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.

BY DR. ALFRED C. STOKES, TRENTON, N.J.

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 the

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

to me, as I had observed on Mr. Dienelt's preparation certain structural points which together form the subject of this paper.

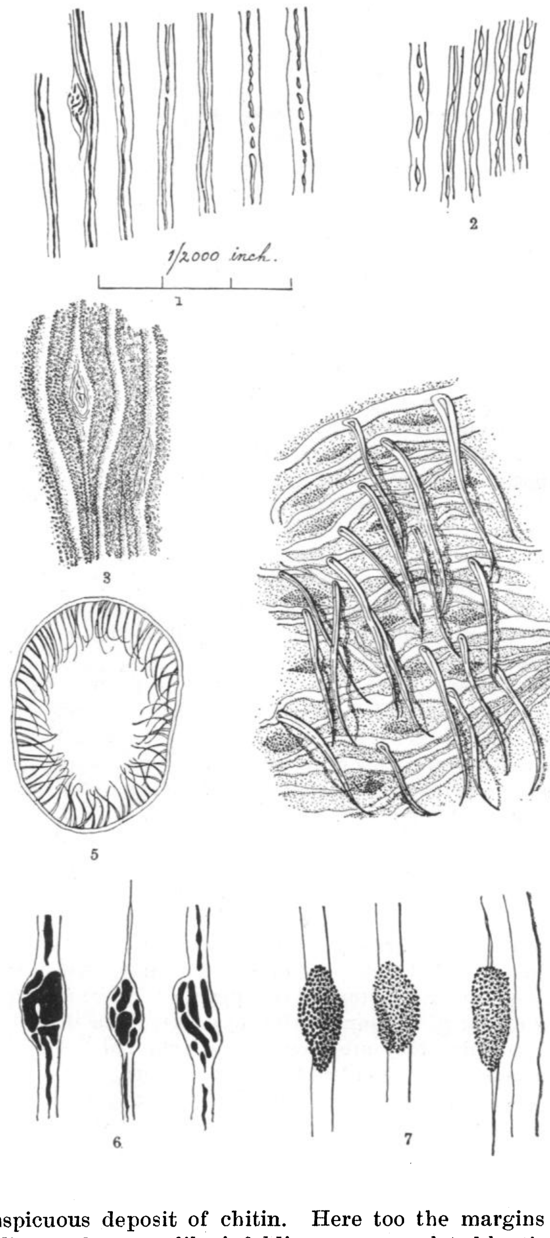
The tracheæ of the insect are large, and, as the tænidia are also comparatively broad, the entire collection of tracheal tubes, especially in the principal trunks, readily lend themselves to investigation. It is here an easy task to demonstrate that the tænidia are fissured tubules formed within and from chitinized folds of the intima, the convexity of the folds looking toward the lumen of the tracheæ, the fissure, as Professor Macloskie has observed, being directed away from that lumen. In balsam mounts, and perhaps somewhat more distinctly in glycerine preparations, under a wide angled, homogenous immersion $\frac{1}{12}$-inch objective, the irregular edges of the longitudinal fissure in each tænidium of the larger tracheæ can be seen and studied at the microscopist's pleasure; indeed, so well marked are they that they may easily be seen with Zeiss's apochromatic 6-millimeter objective, 0.95 N. A., and, in favorable circumstances, with Gundlach's dry $\frac{1}{5}$, N. A. 0.92. The appearances are in no way those of the diffraction phenomena produced by solid fibres, but rather an aspect which suggests the illumination of a hollow tube by reflection from its walls. The method of focussing which gives this bright band yields a picture of the edges of the fissures, with a more or less brilliant space between them. But by using the method employed by every well-informed microscopist when studying the secondary structure of the diatoms, a different appearance is obtained. The method is nothing more than a certain manner of focussing the objective, but one which produces the "black dot resolution" which has revealed so much of importance in reference to the intimate structure of those silicious plants. The "black dot" focus is as correct when applied to these minute tænidia as when obtained over the secondary membranes of the diatoms. With it the margins of the tænidial fissures are separated by a black space that defines them and every irregularity of the edges with convincing distinctness.

These margins are not parallel, a fact which alone would preclude the possibility that the appearances are diffraction phenomena. Neither is the fissure that separates them even in width. It is narrowed in indescribable ways by the approach of one margin toward the other, by a retreat from each other, and by wavy and more or less crenulated outlines. In some tænidia these margins have come in contact and have apparently been united, showing, in many instances, the point of union as an exceedingly slender line, whilst in others the juncture has been obliterated, and in still others the union has been accomplished in such a way that minute and irregular spaces have been left in the course of the original fissure, like little islands of darkness, or of brightness, according as the microscopist uses the black dot resolution, or focusses for the illuminated band.

In Fig. 1 are shown portions of several tænidia exhibiting the fissure, and, although the drawings were originally made with the camera lucida, they are necessarily somewhat diagrammatic. The one two-thousandth inch scale appended, is magnified to the same degree as are the tænidia, but is applicable to these particular drawings only, and not to the spaces between them. In the first two bands on the left-hand side the fissure is shown black, as I think it should be, whilst in the others it is left white, to exhibit rather more distinctly for this purpose the irregular margins and the irregular widths of the fissure. In the last two portions on the right-hand side, and in the five of Fig. 2, are delineated some of the various aspects assumed by the union of the edges of the fissures, and the formation of what may be called apertures in a chitinous bridge.

The fissures are so distinctly defined in ordinary preparations that sections of the tænidia are not necessary to show them. Such sections, however, are desirable, but to make them is an impossibility for me. The microscopist that nowadays tries to work alone and without a laboratory at his disposal, and without the refinements of microtomy and of photo-micrography, can do but little at a disadvantage. Yet when a tænidium is traced to the folded and flattened margin of a large trachea, in some instances the narrow, externally concave fissure can be plainly seen, although confusing diffraction effects must there be contended with. A longitudinal section of the tube, that is, a transverse section of these tænidia, would present a superb and convincing picture.

Not only do the tænidia of this special insect (*Zaitha fluminea*) clearly reveal the fact that they are longitudinally fissured tubules, but these tracheæ as clearly show that the so-called spirals are inwardly directed folds of the membrane. This is especially conspicuous near the spiracles, where the tracheæ, both on their internal and external surfaces, exhibit evidences of the fact. Near the spiracles the tracheal membrane is externally studded with minute papillæ, which become fewer and smaller as the distance from the spiracle increases. Here the intima is thrown into folds so shallow and so broad that they are often mere grooves, and with no specially




conspicuous deposit of chitin. Here too the margins of these shallow and groove-like infoldings are crenulated by the papillæ, which become more conspicuous as they are presented in profile on the edge of the furrow. An attempt has been made to show this appearance in Fig. 3, where are delineated three broad and incomplete tænidia, with the tapering termination, or the beginning, of another. Here they are only broad grooves, with no appearance of the narrow fissure of the completed tænidium, as it is now all fissure; in many instances these shallow depressions are even more irregular than shown in the figure. Near the spiracles they are sometimes hardly more than a collection of wrinkles in the crumpled membrane, as is delineated in Fig. 4, which is an attempt to exhibit a portion of the internal surface of a large trachea near the external orifice, the membrane being hardly more, so far as the tænidia are concerned, than a mass of wrinkles whose folds project into the lumen of the trachea and are scarcely chitinous, when in that respect they are compared with what, for the want of a better name, I have called the completed tænidia.

The second object of my paper is to call attention to certain tracheal appendages which were discovered by Dujardin as long ago as 1849, and by him referred to in a brief note published on page 674 of *Comptes Rendus* for that year. Since then they seem to have been almost forgotten. These are internal, chitinous, hair-like bodies arising from the fold of the tænidia and projecting into the lumen of the tubes. Dujardin gives a list of the insects in whose tracheæ he has seen these hairs, and remarks upon the evidence which they afford as to the external origin of the tracheal intima. A few scattered references to the observation may be found in the European literature of the subject, with absolutely none in this country, with the exception of one contribution by Dr. Henry Shimer of Mount Carroll, Ill., in an elementary microscopical magazine, with one or two made by me in the same journal, my hope being thereby to interest amateur microscopists in the matter, and one or two additional notes by Mr. Fr. Dienelt in a similar magazine (*The Observer*, Portland, Conn.), intended to accomplish the same purpose. This occurred within the last two years, and with these unimportant exceptions, internal tracheal hairs seem never to have been noticed by any American microscopist, although insects possessing them are not uncommon. My own first acquaintance with them was brought about through the courtesy of my correspondent, Mr. Fr. Dienelt of Loda, Illinois, who sent me a slide of the tracheæ from the common Colorado potato beetle (*Doryphora decemlineata*), calling my attention to certain appearances within them which he was at a loss to interpret. These proved to be produced by tracheal hairs similar to those discovered by Dujardin, and since examining that preparation I have seen the appendages in the tracheæ from the ovipositor of the common house fly, whilst Mr. Dienelt has observed them in several other insects; indeed, it was he who called my attention to their abundance and to their great size in the tracheæ of *Zaitha fluminea*.

Whether they are of any importance in the economy of the insect possessing them, it is of course impossible to do more than to conjecture. Dujardin has called attention to their use as evidence in regard to the external origin of the tracheal membrane, referring to them as epidermal appendages, analogous to those of the wings or of the tegument.

In the larger tubes of *Zaitha* these hairs are so abundant that the surface is villous with them. They gradually become fewer as the tracheæ ramify and grow smaller, until they entirely disappear from the finer divisions. They arise from the chitinous folds of the membrane, rarely from the intima itself between the tænidia, and extend obliquely into the lumen, their free extremities usually being directed toward the spiracle. They are hollow, their minute lumen communicating distinctly with that of the tænidium, to which they are attached, or from which they arise by an enlarged base. Their length averages about $\frac{1}{400}$ of an inch, although it is difficult to measure them with any accuracy, as they are rarely straight. The free extremity of each tapers to an exceedingly fine point, which is sometimes bifid, occasionally trifid. In Fig. 4 several are shown attached to the wrinkles of the tracheæ near a spiracle, and in Fig. 5 is exhibited a transverse section of a tube with the hairs projecting into its lumen.

The third and last of the points to which this paper is devoted is one which, so far as I have been able to ascertain, has not been previously observed as a part of the structure of any insect's tracheæ. These are certain minute, elliptical bodies in the tænidia, each with an internal, presumably glandular, appendage, to all appearance forming part of the tænidium from which it springs. Whilst these are numerous in the main trunks and in the larger branches where the hairs are abundant, they are more conspicuous and seem also to be more numerous in those that bear but few of these internal filamentous appendages.

The external bodies were at first supposed to be the remains of hairs which had been broken away in the preparation of the tracheæ for microscopical study, but further examination soon dispelled that illusion, as the objects differ widely from the bases of the hairs, which are only thick-walled circular openings. The enigmatical bodies are more or less elliptical or elongate-ovate in contour, no two being of precisely the same shape nor of the same size, although in size they are rather more constant, the diameter varying from $\frac{1}{5000}$ to $\frac{1}{8000}$ of an inch, the length externally being about $\frac{1}{3000}$ of an inch, or but little longer than the diameter of a human red blood-corpuscle. They are commonly in the tænidia, the lateral margins of the fissure within the latter separating to give them space, and they are perforated in the most irregular way, the small apertures varying in number and in form as the bodies themselves vary in shape, the openings occasionally being reduced to a single circular one. These objects are shown in Fig. 1, within the short tænidium beside the second on the left-hand side; in Fig. 3, where there are two in the broad, shallow folds of the membrane, and more in detail by Fig. 6.

Here again enters another application of the diatomist's black dot resolution which has made plain the structure of the secondary membrane of so many of those plants. In Fig. 6 the black dot resolution shows the perforations, which are always irregular in number and in form, with the space between the uneven edges of the tænidium, and, in the sketch on the right-hand side, the continuation of an aperture with the tænidial fissure.

These elliptical, cribriform bodies seldom occur on the tracheal membrane between the tubules. Occasionally they are seen to form the principal portion of a short, otherwise solid, tænidium, which to all appearance has been produced only to accommodate that special object. In such cases there is but one; usually a single tubule possesses several.

The perforations pass through the substance of the tænidium and are received, usually by means of a short pedicle, in a cushion-like, apparently glandular, body attached to the inner surface and projecting into the lumen of the trachea. In Fig. 7 are shown three of these glandular bodies, if they are glandular; and it is equally difficult to suppose that they are and that they are not. They appear under the microscope as collections of exceedingly minute, rounded apertures, which, in certain positions, may be seen to be continuous with narrow passages directed toward the pedicle, when that exists, and toward the external cribriform plate. Their structure in minuteness is comparable with the secondary structure of the diatoms, which I have so often mentioned, being as exquisite and as difficult to resolve, in this taxing the good qualities of the microscopist's best objectives. The thickness of the cushion-like objects is about $\frac{1}{8000}$ of an inch, a space capable of being occupied by much microscopic structure.

Although they do not commonly occur on the tracheal membrane between the tænidia, they may be found there, as shown in Fig. 4, where is delineated a portion of a crumpled region of the membrane near a spiracle, with a few hairs and with several of these problematical, presumably glandular, bodies scattered about ike so many islands in a sea of wrinkles.

What their function may be it is difficult to conjecture. Their position within the lumen of the tracheæ, and their connection with the external cribriform spaces, in no way simplify the problem.

Their presence, however, seems to add a unique scientific value to the tracheal tubes of *Zaitha fluminea*, to say nothing of microscopical interest. A microscopist, with a well-trained and intelligent microtomist to do his bidding, might be able to add much to our knowledge of the structure, not only of these apparently glandular organs of the pedicle and the perforated, elliptical objects, but of certain other regions of these remarkable tracheæ.

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## CURRENT NOTES ON ANTHROPOLOGY.—XXI.

[*Edited by D. G. Brinton, M.D., LL.D.*]

### The So-Called Caucasian Race.

IN a paper which he presented to the Moscow Congress last summer, M. Ernest Chantre, well known for his profound studies in the ethnology of north-western Asia, enters a remonstrance against the erroneous use of the term "Caucasian Race," as