

The Future of Systematic Botany.¹

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In his presidential address before the Biological Section of the British Association, in September, 1888, Dr. W. T. Thiselton-Dyer closed with the following words:

"At the bottom of every great branch of biological inquiry it has never been possible to neglect the study of plants; nay more, the study of plant-life has generally given the key to the true course of investigation. Whether you take the problems of geographical distribution, the most obscure points in the theory of organic evolution, or the innermost secrets of vital phenomena, whether in health or disease, not to consider plants is still, in the words of Mr. Darwin, 'a gigantic oversight, for these would simplify the problem.'"

If this broad claim be true, a botanical theme is an eminently appropriate one to present to a Biological Section. In the opinion of many, however, all kinds of botanical work are not equally bound up in the bundle of biological inquiry. It is for this very reason that I have selected as my subject "The Future of Systematic Botany."

I know that it is unscientific to deal with the future, although our knowledge of the past and present becomes especially fascinating when we begin to turn it into prophecy. Moreover, upon occasions like this, it is more customary to review and sum up actual knowledge than to cast the horoscope of the future, although the latter is far easier. But, setting aside the custom of presenting either an interesting bit of research or a summarized view of information concerning some attractive subject, I would invite your attention to an ancient, and, to my notion, a much abused department of work. It is perhaps well to say in the outset that the abuse to which I refer is not only that inflicted by Gentiles, but also by Jews; for often one's worst foes are those of his own household.

The ancient history of Systematic Botany is too well known to this audience to need even brief repetition, especially since the masterly sketch by Professor Sachs has found its place in all our libraries. The names of illustrious systematists are household words, and their various "systems" form

¹ Vice-Presidential Address before Section F., A. A. A. S., Washington meeting, August 19, 1891.

a part of our training. The one desire which runs with increasing purpose through all this well known history is to reach eventually a natural system of classification. The one obstacle in the way of gratifying this desire has been a lack of knowledge. You remember the time when the knowledge of affinities was so slight that no attempt even was made to express relationships, and plants were simply systematically pigeon-holed for future reference. The ingenuity of those days was taxed to construct the most convenient pigeon-holes, and to properly assign to them the hosts of plants that were clamoring for recognition. Those who could thus properly assort a collection of plants, and could recognize when a new pigeon-hole was needed, were known first as "botanists," afterwards as "systematic botanists," an appellation proper enough, but one unfortunately not having sufficiently outgrown its original application. The unfortunate result of this necessity to systematize facts so rigidly and thus render them readily accessible was, as you well know, to make the pigeon-holes as permanent as the facts they were intended temporarily to contain. A convenience at first became at last a tremendous hindrance, and we are even yet but slowly giving up our firm belief in the reality of the ancient pigeon-hole and its appropriate label. The fact is, that although our belief in them is oozing out, our necessities still compel us to use them; but it is to be hoped that they are being relegated rapidly to their proper position as conveniences, devices of semi-ignorance, and not considered as actual facts.

You also recall how knowledge presently became sufficient to justify an attempt at natural arrangement, crude enough, but still advanced enough to mark an epoch in progress; and the authors of these first "natural arrangements" understood their own limitations better than any one else. One natural arrangement has succeeded another, from that day to this, until in those of to-day we have presented to us simply what the earliest contained, viz.: the expression of man's knowledge of affinity; the difference being a slowly diminishing amount of artificial padding. I need not suggest to you how exceedingly imperfect that knowledge is yet, and how, of necessity, the best of our present systems must meet the fate of those that have gone before and become merely chapters in the history of systematic botany. This becomes doubly apparent when it is considered that "pigeon-holing" is going on almost

as rapidly as ever ; although we may fairly consider that we have now in hand sufficient material for the broadest generalizations. I say "material," not meaning by any means to imply the knowledge which proper investigation of this material is to bring us.

Systematic botany, as formerly understood, has probably done all that it can, unaided, in the natural arrangement of plants. Of course it could indefinitely juggle with sequence and nomenclature, but, after all, that is like arranging a card catalogue, and is of such secondary importance, when the real purpose of systematic botany is considered, that it can hardly be taken as indicative of progress. Let me interject a word at this point. It is my impression that the decriers of Systematic Botany have only in mind this "juggling with sequence and nomenclature" when they make their strictures, and are mistaking the art of the tailor for the evolution of the real man. One must be respectably clothed, but he must be an unspeakable idiot if that is all that can be said of him. It has always been my impression that the depreciation of any other kind of scientific work argues either lack of knowledge or conceit.

But the ancient kind of Systematic Botany was not left without aid, and a group of new departments was made possible by the microscope and the unexampled progress of powers and manipulation. The study of the cell, and of nascent and mature organs, and the recognition of plants as living things that are the resultant of the interplay of internal and external forces, have simply revived the ancient mummy called Botany, and have made it the living thing it is to-day, capable of endless development. It is not to be wondered at that these new and vigorous departments of work, in the first glow of the vital service they have rendered, should look at the older department as a thing of the past, as something to be buried out of sight, and remembered only as a part of mediæval history. But this is only the first glow of a natural enthusiasm, and I glory in it, for it promises an enormous amount of self-denying work, and the results will all fall into the lap of Systematic Botany. The corpse is not buried, but revived, and this gush of new work has been but the infusion of an elixir of life into a body that was perishing from starvation.

Some one has said that "the highest reach of the human

mind is a natural system of classification"; and Dr. W. T. Thiselton-Dyer, in the address quoted at the opening of this paper, remarks that "such a classification, to be perfect, must be the ultimate generalization of every scrap of knowledge which we can bring to bear upon the study of plant-affinity."

This simply means that when the results of all departments of botanical work are well in hand, then the systematists will be in a position to put on a sure foundation the structure they have always been planning, for it will rest upon known affinities and not upon unmeaning resemblances. To my view, therefore, the real Systematic Botany is to sum up and utilize the results of all other departments; and its work, so far from belonging entirely to the past, is well-nigh all in the future. It is the highest kind of generalization upon an enormous array of facts, and is bound to be the *last* expression of human thought with reference to plant-life, just as it was the *first*. Systematic Botany, therefore, the Systematic Botany which deals with genetic characters, and recognizes the fact that every plant is a living thing with a history and all degrees of consanguinity, and that "the final form of every natural classification must be to approximate to the order of descent," is in its early infancy, and can only develop to completest power when all the facts of plant origin, structure, and life are in. This would seem to make it a slowly developing department of a somewhat endless future, with every distinct advance in knowledge embodied in some "Natural System." These invaluable "systems" will well stand for a series of approximations towards the truth, each succeeding one probably somewhat nearer than the one before, but still far enough removed to stimulate further research.

My position, therefore, is that for the systematists of to-day and of the future there must be three distinct lines of work, related to each other in natural sequence in the order in which I shall present them, and each turning over its completed product to the next.

I. THE COLLECTION AND DESCRIPTION OF PLANTS.—This *preliminary phase* of Systematic Botany is that which most frequently stands for the whole, especially in the minds of those who have been trained in the ancient fashion. It is really strange why this particular and very necessary phase of systematic work has fallen into disrepute among the younger

botanists; and I can explain it only by the fact that it is the oldest representative of the science, or that it so frequently stands for all of botanical science in the popular mind, and this popular verdict is resented. With this last position I am thoroughly in sympathy, and it is perfectly proper for the public mind to be disabused and made to understand that botany is a science of living things and not merely of mummies; but this can be best done by treating courteously the ancient and ever to be present and necessary work of collection and description. Such workers are curators of botanical material upon an extensive scale, a function that, properly exercised, requires a skill and patience that few possess, but that many assume.

I grant that the discovery and description of new species is such an inspiring pursuit that it may degenerate into a mania, and sometimes into kleptomania; but the worst of it is that it attracts many who are wholly incompetent, and who have burdened our literature with rubbish that is both discreditable and confusing; but this can be no more true of this than of any other phase of botany or scientific work.

I do not desire to be understood as defending this kind of botanical work, for it needs no defense of mine; but simply, in view of certain fraternal thrusts that have been given, less frequently now than formerly, to call attention to the fact that this is one of the living and necessary kinds of botanical work, subject, like all other kinds, to degradation at the hands of its friends.

• While I have spoken of this phase of botanical work as the most ancient, and one which, like the poor, we are always to have with us, I by no means intended to imply that its methods cannot be improved. It must have long since occurred to some that many things besides the mere sporadic collection and recording of species should be included as legitimately belonging to this line of research. It is the common plan to collect and record a plant in such an isolated way that it becomes a text without any context, and is thus robbed of much of its significance. Collectors send in from the field large amounts of miscellaneous material, and usually the only accompanying information is a locality, mostly very indefinite, and a date. In some cases the size and habit is appended, and possibly some local economic note. I take it that this

fairly represents the average amount of information obtained from field contact with species; and how meager and unsatisfactory this is can only be appreciated by one who undertakes to make a thorough study of the flora of any region. I have no fault to find with the facts, so far as they go, but they are not half that we have a right to expect from the expenditure of time and energy. There seems to be nothing more unsystematic than field-work in systematic botany. The result is that we know a little about all our floral regions, and all about none, however small. All information that can be obtained in the field concerning species is the province of the collector to procure and of the taxonomist to record. This additional information is important, not merely as additional information, but frequently in correcting errors of judgment concerning species. A species surely holds important relations to its environment, and its characters in some unusual position, or in the penumbra of its range, can hardly be taken as typical; and yet this thing of range and relative abundance, involving centers of distribution, is rarely looked after. What I protest against is the search for species as for diamonds, as things solely valuable in themselves, apart from their surroundings; and what I would urge is the conversion of collecting trips into biological surveys. I know that this means the better training of collectors, that they must be not mere manipulators of drying paper, but scientific men; but is that any objection? I would not for a moment disparage the work of that splendid array of collectors who have triumphed over innumerable difficulties in a self-denying way worthy of any cause, and who have brought to light a wealth of material for which we can never be too grateful; but I would claim that the time has now come when the same amount of devoted labor can be expended to better advantage; and that we must train up a race of field-workers who shall follow their profession as distinctly and scientifically as the race of topographers. In this center of public scientific work in which we have met, devoted to obtaining the largest amount of information in regard to our national possessions, and with means commensurate with the largest plans, it seems an appropriate thing to urge a thoroughly equipped system of biological surveys. This subject is not a new one here, and steps have already been taken to organize some work of this kind, but I desire

to voice the sentiment of this section in commending all that has been done in this direction, and in urging that the organization be made more general and extensive.

With regard to the work of description I have little more to say than to express a feeling of regret that it is not always wisely done. This feeling, however, is not peculiar to any kind of work, and it must be always a jumble of good, bad and indifferent. It is simply a case of "let him that is without sin among you first cast a stone," and the man who publishes nothing that he afterwards regrets is either a transcendent genius or a simpleton. It might as well be accepted, however, that description will continue as before, probably in an increasingly miscellaneous way, for there is no feasible way of restricting it, even if it were desirable. We can simply urge, and continue to urge the necessity of long training, abundance of material and literature, and a patience that will be content to wait. Dr. Asa Gray, in a short paper that has never been published, has this to say:

"The publication of new species is always an anxious business to those fitted for the work and impressed by the responsibility of it, and is lightly undertaken only by those who have no appreciation of the trouble and labor they are giving to the faithful working botanist, both now and hereafter. Some enter upon this seemingly in the spirit in which an ill-disposed person was recommended to throw as much dirt as possible, on the chance that some may stick. The aggrieved author of monographs, floras, and bibliographical indexes has all this dirt (matter out of place) to take care of. He has enough to do in rightly arranging and ascertaining the limits and characters of the species of a difficult genus, without being vexed with riddles which, when solved, often prove to be curiosities of ignorance or marvels of recklessness. The added misfortune is, that superfluous names, however needless or absurd, cannot be buried in oblivion, but must be embalmed in synonymy."

There seems to be abundant indication that, with a better conception of the limitations of a species, the old characters will yield in importance to new ones of deeper significance. The microscope, which was necessary to reveal the existence of any usable characters in the lower groups of plants, is rapidly becoming hardly less necessary for satisfactory systematic work in the highest groups. While the use of gross organs will probably never disappear in specific discriminations, their *exclusive* use must be given up, and such characters will be supplemented by minute ones, which their very minuteness renders of more permanent diagnostic value. You are all familiar with several troublesome groups in which minute characters have already been made of great service in steadying characters obtained from the gross, the largely used, and

hence the variable organs. I look upon this as one of the most promising features of the work of future taxonomists of the higher groups.

The serious danger lurking just here is that when one set of characters has proved serviceable in a number of specific or generic limitations the tendency is to make the fabric of the whole group conform to that one set. This gives, of course, a kind of mathematical precision, and every problem is solved by the same formula. But, unfortunately, nature never conforms to such arbitrary rules, and the resulting arrangement may be as purely artificial as those that are confessedly so. The character of a species is an extremely composite affair, and it must stand or fall by the *sum total* of its peculiarities and not by a single one. A specific character in one group may be a generic character in a closely related one, or no character at all. Therefore, there is nothing that involves a broader grasp of facts, the use of an inspiration rather than a rule, than the proper discrimination of species. I have a belief that the arbitrary, rule-of-three mind will never make a successful taxonomist; and that there is a sort of instinct for specific limitations which the possessor cannot communicate to another. This taking into account the total character of a plant, from *facies* to minute characters, will furnish the basis of future descriptive work. The more obstacles that can be put in the way of hasty determination the better.

I have dwelt thus upon the work of collection and description, both to magnify it and to indicate that its proper position is that of a preliminary phase in the study of Systematic Botany.

II. THE STUDY OF LIFE-HISTORIES.—A second phase of Systematic Botany may be called the study of life-histories. It follows the former in natural as well as historical sequence, and, curiously enough, its votaries do not usually class themselves with systematists, although their work is chiefly an attempt to discover affinities. True, they deal in the main with the larger groupings, but this is only possible when a wealth of species is at hand. By "life-history" I do not mean simply that gross observation which watches a plant from germination to maturity, although that must be considered an extremely useful service; but even more that minute tracing, cell by cell, from the primitive cell to the mature plant, a work which is now conceded to reveal more

of the deep secrets of affinity than perhaps any other. The tremendous amount of material to be thus investigated, and the numerous obstacles to be overcome, have been the chief stimulus of recent botanical activity; and there has sprung into existence a race of workers whose powers of manipulation are little short of marvelous. These observers are bringing the hidden things to light, and out of the facts they are accumulating is to be constructed the Natural System. But the field is comparatively a new one, and the material so exhaustless that it can well satisfy the ambition of the most diligent. I would consider this work of searching for the affinities of great groups the crying need of Systematic Botany to-day. The need is so evident, and the work so attractive, that there is no lack of numbers in those who are undertaking it. The multiplication of facilities for this work is all that could be asked; but too often "facilities for work" and a little knowledge of technique are considered to be the only things necessary for this difficult kind of investigation. The consequence is that "life histories" have been published which are not histories of any living thing. The amount of work to be done is so great, and the use to be made of the results is so important, that incompetent work is peculiarly exasperating. Nothing is more capable of misinterpretation than the observations made in work of this nature, and the tendency to generalize upon few or even doubtful facts is a constant temptation.

It is really a question as yet, whether, even among skillful investigators, too much stress is not laid upon certain single characters, and the sum-total of development not sufficiently considered. There is a marked tendency to select certain parts of certain organs and square the affinities of the whole organism by these, rather than to consider them in the light of cumulative testimony, to be used in connection with others. The tendency is not pernicious, for it is rapidly accumulating a vast amount of partial testimony, but the broadest generalizations concerning affinity cannot be made until every part of every organ is considered, and the position of the organism be made the resultant of all. There is no question but that certain periods in the development of a plant, or certain important organs, notably the sexual ones, are freighted with deeper meaning than others and rightly exercise a dominating influence in determining affinities; but development at every

period, and of every organ, must eventually be taken into account before the last word can be spoken concerning a Natural System. The possibilities of adaptation seem so great that it is possible to conceive of two forms closely related in fact, but widely separated by some scheme which depends upon any one set of organs however dominant. For example, this trouble has been experienced over and over again in all presentations of *Thallophytes*, and will probably continue to be experienced so long as some single key is used to unlock all the mysteries of affinity. I cannot see why a single set of characters used by an embryologist may not result in as artificial a scheme as the use of two or three organs by the taxonomist.

I have thus spoken of the study of life-histories to indicate that its chief function lies in the field of Systematic Botany; to suggest that it take into account development at every period and of every organ, and so obtain a mass of cumulative evidence for safe generalization; and to urge upon those not thoroughly equipped great caution in publication.

I fear that what has been said concerning the great difficulty of the work of the two phases of Systematic Botany already mentioned may be taken to imply that there is nothing here for the poorly equipped but well-intentioned to do. My frank opinion is that there is an abundance of service that such can render, and that their chief function is to bring facts to the notice of those who know how to use them. Very few of us can be architects, but almost any one can carry brick and mortar.

III. THE CONSTRUCTION OF A NATURAL SYSTEM.—This is, of necessity, the last phase of Systematic Botany, and it is evident that its work will not be complete until the two previous kinds of work have been exhausted. The fact is, it must lay under tribute every department of botanical work, and be a compendious expression of man's knowledge of the affinities of plants. It is just here that the work of the tyro is most common and least harmful; for crude systems need not annoy, they can be buried and no law requires their embalming, no necessity compels a verification of their facts, for no facts are used except such as are already known. I venture the assertion that few botanists can truthfully deny that in the early and most ambitious stage of their development they either had in mind, or were rash enough to publish some idea that

was to simplify the whole scheme of plant arrangement. This tendency may have soon been checked by wise friends or sad experience, but to attack the largest problems first is as natural as youth itself. I speak of this, not only as a generalization, but also as a reminiscence.

But these Phaeton-like attempts aside, wherein lies the necessity of this most difficult work before the facts are all in, this attempting what is conceded to be impossible? Is it of any advantage to construct a system to-day which must be found faulty to-morrow? It is of the highest advantage to construct any system which shall embody every known fact concerning affinity. Every such system becomes, as ought to be clearly understood, simply an expression of our imperfect knowledge, a convenient summary of information, a sort of mile-post to tell us how far we have come, and to direct future effort. In his essay upon "The Significance of Sexual Reproduction in the Theory of Natural Selection," Weismann uses these words, which are well worth quoting in this connection:

"Instead of comparing the progress of science to a building, I should prefer to compare it to a mining operation, undertaken in order to open a freely branching lode. Such a lode must not be attacked from one point alone, but from many points simultaneously. From some of these we should quickly reach the deep-seated parts of the lode, from others we should only reach its superficial parts; but from every point some knowledge of the *tout ensemble* of the lode would be gained. And the more numerous the points of attack, the more complete would be the knowledge acquired, for valuable insight will be obtained in every place where the work is carried on with discretion and perseverance. But discretion is indispensable for a fruitful result; or, leaving our metaphor, facts must be connected together by theories, if science is to advance. Just as theories are valueless without a firm basis of facts, so the mere collection of facts, without relation and without coherence, is utterly valueless. Science is impossible without hypotheses and theories; they are the plummets with which we test the depth of the ocean of unknown phenomena, and thus determine the future course to be pursued on our voyage of discovery. They do not give us absolute knowledge, but they afford us as much insight as it is possible for us to gain at the present time. To go on investigating, without the guidance of theories, is like attempting to walk in a thick mist without a compass. We should get somewhere under these circumstances, but chance alone would determine whether we should reach a stony desert of unintelligible facts or a system of roads leading in some useful direction; and in most cases chance would decide against us."

It becomes very evident that the work of constructing even a Natural System which must be tentative, a sort of temporary scaffold, is one which demands not only the widest range of information (and hence a task which is daily becoming more exacting), but also that broad grasp in generalization which is possessed by very few. The marshaling of facts is like the marshaling of armies, and very few are born generals. Almost any one can arrange the plant kingdom who is pos-

sessed of but few facts, but he who has them all within his reach finds no more difficult task; for it is like fitting together a puzzle of endless pieces.

The question might arise as to the duty of ordinary manuals in this respect, books of limited range, that do not profess to undertake such a path-breaking operation as the construction of a new Natural System. It has always been my opinion that even the most local manual should be an expression of the ascertained facts of affinity. This statement is by no means so sweeping as it may at first appear; for it does not contemplate including the scores of crude notions which are always being advanced, so attractive to many who are naturally restless and mistake change for progress. In the statement made, I desire to emphasize the words "ascertained facts of affinity;" and this is very far from permitting the use of every random notion that may happen to be published. The facts of affinity are slowly accumulating, facts which have reached the dignity of general consent, and it is such that I would always have incorporated even in local manuals, which should not be subjected to the continuous shaking of treacherous ground. I am fully aware that there is a conservatism which is an obstruction to progress; just as there is a galloping rapidity which would land us in the mire; and that we probably all possess one of these qualities in our anxiety to escape the dangers of the other.

The points presented then, in this consideration of the third phase of Systematic Botany are, that the last and highest expression of systematic work is the construction of a Natural System, based upon the accumulations of those who collect and describe, and those who study life-histories; that this work involves the completest command of literature and the highest powers of generalization; that it is essential to progress for a Natural System to be attempted with every advance in knowledge; and that all the known facts of affinity, thus brought within reach, should be expressed in all systematic literature.

In conclusion, I have but to say that I have attempted to indicate the true relation which exists among the different phases of Systematic Botany; to point out an affinity which there is danger of ignoring; and to maintain that all these departments of work, looking to the same end, are equally important, equally honorable.

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