CURIOUS ANOMALY IN HISTORY OF CERTAIN LARVÆ OF ACRONYCTA OBLINITA, GUENEE, AND HINTS ON PHYLOGENY OF LEPIDOPTERA.

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In the autumn of 1873, numerous larvæ of *Acronycta oblinita* were observed by the writer feeding upon the leaves of *Polygonum Pennsylvanicum*. Their ravages were confined to a limited region, in which a plentiful supply of their favorite food was found to meet the most vigorous demands. Within a space of fifty feet square, more than a hundred were counted. A diligent search through the adjoining country failed to reveal any further traces of them. As this species of weed is particularly prolific in Germantown, I had hoped to meet with other larvæ of the same species. Instances have occurred in the writer's experience, and doubtless in the experience of others, of comparatively small scopes of country yielding ample nourishment to hosts of larvæ of a particular species. This is usually noticeable among lepidoptera, which instinctively deposit their ova either in single clusters, or in small collections but slightly isolated from each other. *Vanessa antiopa* affords a familiar illustration of the foregoing assertion.

During the summer of 1867, I daily observed in a grove of red maples a desperate encounter which a score of *Calosoma scrutator* was waging against the harmless, though terrible-looking caterpillars of *Vanessa antiopa*. Although the destruction was on a singularly grand scale, yet hundreds of larvæ remained to undergo their transformations during the latter part of August. The eaves of the buildings in close proximity, fence rails, and in short nearly every available place, were hung with the angular chrysalides. So numerous were the latter, that after the final metamorphoses had passed, the red fluid which was ejected by the tender and newly-formed butterflies, gave everything the appearance of having been profusely spattered with blood.

The area subjected to the desolating influence of these larvæ, did not cover less than two acres of ground. It is worthy of remark, that during the same summer this section of country was unfortunately visited by legions of *Cicada septemdecim*.

It is but occasionally in many years that unusual numbers of a

particular species make their appearance in the same locality. A combination of circumstances exists to impose an effectual check upon the undue multiplication of insect life, where nature is not interfered with by man's devices. There are without doubt, in the case referred to, assignable causes for such an undue increase.

Coming back from this digression, the larvæ of *Acronycta* continued to feed during the entire month of October before entering into the pupa state. As a matter of convenience, many were taken home by the writer, placed within a *vivarium*, and fed indiscriminately upon the leaves of various species of *Polygonum*, with remarkable success.

During the latter part of the feeding-time, there being a scarcity of food plants in the immediate neighborhood in which he resided, the thermometer indicating a rather low degree of temperature, his charges were uncared for, and permitted to ramble about their cage for days without suitable and wholesome nourishment. In this predicament many passed into pupæ.

It is well known that the larva of this species constructs a slightly spindle-shaped cocoon. To constitute a framework for this essential covering, it places itself upon a small branch where there is an abundance of leaves at convenient distances which it unites by a perfect network of fibres, stretching from leaf to leaf, or from stalk to leaves, lengthening and shortening as necessity demands, until the desired configuration is assumed. Within this structure, after the lapse of a definite period, it passes into a chrysalis.

Being a spinner of silk, this *Noctuid* approximates very closely a *Bombycid*, the numerous members of whose family, with comparatively few exceptions, are cocoon-builders. So intimately related to this family is the genus *Acronycta*, that it has been retained in the tribe *Bombycoides* of Hübner. So important is the habit of cocoon-manufacture, that it constitutes one of the chief points of distinction between Nocturnal and Diurnal Lepidoptera. For a species that has been proverbial for cocoon-making, any marked deviation from what has been ordinarily observed, would excite no little surprise, and, doubtless, would be accepted by some who are slaves to their prejudices, with considerable hesitation.

While the majority of my larvæ of *Acronycta* passed through their transformations in the normal manner, at least three without the slightest attempt at cocoon-making, like the larva of *Thyreus*

Abbottii, lay upon the surface of the soil, and after a period of five days entered the chrysalis form. By comparison with chrysalides which had been divested of their silken coverings, I could not discern more than ordinary variation. These chrysalides developed into male moths.

That differences occur in the size, shape, and color of cocoons, I am convinced beyond a doubt. The surroundings of a larva and the quantity of its food, have much to do with the size and configuration of its cocoon; while the character and quality of the food affect the color of the same.

Where the molecules of matter that enter into the physical composition of a leaf maintain a nearly perfect stability, by undergoing few or no re-arrangements, the characteristic color will be reflected. Various circumstances, such as the existence of an acid, tend to bring about these molecular re-arrangements. The puncture of a leaf by a *Cynip*, and the want of healthy action therein by inability to decompose the carbonic acid of the atmosphere, are producing causes.

We are all familiar with the changes which leaves undergo in the autumn consequent upon the diminished flow of sap into their petioles, and the somewhat lessened vigor of the sun, that source of life and light, passing from green to black through the transitional tints of yellow, orange, red, and brown.

If the colors of leaves are determined in a measure by molecular arrangements, why may not the introduction of certain kinds of food into an insect's economy, materially different from what it has been accustomed to, so impress with change the organs whose functional business it is to elaborate the fluid which it utilizes in the manufacture of its cocoon as to reflect different colors or shades of colors? I can see no difficulty in the matter. Indeed, it has been shown that if the mulberry silkworm, *Bombyx mori*, be fed upon its natural food for a limited period, and then upon the leaves of different plant-species, it will elaborate a thread dissimilar in color to what is ordinarily produced. To the success of this experiment it is not absolutely essential that the larva should be fed upon its natural food primarily as asserted, as some late experiments of mine testify.

Where the essential conditions are present, such as abundance of leaves of natural food-plant, and a freedom upon the part of

the insect to carry out its natural instincts, the cocoon of the same species varies but little, if at all, from the characteristic type.

It is well known that birds vary their styles of architecture in correspondence with changes in their *environment*. What just reason can be adduced for non-variation in the cocoon-making of silk-spinners? Primitively, when the natural sequence of events was not disarranged by the devices of man, a remarkable degree of uniformity, doubtless, prevailed in *nidification* among individuals of the same species; but, latterly, with some exceptions, however, varieties do occur which betray such marked deviations from ordinary types that to the most experienced and critical eye they seem stamped with a newness of design truly astonishing. In the absence of positive evidence *per contra*, they might, with some show of reason, be attributed to the workmanship of essentially different species of unknown habits.

Sticklers for the doctrine of never-varying instinct as determining and controlling the actions of the feathered creation in opposition to intelligent reason, would easily persuade themselves, no doubt, that perceptible differences did not occur, and would argue that the same species manufactured the identical style of nest in these latter times as in the beginning, in the face of the strongest array of evidence.

Instances of variation have been recorded in ornithological literature. The writer has noticed in the Proceedings of the Philadelphia Academy of Natural Sciences, a remarkable deviation fron the typical nest in the case of *Sayornis fuscus*, Baird, so striking and marked as to elicit considerable astonishment, but based upon the most satisfactory and positive evidence.

If changes be introduced into the *environment* of a species of *avis*, by the arts of civilized life or otherwise, sufficiently potent to impress its *sensorium*, so as necessarily to lead to changes of habit whereby a continuance of the species is provided for, and the existing harmony of a moiety of creation remains undisturbed, the argument is irresistible, that, in localities where the food-plant or plants of a larva have disappeared through human civilization, or defeat in the plant's "struggle for existence," being supplanted by another better adapted to the new conditions of life, the insect itself will either succumb or adapt itself to the altered phase of affairs.

Such facts as this hypothetical case presupposes, have fallen

under my notice. *Eacles imperialis*, Hübner, was, a few years ago, always to be looked for upon coniferous plants. During the last three years but few individuals have been observed upon plants of this family; for every one feeding thereon, scores have been taken from *Acer rubrum* and *A. saccharinum;* occasionally from the English walnut, *Juglans regia*. *Citheronia regalis*, Fabr., upon *Acer rubrum*. *Platysamia cecropia* upon *Ribes rubrum*, *Acer rubrum*, *A. saccharinum*, and *Pyrus malus*. Other examples might be cited, but enough have been adduced for the writer's purposes. In the cases of *regalis* and *imperialis*, alterations in larval structure have occurred, as diminution in size, smaller development of spiniferous tubercles, color variations to a limited degree; and in case of *imperialis* particularly, comparative smoothness of body, very *few hairs being noticeable*. Still further changes have been observed. It is stated in books that many larvæ which enter the ground preparatory to assuming the chrysalis form, ordinarily construct earthen cells which they line with a thin layer of silk, and subsequently coat with a varnish-like secretion, to render them impervious to water. That this is only occasionally so, I am satisfied from years of experience. That *regalis* and *imperialis* enter the ground is the common experience of lepidopterists; but it is not necessarily so. In many instances, I have witnessed the change effected near the surface of the soil, within a slight cavity which the larvæ by their motions had created, and with considerable portions of the upper surfaces exposed. Again, the change has occurred upon the surface of the soil, without even the slightest attempt at cell-making being manifested. It is necessary to state in connection herewith, that the larvæ were amply provided with earth of the proper consistency, so there could not have been, as far as could be discerned, any obstacle to the fulfilment of their usual habit. *Thyreus Abbottii* in the chrysalis form has been found reposing upon the surface of the ground underneath the shelter of a cultivated variety of *Vitis cordifolia*, Mich., in a very open and exposed situation; undoubtedly the identical spot which the larva reached after separating itself from its favorite food-plant, was the scene of its assumption of the chrysalis state. This circumstance appears curious and unique, in view of the fact that ordinarily there is a disposition upon the part of larvæ to seek *sequestered situations*.

After this rehearsal of facts to show that the surroundings of a

species operate to produce functional changes within its economy, the rare occurrence of a cocoon-making species laying aside this hitherto supposed indispensable habit, becomes divested in a measure of the mystery which envelops it, without losing any of its interest.

To assign a cause for this anomalous natural occurrence shall be my aim. In a series of experiments which I recently conducted of starving larvæ to ascertain the effects produced upon their economy, I have been led to observe that in cases effectually accomplished, there is, besides a remarkable diminution in natural size, in cocoon-producing species, as Cecropia, Polyphemus, etc., a considerable saving of silk. Last year I produced cocoons of Polyphemus, three-quarters of an inch in length, by less than one-half in thickness. The flies which emerged from these cocoons measured $1\frac{3}{4}$ inches in expanse of wings. In the generality of cases *males* were the result of starvation.

This last year I fed a number of Cecropia upon the leaves of our ordinary red currant. One of the cocoons which I gathered was less than one inch in length with a thickness of one-half inch. Prompted by curiosity, I tore the cocoon open and discovered that the larva had been *ichneumoned*. In the place of a chrysalis was found the black cylindrical cocoon such as we ordinarily find in such cases. The larva had undergone its skin shedding, as evidenced by the dried inverted skin which was shoved into one corner of the cocoon. In this case, the larva, being weakened and diseased by the ravages of an internal foe, had not the material, or the power, to construct the characteristic type of cocoon. In the case of Polyphemus adverted to, scarcity of food, and of an innutritious character in the bargain, had reduced the insect to a condition which rendered it powerless to produce the typical form.

May not the stinting process which necessity compelled me to adopt with some larvæ of *Acronycta*, have had the effect of determining the acquired habit which has been noticed? The silk-producing glands of *Acronycta*, in consequence of a diminished supply of aliment, were not provided with the requisite material for the manufacture of silk, there being a bare sufficiency of food to prevent starvation to the insect. These silk organs are most developed at the period when the insects approach their pupa state; but with the larvæ of *Psychidæ*, *Tortricidæ*, and *Lasiocampidæ*, they are already active during the early epochs of life. As the

necessity for their use mainly occurs in the interval between the last skin moulting and assumption of the pupa form, they would attain during this period their functional maturity. There may be instances where growth has received a check through adverse climatic influences or otherwise, and the functional activity of these glands has been early attained. If in *Acronycta* the mature stage had been reached, and the nutriment provided was insufficient to maintain both the life of the larva and the functional activity of the glands, it seems evident that the most vital organs would be sustained at the hazard of those less vital.

In larvæ which do not manufacture cocoons the silk-bearing glands exist, but so reduced in size that they are functionally useless where great quantities of silk are required. It is true these larvæ manufacture silk, but in such exceedingly limited quantities as to be of little or no service for cocoon-making. The Diurnals, as is well known, are able to spin several strands, by which they suspend and engirdle themselves when about to pass into chrysalides. Some moths of the great family *Bombycidæ* make no cocoons, but these are the exceptions rather than the rule. The major part of them are cocoon-builders. While some construct the merest apology, others, Cecropia, for example, attain to the highest perfection in the art. The *Arctians* produce very little silk in comparison with Cecropia; their silk-bearing glands being necessarily small. The larva of *Arctia achaia*, Grote, spins a very thin web of a drab color, through which the chrysalis is distinctly seen. The *Sphinges* would seem to occupy an intermediate position; the earthen cells which they build, with their slight lining of silk, being the homologues of cocoons, since they subserve the same essential purpose. *Thyreus Abbottii* seems to be a real exception. But no. It ordinarily seeks some sheltered locality in which to undergo its critical changes—the under surface of a fallen log or a board, where an abundance of decomposing leaves affords the necessary warmth and shelter. It is obvious that the necessity for a cell does not exist, if the foregoing facts afford any criteria.

In the anomalous cases of *Acronycta* referred to above, it seems to me that we have proofs of the manner in which cocoons have come to be dispensed with in certain *Bombycids*. That *defective nutrition* has been a principal cause almost amounts to a conviction. A parallel case is cited by Stretch in his "Zygænidæ

and Bombycidæ of N. A." Having taken a number of larvæ of *Arachnis picta*, Packard, on the 9th of May, 1870, near San Francisco, he placed them in a box, and furnished them with a plentiful supply of their appropriate food for two weeks. They declined to eat, however, and remained thus for a period exceeding three months, when they passed into chrysalides, a few without spinning cocoons. The remainder, as though all the moisture in the body had been eliminated during their protracted fast, wove a very thin open white web, dotted with minute glistening beads like tiny dew-drops. Here there can be no doubt as to the part which *lack of nutrition* has played. If these examples of almost complete starvation had appeared late in the season, the effects would have been attributed in a measure to climatic influence; but, in the language of Mr. Stretch, they were brought about "in the height of summer."

Some few of the *Bombycidæ* are not cocoon-builders, but merely pass into chrysalides. On the principle that these are the modified descendants of pre-existent forms that possessed the habit, we are prepared to explain very much of the mystery which envelops *Acronycta* and *Arachnis*. This acquired habit upon the part of each, if permitted to bear offspring, would no doubt react favorably in the line of higher development. At this point a few hints upon the present natural arrangement of lepidopterous life upon this planet can not be amiss.

Among Lepidoptera the *Rhopalocera* constitute the highest division of the suborder. The arrangement of A. S. Packard, Jr., in his "Synthetic Types of Insects," seems to countenance no other idea. The *Heterocera* embrace all that were formerly known as Crepuscular and Nocturnal Lepidoptera. These terms, with that of Diurnal, which were once applied to the entire suborder, though strictly unnatural, subserve a good purpose.

This arrangement harmonizes in a measure with their natural sequence in time. If the highest types of life are the modified descendants of pre-existent forms, then, from an evolutionary point of view, Butterflies, which are assumed to be pre-eminent among Lepidoptera, have sprung from the *Bombycidæ*. There has undoubtedly been a gradual succession from certain Nocturnals to Diurnals.

There seems to be a tendency now-a-days upon the part of naturalists to refer the entire animal creation to a primordial

form—the *Protamœba* of Hæckle, from which has been reached through endless ramifications the present *regime*.

That our myriad forms of Butterflies have arisen from a single form in a uniform direction, is an hypothesis that cannot be entertained, in view of the array of evidence to the contrary. They have certainly reached their present *status* by several roads; but assumed in their entirety, there can be no question about their evolution from the *Bombycidæ*.

The *Sphinges* have been possibly reached from a Trichopterous form through the *Noctuidæ* and *Bombycidæ*. Although this family does appear to hold an intermediate position to Diurnals and Nocturnals, and would seem to form a principal link in the chain which has led to the former; still the absence of any positive testimony upon this subject effectually precludes any such arrangement. Were this the road by which the higher types have been reached through the play of natural forces, we should expect to meet some of the old landmarks, or to see in existing forms some proofs thereof.

The *Ægeridæ* must also be traced back to a pre-existent Caddice-fly. In their general form, in the outline and the transparency of their alar appendages, in their manner of flight, and the time of the day when they are most active, the *Ægeridæ* approximate the *Hymenoptera*. The genus *Trochilium*, of this family, resembles in all the above particulars many of our ordinary Membranous-winged insects. While this family undoubtedly leads forward to the *Hymenoptera*, it reaches backward and claims a near alliance with the *Zygænidæ*.

These facts have strongly impressed my mind as to their near relationship; and the thought has been frequently suggested, may not the *Hymenoptera*, the highest of insect life, have been reached through some member of the *Ægeridæ*. As *Trochilium* bears the nearest approach to a *Hymenopteron* of any form of Lepidoptera with which I am familiar, so the genus *Cosmosoma* of the *Zygænidæ* in many particulars resembles *Trochilium*. From the *Zygænidæ* to *Phryganea* through the *Noctuidæ*, retrocession is moderately gradual.

An examination into the provisions which lepidopterous larvæ make preparatory to entrance upon the chrysalis state, rather countenances than opposes this theory. From the cocoon of the least developed of our moths to the loop and girdle of the *Papili-*

onidæ, etc., remarkable gradations can be established. The highest perfection in the art of cocoon-manufacture is attained by members of the old Linnæan genus, *Attacus*. Between the lowest moths and the lowest type of butterflies a wide gulf intervenes. This is bridged over by many small genera, which enable us to reach the latter by a slightly circuitous course. Leaving out the genus *Attacus*, there seems to be a more nearly continuous route. May not certain members of this genus constitute the extreme limits of one or more branches of the great tree of lepidopterous life

The small loop by which a *Papilio* or a *Vanessa* suspends itself to a support, when about to pass into a pupa, and the girdle which it throws around the middle of its body to prevent unlimited and undue motion whereby injuries are prevented, are, it seems to me, but the last traces of the cocoon with which in primitive times it was wont to inclose itself. Indeed, there is a Brazilian moth of the subfamily *Tineina* which swings itself from a twig by means of a compound silken thread, thus imitating, though on a grander scale, many of our *Papilionidæ*, after which it spins a cocoon, a perfect network of fibres, so loosely arranged that the chrysalis may be discerned in all the distinctness of its parts. In this instance, the sole object of the cocoon, if there can be no impropriety in recognizing it as such, is not to protect its inmate from the inclemency of the weather, but to be, as it were, a domicile in which the almost immobile pupa can sleep until it wakens to newness of life. In point of utility this cocoon, judging from the laxity of its formation, is but little superior to the slight silken covering with which some of our earth-seekers line their cells. *Alucita porectella* builds a somewhat similar cocoon; but its beautiful network, rivalling in beauty the mechanism of art, is hidden away within curled-up leaves, or underneath them. There is a very close resemblance in the cocoons of the above two species. While the Brazilian larva utterly discards all extraneous objects which would mar the beauty and transparency of its house, *Alucita porectella*, for some unknown reason, selects a leaf as a basis whereon to build its showy fabric, a very common occurrence. As far as my knowledge extends, these are the only two species of the family to which they belong that do not construct cocoons of ordinary compactness. In *Alucita*, this marked looseness is in a great measure atoned for by the leafy envelope

referred to. Why this deviation from what is usual in the case of the Brazilian species? The conclusion is not far-fetched. There seems to be a tendency towards the abandonment of a habit which has been proverbial. What the circumstances are, which are determining this change, it is not easy to divine. In this climate cocoons serve to protect their inmates, when placed in exposed situations, from undue moisture. Experience has shown that they are capable of enduring with impunity a high degree of cold. Successive alternations of temperature from cold to warm, and *vice versa*, are accompanied by injurious effects. In tropical countries where the year is divided into two seasons, the wet and the dry, it is during the latter that the larva changes and prepares for a winged existence; consequently, the necessity for cocoon-making does not exist.

The cocoon being of little service to this Brazilian larva, other than as a suitable and comfortable support, being a relic of the past, will doubtless in time be abandoned. The insect will by degrees adapt itself both structurally and functionally to the new conditions of its *environment*, and support itself by a girdle like that of the *Papilionidæ*.

If butterflies have been evolved from moths, we should expect to find some evidences of the fact, if not in the forms of existing species, at least to a certain extent, in the gradations which can be established between cocoon-manufacture and the almost complete abandonment of the art, save in a rudimentary state, if the girdle-like-support of the *Papilionidæ* and others can be construed as the traces thereof. If moths are the parents of butterflies, an examination into the past history of our globe as contained in its rock-structure, ought to afford some confirmatory evidence. We should expect to meet with some traces of moths, as proofs that they were the earliest lepidopterous life that inhabited this globe. A review of palæontological literature upon this subject dissipates all suppositions to the contrary.

In the iron-stone concretions from the Carboniferous beds of Morris, Illinois, besides the remains of *Neuroptera* proper and *Pseudo-neuroptera*, there have been discovered two other forms of extinct articulate life. Naturalists have described one form as a centipede, the other as a caterpillar of a moth; the caterpillar was referred to the family of *Arctians* to which our woolly bears belong. As to the propriety of so doing, Mr. Scudder, of Mass.,

entered a protest. To this distinguished entomologist, they have every appearance of worms. Leaving this form, therefore, as unsatisfactory for our present purpose, another advance in time brings us to the Jurassic period, where more reliable information is awaiting us. In Europe, where the formations characterizing this period are developed on a singularly grand scale, but two forms of extinct Lepidoptera have been discovered to my knowledge, and these are a moth pertaining to the lowest family, the *Tineids*, of which the clothes-moth is a well-known example, and a *Sphinx*.

In an uninhabited region beyond the Rocky Mountains, near the union of the White and Green Rivers, Colorado, exists a deposit, probably far richer in insect remains than that of Œningen in Germany. In two localities separated by a scope of country about sixty miles wide, called by Prof. William Denton, Chagrin Valley and Fossil Cañon, considerable remains have been found. It is peculiarly interesting that these two regions have every indication of being distinct; the ants, the moth, and the thrips, nearly all the small coleoptera, and the bulk of the diptera, come from Fossil Cañon; while the larva are restricted to Chagrin Valley.

While no definite conclusion can be arrived at respecting the age of the beds in which these remains are found, there can be little hesitancy in assigning them to the Tertiary epoch. Professor Denton affirms them to be at least as old as the Miocene. As far as our present knowledge extends, the great Tertiary epochs rank pre-eminently above all others in their yield of fossil lepidoptera.

In confirmation of my position that butterflies are a higher type of Lepidoptera than moths, the former being the modified descendants of the latter, through several lines of development which had, during æons of cycles, gradually almost entirely lost their cocoon making propensities, Palæontology, the key which has unravelled so many mysteries in biological science, lends its all-potent influence.

It has been seen that the earliest of moths of which the globe bears any record, belongs to the *Tineids*, the lowest family of Lepidoptera. This is what our theory presupposes. As the larvæ of these moths generally construct at the present day cocoons of remarkable compactness, analogy would seem to argue a nearly similar habit in their early progenitors of the dark days of the Jurassic period. If it were possible to bring the cocoons of species so

widely separated in time into juxtaposition, perceptible differences no doubt would be noticed. Allowing for variation at the ordinary rate of increase, during the immensity of time that has elapsed since the Jurassic tineid flourished, the contrast would be astounding. While variation progresses in some species of animals by the constant addition of infinitesimally small increments, which are seen after the lapse of indefinite periods of time, there are other species which have maintained their own with comparatively few and trifling changes of character, from the early dawn of Silurian times down to the present moment. The *Terebratula* of our seas, closely resembles its most distant kin. Why may not the line which has terminated in our typical *Tineids*, have been marked by a similar uniformity of structure and habits? Other lines of growth may have led from these ancient *Tineids* to our highest types of cocoon-builders, through which in course of time our butterflies and sphinges were evolved.

If, as has been previously remarked, the habit of cocoon-building originated in the necessity of the times, as a means of protecting the builder against undue moisture, rather than a low degree of temperature, then we should expect to meet in the history of those early times, some confirmatory facts which would add further links to the chain of argument which has been assumed to prove that the line of development has been from Nocturnal lepidoptera to Diurnal.

Respecting the climate which prevailed upon the globe when the Jurassic tineid and Sphinx flourished, no facts associated with the geographical distribution of species have been ascertained, that uphold the idea of a diversity of zones, such as now exists. The facts sustain the view that the climate of the Arctic during this period was at least warm-temperate. The presence of *Belemnites paxillosus* and *Ammonites biplex*, or some closely-related species, according to the authority of Dana, in the Arctic, the Andes of South America, and Europe, indicates a remarkable uniformity of climate over the globe.

The character of the plants which then existed affords a cogent reason for believing that a moist climate prevailed. Experience has taught us that *Conifers* and trees allied to *Yucca* and *Bromelia*, *Equiseta* and *Ferns*, do best where the soil possesses much moisture and the climate is uniform. The gigantic *Conifers* of Western North America, and the tree-ferns of the East, attain

their greatest grandeur where nature abundantly waters the lap of earth. Such being a true statement of facts, as at present existing, what must have been the condition of the earth and atmosphere in those early days to which we have previously referred, to have given rise to such profuse and rank vegetation? The atmosphere must have been deeply surcharged with aqueous vapor, which was frequently condensed into rain and precipitated in torrents upon the earth.

The *Tineina* are the smallest of the small among the Lepidoptera, and, perhaps, the most eccentric in their habits of life. The larvæ also vary in their habits: some feed in the open air; others in rolled-up leaves; others are miners, some case-bearers, and some feed upon clothes or the lining of upholstered articles. There can be no doubt that the situations in which the larvæ are found are well adapted to conceal such tender creatures from the rapacity of vigilant foes. The cases which these larvæ construct with so much taste and skill, after having sheltered their fragile forms during the period of feeding, serve by slight additional improvements to become fit dwelling places for pupæ while preparing for winged existence, by affording comfortable shelter from inclement weather.

Whether there existed forms closely allied in habits to *Tinea tapetzella*, *T. pellionella*, and *T. crinella*, that feed upon carpet, feathers, furs, and skin, at present, palæontology must bear answer. It is evident that the majority of the species that flourished during past ages were vegetarians, and plied their gastronomic art within some sheltering leaf or case. During this epoch there flourished various genera of *Ferns*, *Cycads*, *Conifers*, and several species of *Equisetum*, materially dissimilar to any existing forms.

If there were *Tineids* that subsisted upon feathers, and such like, as at present, they were conspicuously few in number and confined to restricted areas. The Portland dirt-bed has yielded relics of fourteen species of mammals that have been referred mostly to the marsupials, and but one or two to the non-marsupial *Insectivora*. These mammals were associated with remains of insect life. These facts encourage the idea of a possibility of hair-eating *Tineids*.

This period, being preëminently one of reptiles, when the gigantic *Saurians* lived and delighted in their carnivorous exploits, could scarcely have witnessed any remarkable development of moths.

Vegetation of a particular character being very prolific then, there is ground for believing that an excess of *Tineids* of herbivorous habits would have been better adapted to the existing condition of things.

As living *Tineids*, so far as I am conversant with their history, only attack woollen stuffs, furs, feathers, etc., when stripped from their rightful proprietors, and not when constituting their living vesture, analogy would expect a similar exhibition of character upon the part of their remote progenitors. The fur of dead animals is, however, utilized while also remaining intact.

Many of our living larval *Tineids* construct cases into which they retire and which they bear with them from place to place, when they do not otherwise tunnel the leaves of their favorite food-plants. There can be no impropriety in presuming the existence of similar habits upon the part of their distant ancestors. The warm temperate climate which prevailed during the Jurassic epoch, with its excessive moisture and humid atmosphere, offers a weighty argument in favor of cocoon, or rather case-builders.

Lepidoptera, as a rule, are exceedingly delicate and fragile beings, very liable when life is extinct to speedy decomposition. Therefore, it is not to be wondered at that their remains are not found in greater abundance. When we reflect that there have been many alterations of level since the day when the Jurassic fauna flourished, it is highly probable that many forms have irrecoverably perished. But when the rock-structure of the globe is better known, new forms may come to light, which will doubtless help to fill up existing gaps in the chain of historical sequence.

The presence of a *Sphinx* with moths that occupy so low a position in the order as *Tineids*, is a remarkable coincidence, and would seem to require a different explanation, in view of the then existing aspect of affairs, than the one which I have endeavored to establish. If future explorations and discoveries should fail to reveal the existence of lepidopterous life further back in time, or the existence of intermediate forms to the *Tineids* and *Sphinges*, it is almost impossible to resist the conclusion that these forms originated almost synchronously from some lower forms of articulate existence; in other language, that they are branches from a common scion or stock. It seems to be more in harmony with known facts to consider the *Sphinges* to have been the modified descendants of some pre-existent *Bombycid*, the latter of a *Noctuid*, etc., and to await

the further developments of palæontological science in confirmation of this position.

As previously remarked, there has been found in the Carboniferous strata of Morris, Illinois, a larva that has been referred to the *Arctians* or woolly-bears. Granting the truth of this identification for the sake of argument, the period of time that has elapsed since the Carboniferous arctian flourished, down to the ushering into existence of the Jurassic sphinx, has been ample, no doubt, for the gradual evolution of an *Arctian* into a *Sphinx* through intermediate forms. The fact that *Tineids* are not found in Carboniferous strata is no argument for their non-existence. If the *Tineids* of those early days had many points in common with existing types, it is only under the most favorable conditions that parts of them could be preserved.

That these conditions did not exist during the Triassic period, is inferred from our knowledge of the disturbances which took place in America, and the shallow basins both of fresh and salt water that existed in foreign localities where this formation is developed. Evidences of disturbance occur in this country in the tilted and displaced condition of the beds constituting the formation. This tilting is, doubtless, due to mechanical force, very gradual in its action. Still further evidence exists in the profound subsidence which has been shown to have been in progress in regions of depression, occupied by the strata. Such a subsidence would obviously have brought a strain upon superincumbent beds, and sooner or later would have produced fractures and disarrangement. The injection of igneous rocks which have intersected sandstone strata, affords still another proof. In our Triassic regions, rocks of igneous origin are intimately connected with rocks of aqueous origin. Throughout most of the European sandstones and marls of this period, the occurrence of ripple-marks, rain-drop impressions, and cracks from drying, plainly show that the strata are of shallow-water and mud-flat origin; and the salt which has been found and referred thereto, points to the existence of flats that were exposed to occasional inundations of the sea, where the salt water underwent evaporation.

It is evident that in America where the greater disturbance of the strata has occurred, as indicated above, such light and airy creatures as moths would stand but a slim chance of leaving the slightest vestiges of their remains imbedded. The tilting and

subsidence alluded to, combined with the metamorphic character imposed upon many strata by the injection of trap in a state of igneous fluidity, if lepidopterous life then existed, have either completely removed it from our reach, or obliterated every trace of remains once preserved.

In Europe, when we take into consideration the areas in which these beds were deposited, we are not surprised at the absence of traces of lepidopterous life. Being shallow basins of fresh water, with mud-flat margins, and occasional flats submerged by inundations of salt-water, we should not expect to meet with lepidopterous life. It is only in such localities that we should look for the remains of neuropterous insects. It is a remarkable fact that the only fossil insect thus far observed is the larva (or exuviæ of the larva) of a neuropter, related to the genus *Ephemera*, which was found in the shales at Turner's Falls, on the Connecticut River, and described by Prof. Hitchcock. The impressions of the feet of insects found in the sandstones of the Connecticut River valley, were undoubtedly of neuropterous and crustaceous character.

Unless the advent of the *Tineids* dates further back in time than the Jurassic, allowing the family to be the lowest of the *Heterocera*, we have the simultaneous origin of insects as low in the scale of creation as these, with others, the *Sphinges*, which mark a pre-eminently higher type of development, unless it can be shown, which is exceedingly uncertain, that the former claim priority of birth, and constitute the immediate and proximate ancestry of the latter. The chapters of the Stone Book of Nature, so far as they are perusable, do not reveal any such history. The intermediate links by which the chain of existence from *Tineids* passes into *Sphinges*, are missing, and doubtless will never be restored. If *Tineids* have passed directly into the *Sphinges*, would not, unless our present types are the degenerated forms of pre-existent ones, some unmistakable evidences be found in studying the early stages of modern species? Instances could be multiplied beyond limit of the special roads which nature has pursued in reaching particular forms, from others that occupy an inferior position.

The simplest forms of life of which we have any conception, are the *Monera*, which may be defined as living jelly, formless and structureless. They move along by a sort of gliding motion, which is produced by a protrusion and retraction of portions of their sub-

stance. Their reproduction is exceedingly simple, being a splitting of their body into halves, each half developing into a new *Monas*.

The absence of a nucleus characterizes the chief point of distinction between these and the *Amœbæ*. A Sponge may be considered as a colony of *Amœbæ;* the individual members of which are united by a common bond of union; this view is suggested by the young of the Sponges, which cannot be distinguished from *Amœbæ*. The development of flagella and cilia, as in *Euglena*, has led the way to the *Animalcula* or *Infusoria*. Nor need we confine our attention to these simple forms of animal life.

As we ascend the scale, we meet with equally forcible illustrations. Prof. Cope, in his "Origin of Genera," in writing about the higher *Cervidæ*, affirms that "*Rusa* and *Axis* never assume characters beyond an equivalent of the fourth year of *Cervus*. In *Dama* the characters are, on the other hand, assumed more rapidly than in *Cervus*, its third year corresponding to the fourth of the latter, and the development in after years of a broad plate of bone with points being substituted for the addition of the corresponding snags, thus commencing another series."

In the *Cephalopoda* a number of series of remarkable regularity can be established. The advance in the first place being in the complicated arrangement of the plicæ of the external borders of the septa; in the second place, in the approach which one or both extremities of the shell make to the spiral; and, lastly, in the position of the siphon. Alpheus Hyatt, in an interesting and important essay upon this topic, makes the assertion that the less complex forms are identical with the undeveloped condition of the more complex. His language is, "There is a direct connection between the position of a shell in the completed cycle of the life of this order, and its own development. These shells occupying the extremes of the cycle, the polar forms, being more embryonic than the intermediate forms."

Such evidence as has just been adduced of the gradual modification of living species, some of the separate links of the chain which bind the less with the more highly specialized, being observable in the history of development of individual species, is of the most positive and satisfactory character. Can we bring forward similar evidence in confirmation of the position that the *Sphinges* are directly descended from the *Tineids?* I apprehend not. Whence the simultaneous occurrence of these two forms in

the same formation? Is it an argument in favor of the descent of the former from the latter? As an answer to this query, two theories suggest themselves; either to consider the *Tineids* to have come into existence long anterior to the Carboniferous arctian, and to have been the remote progenitor of the latter, as it has doubtless been of the *Sphinges;* or to consider the *Sphinges* as a highly specialized form of Pseudo-neuroptera with *Bombycid* and *Noctuid*-like characters.

In some of our modern classifications of insects, the Caddice worms, which are comprehended in the genus *Phryganea* are reputed as belonging to the order Neuroptera. According to Westwood, however, this genus constitutes the connecting link between the Neuroptera and Lepidoptera. Since the Caddice worms present many marks of resemblance to the Neuroptera, while in others they approach the Lepidoptera, they are considered by the above-named eminent authority as constituting a distinct order called Trichoptera.

In their larval condition, these Trichopterous insects are not altogether dissimilar to caterpillars in configuration, and construct for themselves cylindrical cases or tubes, made up of sand, small pebbles, fragments of sticks, leaves, or even shells. When fully grown, the larva secures its case to a stone, the stem of a plant, or some other fixed material, and closes somewhat the two ends with an open grating of silken threads, so as to admit the ready access of water, and keep out intruders. Within this covering the pupa condition is assumed. It bears a very close resemblance to the perfect insect, except that the palpi, wings, antennæ, and legs are shorter and inclosed in distinct sheaths and disposed upon the breast. The pupa is not so perfectly quiescent as the pupæ of Lepidoptera, since as it approaches maturity it comes to the surface, and in a few instances makes its way out of the water. It is obvious that in the points of character thus briefly detailed, there is a close relationship to the early history of Lepidoptera. But the larvæ being aquatic, which is the case with very few Lepidoptera, and the pupæ being capable of locomotion near the time of emergence from the tube, on the other hand ally them to Neuroptera.

Besides a resemblance in habits to the case-bearing larvæ of the genera *Psyche* and *Tinea*, a still further affinity has been noticed; the analogous covering of the alar appendages in the *Phryganidæ*

and some *Papilios*, and the analogously spiniferous tibiæ in the two groups. DeGeer deduced this affinity from the analogous configuration of the wings, and from the internal conformation of the larvæ; Kirby from resemblances in the buccal apparatus, and Reaumur from general considerations upon insect analogies.

The *Phryganidæ* are an intermediate group to the Neuroptera and Lepidoptera, as the most satisfactory evidence, backed up by the well-balanced judgments of competent authorities, so amply and ably testifies. The *Ephemerids*, though a somewhat distant kin of the *Phryganidæ*, in the Triassic Ephemeron referred to above, is it not a plausible hypothesis that we have the progenitor, though very remotely, of the Jurassic sphinx? Future discoveries may reveal to us, when these formations are more thoroughly known, the intermediate links by which the Sphinges were reached from an *Ephemerid*-like neuropter, through a Trichopterous form allied to our present Caddice flies, thence through certain extinct species of *Noctuidæ* and *Bombycidæ*, doubtless having characters which relate them somewhat intimately to existing types. That the passage of the Sphinges proper has not been through the *Zygænidæ*, amounts to a conviction in my mind. There are reasons of a morphological character, and others that favor such a pre-conception. Among existing *Bombycids* there are forms that resemble, both in the larval and imago states, our *Sphinges* proper. *Notodonta Californica*, Stretch, is a good illustration. The larvæ, in general form, and in having a horn upon its anal segment, according to Dr. Behr, would be taken as a *Sphinx*, and doubtless would be described as such in the absence of any knowledge concerning its early stages. The imago presents, in the general contour of the body, in the attenuated form of the anterior wings, in being decidedly *chalinopterous*, and in the characteristic shape of the posterior alar appendages, a very close alliance to some *Sphinges* with which I am familiar. I do not assert the belief that this species is identical in the aggregate of its characters with the *Bombycid*, from which the Jurassic *Sphinx* sprang, but that it can be taken as a fair sample of the proximate ancestor of the latter.

As before remarked, there is some resemblance upon the part of *Phryganea* to the genus *Psyche* among moths, and the *Papilios* among butterflies; from which it might be argued that the *Bombycids*, if they have come from the *Phryganeæ*, must have passed

through the *Psychidæ*. But the slight similarity of the Caddice flies, instance *Neuronia fasciata*, Say, to the *Papilios*—the highest type of Diurnals—and a similar resemblance of *Neuronia* to certain existing *Bombycids* and *Noctuids*, seem to bring *Phryganea* more closely to the *Bombycidæ*. The resemblance of Phryganea in habits to *Psyche* and *Tinea*, would, in face of previous evidence, rank these forms as branches thereof.

In a careful examination of our ordinary *Neuronia fasciata*, Say, I find that the anterior wings, in their general contour and venation, resemble the typical Neuropters; while the posterior, in the same important characters, bear a decided approach to some of our *Zygænidæ*. In general form there is some resemblance, fancied or otherwise, to Hopffer's *Gnophœla;* but a more decided likeness to some existing forms of the genus *Ctenucha* is found to exist. The contour of the first pair of alar appendages in the genus *Ctenucha* is not essentially dissimilar to those of *Neuronia*, although the variation may be slightly different. In *Neuronia*, the external margins of the posterior wings, midway between the apical margins and the commencement of the line of descent to the abdomen, display a slight curvature inwardly, producing a peculiar conformation. By examination of figured specimens of *Ctenucha*, *brunnea* and *ochroscapus* more particularly, unmistakable evidences of these curves are found to exist. From *Zygænidæ*, like these, together with *Cosmosoma omphale*, Hübner, it would seem to require but little effort upon the part of "natural selection" to reach from certain Caddice flies, through intermediate forms, living or extinct, the *Ægeridæ*. In this train of argument, I have assumed the *Ægeridæ*, from which the Hymenoptera have sprung, to have descended from some form of *Phryganea*, through the *Zygænidæ* and others, and to represent the terminus of one branch of the wide spreading tree of Lepidopterous life; and the *Sphingidæ*, through the *Bombycidæ*, *Noctuidæ*, and *Phryganea*, another.

That the *Sphinges* have descended from a *Phryganea* with *Bombycid*-like characters is entertained for several important reasons. The absence of intermediate types to the *Tineids* and *Sphinges* in the rock-structure of the globe, as far as I have been permitted to read it; the great abundance of Neuropterous life that inhabited the globe during the period when the Triassic and Jurassic faunæ flourished, from forms resembling our May flies to the highest type of the order; the very close resemblances

which subsist between certain existing Lepidoptera and Trichoptera, both internal and external, in their three stages of existence as larvæ, pupæ, and imagos; and, lastly, their remarkable similarity of habits.

In commenting upon the first consideration, it strikes me as peculiarly novel and remarkable, that such delicate creatures as *Tineids* should be preserved in association with *Sphinges*, there not being the remotest affinities between them, while the intermediate types, if there are any, which palæontology alone must decide in the future, should have left not even the slightest evidence of their existence.

A few thoughts having reference to the second consideration, lead to more important results. The great abundance of Neuropterous life, both high and low, that existed during the Triassic and Jurassic epochs, backed up by the third consideration which shows that notable affinities exist between certain forms of Lepidoptera and *Phryganea*, seems to argue strongly in favor of the theory that the Jurassic sphinx was the remote modified descendant of some pre-existent Caddice fly, which latter was the offspring of some formerly-existing Neuropter.

The *Tineids* of to-day are, as a general rule, but diminutive specimens of lepidopterous life, notable alike for their inconspicuousness and insignificance. Rarely if ever attaining any remarkable development of size, they, doubtless, have retained much of their primitive character. Like some forms of *Terebratula*, as before remarked, they have maintained the even tenor of their lives doubtless for ages. Natural selection has had little play in the line of variation in this family. It has been affirmed that the Caddice worms construct cases like the larvæ of *Psyche* and *Tinea*, which they line with silk. From this it is argued that *Psyche* and *Tinea* have been evolved from some form of *Phryganea*, and that the *Sphinges* have come through the former. But this does not necessarily follow. May not the *Phryganidæ* have been the common stock of both *Tineids* and *Sphinges*, the latter being a more highly specialized type, from having been reached through greater and more persistent modifications? Perhaps there were existing in those remote ages many forms of *Phryganidæ* differing greatly in size, but still retaining similarity of habits. Granting this, for the sake of argument, there can be no impropriety in considering the *Tineids* to have been the immediate de-

scendants of some low form of Caddice fly, and to have long since reached the limit of their capacity for further modification. They would thus constitute the summits of several small branches of the Phryganeid root from which the *Psychidæ* and *Tortricina* were derived.

Although it is possible, as previously remarked, to trace with considerable success the gradual abandonment of cocoon manufacture, from rather low moths, where it exists in wonderful perfection, to its rudimentary condition in Diurnals, and even to show certain stages which appear to have led to the cell-making of the *Sphingidæ;* yet in the absence of further evidence of a different character, in the face of previously-cited facts, it would not be advisable.

It is well known that among the *Bombycidæ* there are existing forms that resemble in some points of character the butterflies. In color, bodily form, and in being, to a certain extent, lovers of sunshine, *Utetheïsa bella*, Linn., approaches the butterflies.

Among the Zygænidæ similar relations are known to exist, as instanced by *Alypia Brannani*, Stretch. Other examples might be given, but time will not permit the merest mention of them.

The larva of *Alypia* enters the ground where it constructs an earthen cocoon, and lines it internally with a varnish-like secretion before assuming the pupa condition. In this particular it imitates certain moths.

The early history of the genus *Utetheïsa* is partially involved in obscurity. It is impossible to say where the pupa state is assumed. It seems in harmony with facts to consider butterflies to have descended from some species of *Bombycid*, whose larva possessed a comparatively smooth exterior and was a moderate spinner of silk—the support and girdle of the *Papilionidæ* and others being the remaining traces of the cocoon by which their remote progenitor was accustomed to envelop itself. The larva of *Utetheisa bella*, Hübn., has been found in the pods of *Crotelaria*, from which it is inferred that it is an internal feeder. It is yellow, with black and white rings. In markings and in its comparatively smooth integument it resembles some of the *Papilios*. If it should be shown in the future that it spins a slight cocoon, this fact would lend material aid to the views herein set forth.

The larva of *Phryganidia Californica*, with its naked skin and uninclosed and pendent pupa, reminds me of many *Rhopalocera*

and some *Geometræ*. It has been classed with the *Psychidæ* by Packard, and, owing to its near alliance to Heterogynnis, which is removed by many European writers to the *Zygænidæ*, it has been placed by Stretch in that group. One of the latter's reasons for this removal is the resemblance which its larva holds to that of *Eudryas*. But its habit of carrying the last segment elevated in the air, which shows a certain affinity to some *Notodontas* as well as to *Cerura* and *Platypteryx*, and of suspending itself by the tail like the *Geometræ*, combined with the close resemblance which the wings bear to some butterflies, renders it an interesting form. The facts for the origin of butterflies herein embodied in connection with the above, aim to place it high up in *Bombycidæ*.

It has been suggested that the *Sphinges* are the remotely modified descendants of a pre-existent *Phryganea*. It is well known that the larva of the latter constructs a case into which it retires after feeding. As this case with its inmate remains in its watery element until the imago state is near at hand, if the argument previously advanced to prove the remote origin of the *Sphingidæ* through intermediate forms, from a *Phryganea* allied to existing types, amounts to aught, we have in it a clue to the habit which many of our *Zygænidæ* and *Sphingidæ* possess of entering the earth in assuming the chrysalis stage. The *Ægeridæ* in their larval stage bore into the stem of plants, and when ready to pass into pupæ, construct oblong follicles, composed of small fragments of barks and earth closely united together by the silk of the animal. This style of cover is not essentially different from that of the *Sphinges* and the *Glaucopidians*. As the ravages of these insects are confined to the inner parts of plants, it is not unreasonable to suppose that when the time for change arrives, it will be undergone where there is least trouble and least outlay of strength, in the burrows created. The *Zygænidæ*, as a rule, subsist upon the outer parts of plants. On the supposition that some pre-existing individual of this family had profited by a change from outer to inner, it would be a comparatively easy matter to trace the effects which a change of *environment* would impress upon said individual. We might expect considerable alterations in larval color, form, and structure, with but a trifling change in cell-manufacture.

In the condition of larvæ the Trichoptera are vegetarians; but will occasionally attack minute fresh-water animals when driven

to it by necessity. As vegetable feeders they resemble caterpillars. Suppose the stream in which some early caterpillars of caddice-like habits and forms were residents, had become dried up, or directed from its bed in such a manner as not to effect the removal of the worms, and still leave the bed humid, there is no doubt that those worms which possessed some advantage above their fellows, better suited to the altered condition of affairs, would be preserved and leave progeny. These would gradually, as time progressed, become better adapted to their condition, giving rise to a higher type of existence. A change in the specific gravity of their *environment* would necessarily have the tendency, as an obviation of the inconvenience thereby engendered, of producing changes of habit on the assumption of pupation. This hypothetical case would seemingly account for the habitudes of the *Glaucopidians* and the *Sphinges*.

Another explanation suggestive of the same idea presents itself for consideration. A scarcity of food might induce larvæ well-circumstanced in the "struggle for existence," to forsake their habitual haunt, the watery element, for the land, as a preventive to starvation. If slightly adapted to endure the change of habitat, the effects of direct atmospheric influence associated with dietetic causes, might so disturb their equipoise as to lead to a better adjustment of inner to outer actions, and thus be determinative of the same results.

While some of these larvæ, in order to harmonize inner with outer actions, or to restore as nearly as possible former modes of living, on the attainment of pupæ may have passed into the ground, others, doubtless, reached the same end by boring into the stems of succulent plants, with or without a medulla, for cover and protection, as well as for food; some again, as if reluctant to forsake their cases, the scenes of so many pleasures and adventures in the past, carried their cases with them as many of our *Psychidæ* and *Tineidæ* still do, until metamorphoses ensued; others again ceased gradually to encumber themselves therewith during their larval existence, nature having provided them with suitable protective appliances in the form of irritating hairs; dangerous-looking, though perfectly harmless spines; offensive fluids with equally offensive odors, and disgusting carneous qualities; to be only reassumed on the assumption of the chrysalis state,

as suitable protections against inclement weather during this critical period of radical changes.

If the views embodied in the last paragraph have any semblance of reality, we should expect to meet with, in the habits of existing species, confirmatory proofs. Among the *Hydrocampidæ*, *Paraponyx* closely resembles in larval form and habits the Phryganeæ. Its larva is possessed of large branchiæ, besides spiracles, and its pupa is found in a cocoon amongst leaves under water. There is another species quite common in France, which subsists upon a species of pond weed. In the caterpillar state it cuts two pieces of leaf and fashions them so as to become nearly oval in shape and equal in size. These are joined by their margins by means of a little silk, the larva taking special care to leave an opening for the head and the first segments of the body. It drags this house under water, occasionally destroying it for a more substantial domicile. When it is ready to assume the chrysalis state, it attaches its leafy house securely to plants or stones in the immediate vicinity. The China Mark's caterpillar lives underneath the leaves of a species of *Lemma* in the water, and protects itself in a cylindrical case of silk covered with leaves, in which it subsequently becomes metamorphosed into a chrysalis. Here, it is evident, is the starting point for the development of the higher moths. It is not to be presumed that the *Hydrocampidæ* are the immediate descendants of the *Phryganeæ*. There may be other forms somewhat lower, of whose existence we have no knowledge. In the accompanying tree I have preferred to represent these forms under the name of *ideal Paraponyx*, and to consider them as the immediate progenitors of those whose life-history I have partially described.

The pupa of *Eudryas unio*, Riley, has been found in winter in the stems of a species of *Hibiscus*, as though the larva had been feeding in that location. *Psychomorpha epimenis*, Clem., frequently perforates a piece of old wood and changes into a chrysalis therein. Its habit of boring into some substances to prepare for the change is inveterate, and it always neatly covers up the orifice so that it is difficult to detect. Other instances might be cited. The species just cited belong to the *Zygænidæ* from which it has been assumed the *Ægeridæ* were evolved. There is a manifest resemblance to the latter, with the important difference that the larvæ of the *Ægeridæ* pass through their early stages in the stems

of plants, and never forsake them until fitted for winged existence; while the *Zygænidæ* pass therein when about to change into chrysalides. There may be instances where the entire *suite* of changes is affected in such retreats. It is well known that many of the caterpillars of the genus *Gracillaria* among the *Tineids*, and the genus *Œnectra* among the *Tortricidæ*, possess similar boring propensities. Higher up on the scale of lepidopterous life the genus *Nonagria* of the family *Leucanidæ* imitate still more closely the habits of the *Zygænidæ* and *Ægeridæ*, in feeding in the stems of reeds and grasses. There may be cited instances among the *Bombycinæ*, as the *Hepalidæ*. Our own *Cossus robinæ*, Peck, is a happy illustration. The existence of a similar habit among this latter family, to that which the *Leucanidæ*, *Zygænidæ*, and *Ægeridæ* possess, does not argue in favor of the view that it constitutes a link in the chain which has led from the *Noctuidæ* to *Ægeridæ*. It shows that this family constitutes a small branch from the *Noctuidæ*.

The presence of this habit among such low forms as the *Tortricidæ* and *Tineidæ* embrace, which have deviated but slightly from primitive habits, would seem to argue for analogous habits among some unknown individuals of the *Hydrocampidæ*. When these forms in their larval condition are made the subjects of special investigation by naturalists, and new types or new individuals of existing types are brought to light, it may be the good fortune of science to record types which, instead of constructing cases like those quoted above, derive the same essential benefits by boring into the stems of submerged plants, or into the veins or parenchyma of their leaves, like the members of the Tineid genus *Lithocolletis* which mine the leaves of various plant-species from their under surface and eat their cellular structures. These beings, it is true, must necessarily be very diminutive in size.

Those which have denied themselves such comfortable and protective dwellings as are afforded by cases and tunnels, in consideration of the various defensive appliances with which nature has endowed them, are very numerous. So familiar are these, even to the most casual observer, that it does not behoove me to give the barest recital of a single example. Indeed there are cases where these external tegumentary weapons, by themselves, do not conserve to individual safety; and their unfortunate possessors are constrained to construct immense webs which afford com-

mon tenements for hundreds of individuals of particular species. This is the case with our common American Fruit Caterpillar, *Clisiocampa Americana.*

It has been said that the Caddice worms construct cases in which they reside, and which they close by means of threads at the ends when about to pupate, so as to admit the water through their interstices, and keep out enemies. It is obvious that water does not injure the pupæ. Nature, like a faithful nurse, carefully protects the interests of every one of her countless progeny by making its inner life correspond with outer actions. On the ground that water is beneficial to the pupa of a *Phryganea*, we have an explanation of the comparative openness of its cocoon at the ends.

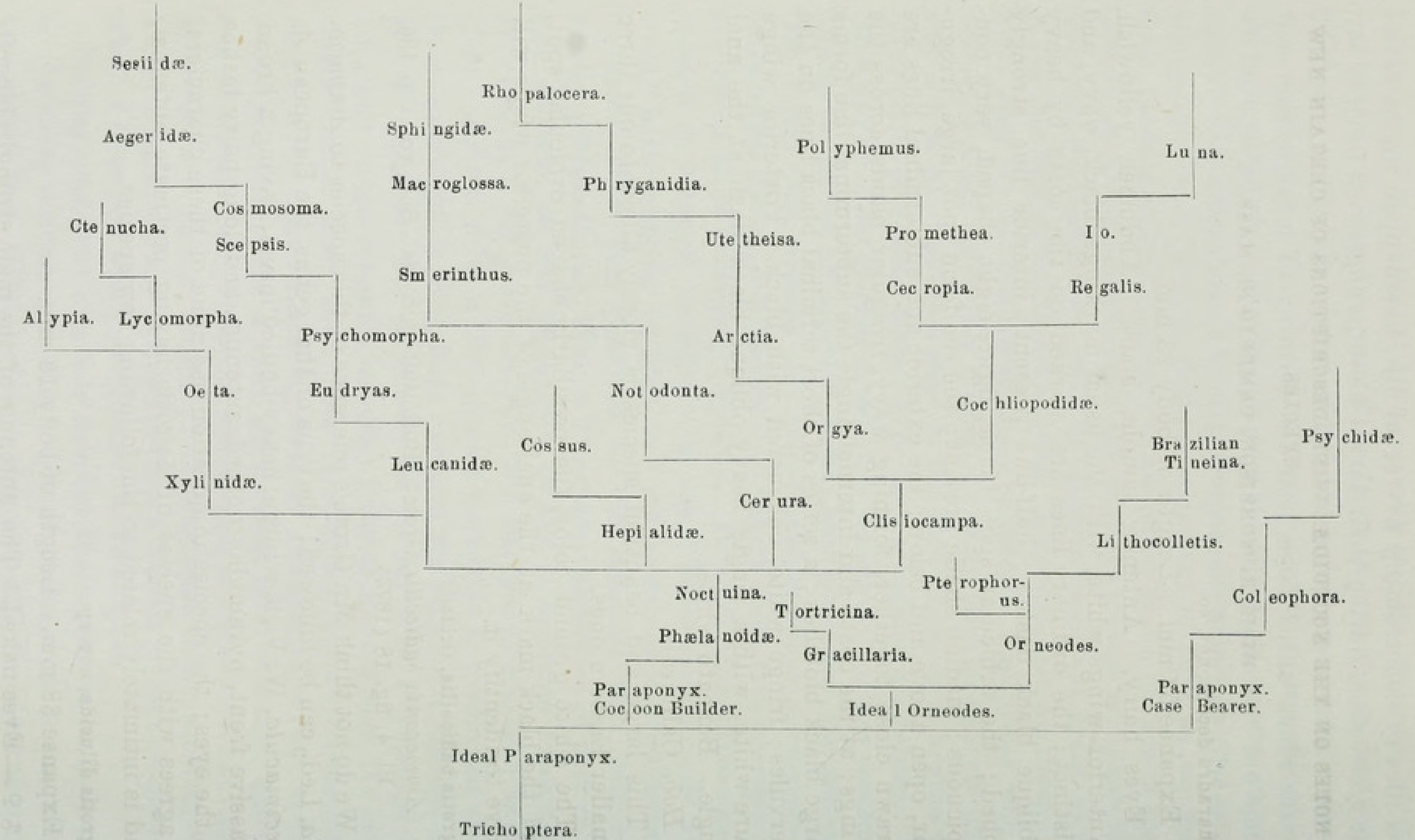
It was further remarked that *Paraponyx* in the larval condition was endowed with both branchiæ and spiracles. This seems to be a very wise provision of nature. The branchiæ enable the insect to breathe like fishes, when immersed in a watery element. May it not be that the spiracles are quiescent, and only come into possession of their legitimate function when the chrysalis state has been assumed, and the animal is inclosed in a cocoon which is perfectly tight? As the chrysalis while in this stage respires but feebly and imperceptibly, there is in this home of its construction, an ample capacity of air for the accommodation of its wants.

It is affirmed that *Lepidosiren*, in addition to lungs, possesses both internal and external gills; the latter being in a rudimentary condition in the adult form. The rivers of South America and of the east and west shores of Africa, where this animal exists, during drouth are dried up. Did it breathe entirely by means of gills, it would be in danger of extinction during the dry season; but being endowed with lungs also, it is enabled to meet the contingency, and thus survive. Should the streams in which numbers of *Paraponyx* larvæ reside, during a season of drouth become entirely dried up, the sudden and doubly renewed efforts of these animals, in their "struggle for existence," would doubtless so operate upon the spiracles and trachea as to necessarily lead to their perfect development and functional activity. It is a familiar occurrence that the wings of moths, butterflies, etc., when first they leave the chrysalis cover, are short, sac-like, bodies; but by their energetic movements speedily develop into their characteristic forms. This is accounted for in the following manner:

These wings are pervaded by numerous minute divisions of the trachea, which, by the violent motions of the wings, are supplied with a superabundance of air, the necessary consequence of redoubled vigor. The continual pressure of fresh accessions of air upon what already exists in the above vessels, exerts an expansive influence upon the wings, which ultimately assume configuration. Such being a faithful statement of facts as we find them, there can be no hesitancy in assuming that a change of conditions as above indicated, in the animal's violent struggles for existence, would so react upon its hitherto quiescent spiracles as to conduce to their functional activity. Like the adult *Lepidosiren*, there may yet be discovered some unknown *Paraponyx* which possesses these gills only during its early larval history. The presence of gills and spiracles in the known specimen, argues in favor of its derivation from a type that possessed gills alone. If these spiracles are quiescent, and only become active in a measure during the period of pupation, as has been presumed, the passage into forms that possess this gill-breathing power during their early larval period, and thence into others that have completely renounced it, is exceedingly gradual. Some of these *Hydrocampidæ*, it is affirmed by Duncan in his "Transformations of Insects," have branchiæ or gills, and exist surrounded and bathed by water. This fact conducts to the inference that they are wholly gill-breathers. From a *Paraponyx* possessed of both gills and spiracles to the *Phryganea*, is but a moderate transition. However, it is not presumed that said Paraponyx has been immediately derived from a *Phryganea*, neither is it predicated that the complete gill-bearing form has been the proximate descendant of a *Phryganea*. But so closely do the larvæ of *Paraponyx* in form and habits resemble existing Caddice worms, that the conclusion based upon their near relationship, seems irresistible. May not the branchia-bearing form of *Paraponyx* have been the immediate descendant of some pre-existent form of similar habits, but of closer resemblance to *Phryganea*, in details of form and structure, in a state of maturity? Acting upon this consideration, I have presumed their derivation from a form at present unknown, which I have previously designated the *ideal* type.

Having somewhat lengthily detailed the truths which have led to the views expressed in this paper, it becomes me to put them to a proper test. With a view to give tone and character thereto,

the idea of constructing a tree of life, based upon the habits of the *Heterocera* during their larval history, suggested itself to my mind. After many hours of toil I have been enabled to construct a tree which will, I hope, bear the scrutiny of investigation and come out unscathed, since it harmonizes in the arrangement of its parts with the most thorough system of classification.


Sesiidæ.
Aegeridæ.
Rhopalocera.
Sphingidæ.
Macroglossa.
Phryganidia.
Polyphemus.
Luna.
Cosmosoma.
Ctenucha.
Scepsis.
Utetheisa.
Promethea.
Io.
Smerinthus.
Cecropia.
Regalis.
Alypia.
Lycomorpha.
Psychomorpha.
Arctia.
Oeta.
Eudryas.
Notodonta.
Cochliopodidæ.
Orgya.
Brazilian Tineina.
Psychidæ.
Cossus.
Leucanidæ.
Xylinidæ.
Cerura.
Hepialidæ.
Clisiocampa.
Lithocolletis.
Pterophorus.
Noctuina.
Tortricina.
Coleophora.
Phælanoidæ.
Orneodes.
Gracillaria.
Paraponyx.
Cocoon Builder.
Ideal Orneodes.
Paraponyx.
Case Bearer.
Ideal Paraponyx.
Trichoptera.