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CONTENTS

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THE RELATION OF BOTANY TO AGRICULTURE[1]

THE relation of botany to agriculture is an interesting subject to discuss, whether stated in this form or as the relation of agriculture to botany. It is capable of being stated in a dozen other forms, equally suggestive. In every one of its aspects it has been discussed and rediscussed until little remains except to piece together selected fragments of excellent thought into the skeleton of a new picture, somewhat as a composite is made of the photographs of hundreds of men and women in a picture that sometimes is thought to present the character of the whole though no one of its components may be recognizable in it,—or one may dominate all the rest.

Without agriculture, there would be no botany. Without botany, agriculture would be little more than empiricism; but this empiricism would contain in itself the seeds of evolutionary improvement, out of which botany must inevitably grow. The interrelation is a little like that of nutrition and sensation in an animal, and you can trace a large number of parallels between the two cases if you wish.

If, when and as (to quote the stock promoters) the human world becomes stabilized in its mastery of itself and its environment, it may standardize and codify all that it knows and does into a uniformity of action and corresponding expression that will make the choice of words easier than it is now. An imaginative Chinese student of agriculture a few years ago pictured an approach to this condition—in one direction—by considering the waste areas of the earth's waters to be covered by floating gardens from continent to continent between favorable isotherms; much as an imaginative engineer might picture the roofs of our houses converted into a continuous highway for terrestrial use marked here and there by landing stages for aerial birds of passage.

At present we not only use different words to convey essentially identical ideas and the same word to convey ideas that are not the same, but we have a confusing habit of defining our expressions differently or, through mental reservations, of talking about something else when we have accepted a nominal definition of a word.

To some people, the word botany is broad enough to comprise anything whatever directly concerning plants: their structure, their function, their interrelations with one another and with environing nature, their structures or stores that we appropriate to our

[1] Sigma Xi address at Iowa State College, May 3, 1924.

own uses, their response to a little protection in reseeding our vanishing forests, their pliability under the hands of the cultivator and the breeder, in fact, anything in which the name plant or any of its synonyms or subdivisions figures.

Not long since, an educator, who is not a biologist but one sympathetic with science, criticized a general college course in botany as too comprehensive because it touched on such topics as the ecology, physiology and pathology of plants. Possibly he would have defined botany in the time-honored sense of a century ago when to be a botanist one must "know plants" and when, as Professor Torrey once expressed it, one who did not "know" four hundred plants was hardly qualified as a professor of botany.

The one-time dean of a great college of agriculture, who at the same time was a botanist who knew his four hundred plants, among other things used to begin his lectures on general botany by stating that botany is the science that concerns itself with plants, that science is organized knowledge and that plants are—well, what are plants anyway?—let us say, living things that are not animals.

A Spanish author accounts for the bull-fighting instincts of his race by carrying these back to the time when that race was a race of hunters and of tamers and then breeders of animals, and that passed to the regulated procedure of the arena by way of the less democratic inquisition.

If, as some people would deny, our remote ancestors were tree-dwellers, they must have been vegetarians to a large extent. Even after that great epoch of progress that the teachers of evolution delight in picturing, when they learned to hold their own on the ground and to defend themselves against the brutes that had claws and fangs and horns, they must have eaten fruits and succulent stems and leaves and starchy roots in larger quantity than flesh. A Darwinian would say that even our teeth show this. How many generations it must have required to pick out and reject the harmful of these reservoirs of nourishment and latent solar energy. How many generations more it must have required to transform some of their crude weapons into even cruder tools and to have acquired the art of transplanting and protecting the best of these!

That, and the domestication of animals, constitute the dawn of agriculture. Before the day of the Jews, and that was five thousand years ago, the art was crudely practiced. Its practice contained in itself the rudiments of biology—this much can be seen in the Scriptures and in echoes of the earliest civilizations. By the time of the Greeks, with their analytical minds and their didactic habits, very much seems to have been known or thought here and there about plants.

Very likely it was Aristotle who winnowed and selected and shaped up this knowledge and tradition, this plant-lore, into a rational whole: but it was his friend and pupil Theophrastus who first put it into permanent written form. As a science, an organized assemblage of the knowledge of plants, botany thus came into existence several hundred years before the Christian era began.

When the idealistic Greek was being supplanted by the more practically minded Roman, agriculture came into its own. Science seems not to have been much talked of, but the pleasures and profits of country life appealed to writers—and to readers without whom there would have been little call for writers. Students of the joint evolution of botany and agronomy and horticulture, find an interesting contrast between the Inquiry into Plants of Theophrastus, three centuries before the birth of Christ, and the Natural History of Pliny near the end of the first century of the Christian era. The one is the orderly organization of a science, containing germs of applicable knowledge rather than prescriptions for its application. The other, with the chaff less carefully winnowed from the grain, is an encyclopedic compendium of what was known or believed.

History is said to repeat itself. The curious thinker possibly may find that, to-day, readers prefer the practical conclusions at end of a learned dissertation to painstakingly mastering the details on which these conclusions are based. Every teacher has noticed that students are keener for the sweets and the nuts in a course than for the meat that must be chewed. I must confess that I myself prefer Bailey's Cyclopedia to the great Floras—for many purposes.

If we follow my friend the dean in considering botany to be the science that deals with plants, we shall have to go a bit further along the same road and consider that—if animals are living things that are not plants—zoology is the science that concerns itself with animals.

Whether or no we frankly consider ourselves as being animals, we have to face the fact that our own natural history and morphology and anatomy and physiology and pathology stand out in particular emphasis in one's mind when these words are mentioned, so that it is not very surprising that separate sciences —first anatomical and physiological, then pathological —should have broken free within the general science of zoology. At first human, then comparative, these offshoots have hung for a time loosely to the parent science, then have separated and drifted away from it like jellyfish from a medusa.

To-day, like chemistry and physics, a knowledge of the general laws of these segregates is presupposed for intelligent study of the generalized and comprehensive science of which they were a part originally

and in which they still enter in its broad and synthetic understanding.

I never have heard it said how many animals one should "know" if he is to qualify as a professor of zoology; but as there are several times as many kinds of animals as there are of plants, it probably would not fall far short of two thousand on the basis adopted for a botanist. The major part of these kinds of animals probably fall among the insects, those wonderful little creatures that sometimes surpass us in social subordination of the individual, in industry and in thrift, and that at times rise to a superhexapoecian if not almost a human intelligence.

Zoologists now and then fall back on selected types of insects like potato beetles or fruit flies for analysis of some of the fundamental problems of variation and heredity, of mutation and evolution; but entomology usually stands apart from zoology, now-a-days, as a separate science—possibly because the novice finds it easier to become acquainted with a thousand individual bepestered bees or hungry grasshoppers or thirsty mosquitoes than with a tithe of that number of kinds of insects.

Botany, likewise, has disintegrated as a whole. Its roots are widespread and its branches cover as much ground, but its proliferation has been somewhat different from that of zoology. Like a Canada thistle it has sent its offsets up in competition with each other and with the parent stock. They are tenacious of the ground that they hold and are not easily eradicable, but they have not that enviable independence of environment that the anatomy and physiology of animals have enjoyed through their relation to the human frame and to life.

In a way comparable with entomology, bacteriology has broken away from the parent stock, with directly economic aims; a modicum of demonstrable structure to work from, but a world of intricate physiological problems to be solved—developing, even, a physiological basis of classification quite its own and not found successfully applicable elsewhere in biology. Debatably plants or animals, these smallest and least structurally specialized of living things, the bacteria, may well be left as the most tenable of protista, in the hope that for them a science may be evolved finally comparable with botany and zoology.

Some years ago the dean of a college of agriculture asked my opinion as to whether—since time could not be spared for both—an elementary course in botany or such a course in zoology should be required in his college, or whether one or the other should be required according to agricultural specialization along the different lines of plant industry or animal industry. It was and remains a hard question to answer.

A few years ago if the question had been asked publicly the answer would have been shouted "Neither: a course in general science!" Half a century ago, when too exclusively descriptive zoology and botany were being revivified by Huxley and his South Kensington associates, the answer would have been "Neither: a course in biology!" Both would have been right: but—I do not say that this is my own opinion—it is claimed often enough to receive attention that a department of biology has the advantage of calling for one professor instead of two, and that one does not need to be a professor, even to teach general science. Possibly, of course, any such opinions rest on a disbelief that a professor of zoology could be found "knowing" his 2,400 kinds of plants and animals—or that an expounder of general science really could be expected to have personal acquaintance with a score in both fields, to say nothing of the constellations and the chemical elements and so on.

My answer to the question asked me, given for what it was worth, was to the effect that—judging from a money standard only—plant industry is twice as important as animal industry, in agriculture, that both depend upon the functioning of living things, that this physiological functioning is closely dependent upon structure differentiation, that structure and function in the main are simpler in plants than in animals; well, perhaps the drift of the argument was that the essential general principles of coordinated structure and function could be taught more simply through botany, and at any rate that green plants are the food-makers for the whole world, so that successful animal life never can be divorced from productive plant life, and that even the stock man, in the main, must have an agronomist's understanding of plant life thoroughly as a foundation for his own specialization.

For very many years I had been out of close connection with botany as taught in agricultural colleges as contrasted with botany as taught elsewhere. During these years it had been my business and my pleasure to keep a pretty close watch on the growth and trend of botanical literature, and now and then I had scanned with interest some new text on agricultural botany or on botany for students of agriculture.

Then I was invited to head the department of botany in one of our great state universities which included an unusually strong college of agriculture. Before replying to the invitation I made a pilgrimage to my old campus, Cornell, to ask of an authority—the dean of the college of agriculture at Ithaca—what botany was needed for such a college that was not needed elsewhere; because that college at Cornell had been absorbing most of the botany of the entire university.

The answer was short and simple, and the argu-

ment supporting it was direct, as any one who knows L. H. Bailey will understand, "Botany for agriculture need not be different from botany for anything else; it ought to be botany; good morphology—more of the kind that Asa Gray used to teach, good physiology, and personal acquaintance with plants."

That *is* botany, after all, isn't it, and can agriculture dispense with botany?

There are two very different ways of looking at questions: the—disinterested, I might say—way of viewing them quite impartially from the outside, and the—perhaps selfish—way of seeing how they may be answered most profitably to us.

Mitchell recently has analyzed our national life and habits and rather unflatteringly tells us that though we have learned a good many things we have not learned how to live.

This process of not learning begins when as very little children we ask questions that our elders—Barrie would say our betters—can not answer. Every one who has seen the racing speed with which the years convert a questioning child into a "don't-know" grown-up has had a chance to see what brings about the change.

School and college are too busy with other, perhaps more obvious, matters to bother with correcting this little detail. This may suggest what I mean when I speak of the different viewpoints on any question taken from the outside and the inside. Until critical—perhaps too often destructively critical—analyses, like that of Mitchell, shall have come home to us in betterments of what we proudly call the finest educational system in the world, we certainly shall not have learned to live—as Mr. Eliot has expressed it, to get the joy out of life.

We are traveling very rapidly now along the road of vocational training, a road that is making of us successful specialists in the great fundamental industries of agriculture, manufacture, engineering and commerce, as well as in what sometimes are spoken of as the learned professions—or the professions, for short. Material national prosperity lies along this road, but if we are to conquer what Mitchell takes to be our national malady we can not wear blinders as we travel it; we must see and enjoy the delights of living as we perform the work that for most of us, happily, gives the means of living.

So the relations of botany to agriculture, as I see them, go far beyond the class-room where botany is taught as a foundation or as a part of agriculture. They begin with the child's interest in everything about it, they touch the reservation of a bit of the home surroundings for a flower-garden pure and simple, they put more than a money value on the woods pasture and the bog meadow, they preserve in natural parks for coming generations some of our heritage of nature which should be inalienable.

I have read many essays on botany, past, present and to-be. I have noted with concern that it is less taught even than formerly in our secondary schools. I have found, more than once, after recommending a teacher of botany to a superintendent, that he has had to get some one who also could direct athletics. I have shared the lament of a distinguished botanist, converted into an eminent agronomist, that botany, however suitable it may be, is not aggressively coming into its own as fundamental to the art out of which it has grown and which as it has grown it has lifted to undreamed-of successes. These and many more of its failures are matters of every-day observation.

Botany, more even than zoology, has suffered through the segregation of its application. When Mr. Wilson was secretary of agriculture, a skilful organization brought together under him the federal branches dealing with agricultural botany—all but forestry which stood and still stands apart from the Bureau of Plant Industry: the significance of ecology was not then so evident as now.

It is not so very many years since in an agricultural college one man served as professor of botany, of horticulture and of forestry, though agronomy as a part of plain agriculture even then stood by itself. To-day, if more than one of these subjects be found in a department it is usually for reasons of administrative correlation rather than because of their consanguinity.

Like agronomy, these specialties all rest on a knowledge of the structure and the work and the environmental relations of plants, all of which conform to laws that form a part of the science of botany and that, under whatever name, have been framed by botanists.

One might almost venture the assertion that whether called a clerical, like Mendel, a farmer, like Lawes, a horticulturist, like Burbank, or an unclassified naturalist, like Darwin, all those men who have made great economic plant-industry advances have been in reality botanists.

If I were to sum up in general terms the relations of botany to agriculture in college, I should say that, whether called genetics or agronomy, every fundamental step in plant breeding is botany; whether called floriculture or olericulture, every recognition of mutation and every selection based upon it is botany; whether called fighting weeds, in agronomy, or reseeding the wood-lot, in forestry, every ecologically grounded procedure is botany; whether you practice prophylaxis or quarantine or bring into existence resistant races, every step in combating plant

disease is directly applied botany; and even the season for most satisfactory pruning, the selection of full-weight seeds and the proper utilization of those that are under-ripened, all rest on botanical discovery brought about—under whatever name you like—by botanical investigation.

The day may come possibly when we shall place all such botanical studies in the hands of doctors of agronomy or doctors of olericulture or doctors of pomology; but learned as the agronomists and olericulturists and pomologists and other specialists are who are adding untold wealth to the country every year through their specially trained and concentrated skill, it appears that to-day for the most part these men actually are doctors who have taken their major work in botany, and minor work only in the paramount field within which they planned to apply their training in this fundamental science, The relation is somewhat that between discovery and invention—with larger financial rewards on the applied side.

So, as to college botany in relation to agriculture, I come back to Bailey's opinion that agriculture needs and ought to have instruction in the essentials of botany—good morphology, good physiology, to-day good ecology, and personal acquaintance with plants.

A real morphologist, with a free hand, can teach the morphology that is needed. Unfortunately, a free hand means free time: he may find that, possibly; but, and this is crucial, his students do not.

A modern physiologist seems to find a modern laboratory necessary if he is to teach the necessary physiology. Quantitative exactness is so much a part of a subject so largely physico-chemical, that we do not appear to pause long enough to realize that its high points were worked out qualitatively and organized into unity without such appliances; but time fails the student even if the teacher see the broader and more generalized side of his needs, or can meet the more specialized requirements.

The hardest part of the prescription to fill, though, is supplying a personal acquaintance with plants: and this should be the easiest. Most agriculturists who talk to me about the shortcomings of students find that they do not "know" plants.

Colleges, and particularly agricultural colleges, suffer tremendously now-a-days from being urban or suburban institutions. They suffer correspondingly from being gigantic institutions. Even with gardens, if we have them, though we may carry reduced advanced classes along, specimen in hand, we can not do this adequately for the beginners who need it most; and few of us have even such gardens as, for example, the old-fashioned course in medical botany has given to so many European universities.

My idea is that the botany needed in agriculture must begin before college and specialization are reached—let us say, for the moment, in the high school. That simplifies it very much—or would simplify it if Bailey's simple prescription could be filled in the high school. Fifty years ago that might have been looked for. Botany did not comprise much more than the elements of descriptive morphology and a personal acquaintance with common (we called them familiar) wild and garden flowers.

This acquaintance is not given now in most high schools because the teacher has missed it. The prospective high school teacher of botany finds now that he or she must be prepared to teach history or mathematics or something else, as well. The bars are being raised steadily, and on excellent argument, for a prerequisite in education that in some states surpasses the major requirements in a balanced college curriculum.

Certainly the educated college student can not be allowed to go out without a general high-points knowledge of the working of the world's food-makers-plants; of the wonders of even their complex mechanism; of the nucleus of each and every cell, which means so much for its formation and functioning; of its chromosomes—the mechanical basis of heredity. But where is the background?

A reaction that it appears very easy to get with a large beginning class in botany illustrates one of the difficulties in the way of making progress in any line of botany. Did you ever sketch the current belief in some phenomenon or other as merely the working hypothesis of the moment, picture its ultimate establishment or replacement through investigation under exact control of conditions and an isolation of factors such as Mendel or DeVries would have ensured and say casually, "Some one of you may give an answer to this question"? The heehaw with which a class looks around for the goat—outward and rarely inward—would be very amusing if it were not so very pitiful.

It takes a long time for the idea of producing to enter into most of us, who are born and educated as consumers: yet somewhere among these beginners is found the material out of which investigators are shaped up when maturity has brought the idea that the opportunity of life really is an opportunity of balanced give and take. After a century and more it is as hard to make the beginner realize that we are merely on the threshold of knowing and understanding nature as it was when Linnaeus, the great systematizer of biological science, showed an unknown moss under his hand, placed at random on the ground, to a student who was expressing his sympathy with the master who knew all nature and

yet spent so much of his time in teaching to others what he knew perfectly.

Here is the kernel of what I am trying to say. Nature-knowledge, whatever you call it, must be brought back into the home—and this ought to be through the kindergarten and the primary school. Teachers in these schools ought to be helped in high school to "know" the plants and the birds and the common insects and other denizens of field and forest.

A high school teacher of biology—under any name—who can not help the forming grade teachers to get this knowledge really is not fitted for the place he holds: but college too rarely can or does fit him. Until what we call our educational system is reformed through evolution or revolution, I fear that we must look for the beginnings of this knowledge where they lay several generations ago—among the self-helped and self-taught fathers and mothers to whom little children turn—at first—in the confidence that they know or have or will learn or will get what is asked for whenever it is neither unreasonable nor harmful. My heart is very warm for the person groping for such self-help: and for the simple-minded apostle of a real nature-knowledge, who in the complexity of our specializations and prerequisite requirements can not reasonably hope to get or hold a teacher's place, whatever he may know, unless he produce some sort of academic sealed and be-ribboned open-sesame.

If ever we can get back to this common possession of our modestly educated forefathers—and the means of self-education are myriad now where they were few for our ancestors—no college class will smile at the thought that it may contain a potential Hales, or Hofmeister, a Gray, or Mendel. Self-evidently it will contain the fundamental of inherent acquaintanceship with the great makers of food concerning which it is acquiring knowledge; and the fact that this knowledge is oscillating and vacillating in its progress toward the real and the full truth will stimulate its every alert member (if this perfection of college classes may be expected) to thinking for himself on the problems and the means of solving them. Then, as formerly, we shall rely on such self-guidance rather than on mimeographed mechanical outlines of work.

Here, in the class-room—even without laboratories, greenhouses or herbaria or gardens—lies our own personal point of contact with the relation of botany or of any science to agriculture—or to anything else. The inspiration of an enthusiastic teacher, an indefatigable investigator, an aging man who never can become encysted by age but whose horizon increases with the years is the contribution of college and university that develop it. These are the men who make laboratories, who devise means to ends—whom others follow.

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ON THE AVIFAUNA OF THE CAPE VERDE ISLANDS[1]

RECENT field work for the American Museum of Natural History has supplied specimens and data for a study of the bird life of the Cape Verde Islands. Water birds, in particular, are so well represented in the collection that it has been possible to employ statistical methods in determining the range of individual variation in certain species, and to contrast, by means of frequency graphs, variation of this kind with geographic variation, *i. e.*, true specific or subspecific variation.

The avifauna of the Cape Verde group comprises 75 forms, of which 37 are seasonal or casual visitants from breeding grounds elsewhere, and three are introduced species. Of the 35 native resident birds, 9 are oceanic, while 8 may be considered Palearctic, 7 Ethiopian and 11 neutral.

The last and largest of these assemblages includes birds of five classes, namely: (1) Those whose breeding ranges extend from areas north of the Mediterranean southward into Africa (*e. g.*, the flamingo and the Egyptian vulture); (2) those which range even south of the forest belt in parts of Africa, but which breed also from southern Europe eastward into Asia (*e. g.*, the white egret, which is resident in India and Ceylon); (3) those which are alike related to representative forms to northward and to southward (*e. g.*, the endemic courser and barn owl, the latter of which is a member of an almost cosmopolitan species); (4) those characteristic of the northerly part of the desert zone, some of which have close relatives in Egypt, Arabia or southwestern Asia (*e. g.*, a lark, *Alaemon*, and a raven, *Corvus ruficollis*); (5) those which have a large proportion of their congeners in South Africa, but which, nevertheless, show closest affinity with species found at the northern edge of the Sahara (*e. g.*, a lark, *Ammomanes*, etc.).

The avifauna is therefore neither prevailingly Palearctic, as Wallace believed, nor distinctly Ethiopian, as has been held by more recent naturalists.[2] It is rather a transition fauna, with numerous desert types akin to birds found along the northern border

[1] Abstract of a paper read before the New York Academy of Sciences on December 10, 1923.

[2] Wallace, A. R., 1876. "The Geographical Distribution of Animals," I, pp. 214, 215. Neumann, O., 1918. *Journal für Ornithologie*, LXVI, pp. 235, 236. Bannerman, D. A., 1920, *Ibis*, pp. 560, 561.