the silicified wood, showing its internal structure as perfectly as if it were still living.

On the other side of the great continental divide, in California, Oregon, and Washington, there are Miocene and still later deposits, in which have been found the later floras of the continent, but whose extent can as yet only be conjectured. Even in Alaska there are great areas which have only to be scratched to make them tell of oaks and willows and a great number of vegetable forms that flourished there in late Tertiary time, the analogues of which are now only found in the latitude of the States and along the Atlantic border.

Is it possible that botanists care nothing for all this? Do they prefer to drudge upon the tissues of living plants to learn what may be known by actually confronting the witnesses themselves of the real character of the ancient vegetation of the earth and the true lines along which it has developed? It cannot be. And yet such would be the logic of their action. The truth is that institutions of learning, much like the masses of mankind, are the votaries of fashion. It is fashionable to found chairs of structural and physiological botany, and it is fashionable to occupy them and work out refined problems in the niceties of the science. Would there were no worse fashions! "These ought ye to have done and not to leave the other undone." The government has led the way, through its several geological surveys, in establishing the existence of these inexhaustible sources of botanical knowledge, but it cannot, and probably should not, sustain the careful and prolonged researches necessary to the solution of the many and important scientific problems that naturally grow out of such a mass of information. It can only use the data thus accumulated in the settlement of the geological questions involved, and in the development of the economic resources of the country to which they serve as aids. The purely scientific results belong to the higher institutions of learning to work out. It is true that only the great and well-endowed ones can conveniently undertake this work, but these are in condition to do so, and there is nothing that could reflect greater credit upon an American university. Such institutions make themselves a history by the original research they foster and not by their pedagogic achievements. A proper amount of teaching in the form of lectures growing out of laboratory work is useful to give precision to such work as well as to instruct, but it should never engross the energy of the teacher to the exclusion of the chief object, the advancement of science. In this case the materials are bulky and their collection and transportation expensive, yet several leading American colleges have frequently indulged in this part of the expense, and then, strangely enough, stopped there, and stored their cellars with undetermined material; or, if they have gone further, as at Princeton, and been to the expense of installing the specimens in their museums and employing a curator to take charge of them, they only cumber their shelves with unnamed and unknown objects, to be looked at as mere curiosities.

To set forth any detailed plan for putting these suggestions into practice would unduly prolong this article, but surely no one will claim that the prosecution of paleobotanical research is impracticable in a country that boasts of such universities as those at Chicago and at Palo Alto. All that is needed is that its importance be recognized; the task of reducing it to practice is only a matter of administration. The difficulty is to persuade educators to look to value instead of custom in the encouragement of research. The great energy that is devoted to small things is only less strange than the little energy that is devoted to great things, and a new and advanced spirit needs to be breathed into our higher education.

The new botany is not merely the study of plants from the paleontological side; it is their study from all sides and from all points of view, and a school of botany in a great modern university should no more limit itself to the facts that living plants present than a school of history should be narrowed down to the old method of recounting the deeds of kings, dynasties, and warriors as constituting all of human history. The mere "determination" of fossil plants, although of course the most laborious part, is a comparatively unimportant part from the botanical standpoint. The great work is their affiliation. As I have shown, we have in America a succession of plant-bearing horizons not so widely separated in time but that the later forms may be in large degree affiliated upon the next earlier ones. so that, in the right hands, there is hope that something like a complete history of plant development may be ultimately worked out. No grander theme presents itself to the scientific world, and the time is ripe for its inauguration. Hitherto the study of fossil plants has been conducted wholly from the geological standpoint, and, as I have been obliged to insist,[1] this does not necessarily involve the correct systematic determination of fossil forms, provided their identity can be surely recognized wherever found. A new method is therefore loudly called for, by which far greater certainty than heretofore can be reached in establishing the real nature and affinities of extinct floras. In other words, they must be studied from the botanical standpoint and all the light brought to bear upon them that the known flora of the whole globe is able to shed. This is no simple task, it is one that demands the highest ability and the widest facilities. But thus pursued, with sufficient time, patience, and labor, its success is certain, and its value beyond calculation.

THE STRUCTURE OF INSECT TRACHEÆ, WITH SPECIAL REFERENCE TO THOSE OF ZAITHA FLUMINEA.

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THE following paper has a threefold purpose. First, to confirm an important discovery made in this country, but, so far as I have been able to learn, never corroborated in any American publication. It was Professor George Macloskie of Princeton College who announced in *The American Naturalist* for 1884, page 567, that the so-called spiral threads of insect tracheæ are in reality chitinous folds of the membrane, and consequently tubules, which are longitudinally fissured. Professor A. S. Packard, in the same magazine for 1886, page 438, in a paper "On the Nature and Origin of the So-Called Spiral Thread of Tracheæ," says, "All the figures of the spiral thread hitherto published I believe to be incorrect," adding in a foot-note that "Thus far I find myself unable to agree with Professor G. Macloskie that the 'spirals of the proper tracheæ' are 'crenulated thickenings of the intima,' or that the tænidia are really tubular." Unless I have overlooked some more recent American contribution to the literature of the subject, this is the latest statement, with the single exception of a short note from Professor Macloskie himself published in a recent number of *Science*, in which communication his former conclusions are re-affirmed, as the result of another examination of the so-called spirals. But, although Dr. Packard does not accept these conclusions, he suggests the word "tænidium" as a name descriptive of the solid thread, as it is generally considered to be, a name which it may be well to adopt but with a meaning somewhat different from that attached to it by its learned inventor, who considers the objects which the word describes "to be separate, independent, solid rings, more or less parallel and independent of each other, . . . usually thin, flat, but often concavo-convex, the hollow looking toward the centre of the tracheæ."

Some months ago my correspondent, Mr. Fr. Dienelt of Lodi, Illinois, sent me a microscope slide of the tracheæ of the not uncommon aquatic bug *Zaitha fluminea*, for a purpose to be specially referred to hereafter, but one that had no connection with the structure of the tænidia; and, still more recently, at my request, Mr. B. F. Quimby of Chicago collected in Jackson Park, in that city, several specimens of the same insect and kindly sent them

[1] American Geologist, vol. ix., January, 1892, pp. 39-40.