OBSERVATIONS ON CULTIVATED PLANTS WITH REFERENCE TO CERTAIN AMERICAN PROBLEMS[1]

E. D. Merrill

IT IS AXIOMATIC that all of our domestic animals and cultivated plants were derived, sometime during the long prehistory of the human race, from wild animals and wild plants. The actual selections for domestication made here and there, in very limited parts of the world as a whole, could only have been accomplished in the regions where the wild species of animals selected for domestication and the wild species of plants selected for cultivation actually occurred in a feral state; and these limited areas in both hemispheres are those in which the early higher types of civilization developed. Selections were obviously made from among the many thousands of species of wild animals and plants on the basis of certain inherent qualities in this or that animal which rendered it susceptible to domestication, and this or that plant species which not only produced abundant and palatable food in the form of fruits, seeds, corms, tubers, or vegetative parts, but which was also a species amenable to cultivation. But for untold generations primitive man was wholly dependent for his food supply on wild animals and wild plants, and it was from these he made wise selections for domestication. It may be assumed that the beginnings of agriculture were accidental, but in the thousands of years during which a permanent agriculture was slowly being developed, whether based on animals or plants or both, man in the course of time learned how to select and to perpetuate those varieties of both animals and plants that showed improvements over the ancestral feral types.

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[1] See also **Merrill, E. D.** Domesticated Plants in Relation to the Diffusion of Culture. Bot. Rev. **4:** 1-20. 1938, reprinted Chron. Bot. **10:** 316-329 1946, and Man's Influence on the Vegetation of Polynesia, with Special Reference to Introduced Species. Proc. Sixth Pacific Sci. Congr. **4.** 629-639. 1940 (1941), reprinted. Chron. Bot. **10:** 334-345. 1946.

EARLY DOMESTICATION OF PLANTS AND ANIMALS

It is clear from the record that all of our domesticated animals and all of our basic cultivated food plants, on which agriculture is based and which in turn permitted the development of early civilizations, were in domestication, as to the animals, and in cultivation, as to the plants, long before the dawn of recorded history. Since the beginning of what we characterize as civilization, man has not added a single important basic species to the long list of those selected by his very remote ancestors. It is true that he has greatly improved the domesticated species and varieties inherited from his more or less primitive ancestors as to yield, quality, hardiness, and other factors, and in modern times has developed numerous improved varieties through accidental or deliberate selection as well as by hybridization. But for an occasional secondary species, he has not increased the total of those wild species actually domesticated in very early times to any appreciable extent. Among such secondary species of plants may be mentioned the cranberry, the American types of grapes, these domesticated in the past century, and within the present century the actual domestication of the blueberry in the United States. But these, and others in this category, such as the strawberry and the cultivated varieties of the raspberry, blackberry, etc., cannot be considered as basic food plants in the sense that the tuber bearing plants like the potato, and the cereals, such as wheat, barley, rye, rice, and maize, and certain important leguminous plants such as the beans and the peas are basic.

VARIATION IN DOMESTICATION

In the case of both the plant and animal species basic to agriculture it is definitely known what the actual ancestors were in terms of modern systematics for nearly all the species, no matter how much the selected forms have changed under the accidental or deliberate selective activities of primitive and civilized man. That such variation has attained enormous proportions one has only to consider our modern breeds of cattle,

horses, sheep, goat, swine, dogs, and poultry in the animal kingdom, or such commonly cultivated plants as the garden beans, maize or Indian corn, rice, wheat, squash, summer squash, and that great variety of forms derived from the wild *Brassica oleracea* Linn. of the European coastal regions, including kohlrabi, cabbage, kale, cauliflower, broccoli and Brussels sprouts. Generally speaking the variations exhibited by these modern domesticated strains or varieties are in the direction of those parts most useful to man, whether it be the vegetative parts or even the flower buds of certain of the *Brassica* derivatives, the seeds, the fruits, or the starch producing tubers and corms that are actually used for food. It should not be forgotten that the actual perpetuation of most or all of the improved varieties of plants and animals are dependent on man.Without his constant intervention year after year most of them would disappear in the course of time.

WILD ANCESTORS OF CERTAIN CULTIVATED SPECIES STILL UNKNOWN

In only a few cases in the plant kingdom are the ancestors of our cultivated crop plants as yet unknown as wild species. Perhaps the two most striking cases are both plants of American origin, maize or Indian corn *(Zea mays* Linn.) and the common garden bean *(Phaseolus vulgaris* Linn.). Both are enormously variable in their cultivated forms, and both are definitely of American origin; they were both very widely distributed in cultivation more or less throughout North, Central, and South America long before the time of Columbus, and are the two most important basic food plants in the early American civilizations. One may perhaps legitimately theorize on the possibility that, because of the great variability of these two basic food plants, and the fact that their wild ancestors are as yet unknown, this supports the idea of an ancient origin of agriculture in the New World, perhaps even older than the types of agriculture developed in Europe and Asia. In any case one can only conclude that everywhere where agriculture has been developed on the basis of plants and animals native to this or that region, it is a very much more ancient

art than anything that we recognize as belonging to what we may designate as civilization; man could advance in the cultural field only after he ceased to be a nomadic hunter and fisherman. The establishment of a permanent and abundant food supply following the establishment of agriculture, enabled him to forge ahead in other fields.

DE CANDOLLE'S OPINION

De Candolle in his classical work, *Origin of Cultivated Plants* (p. 461) published in 1885, on the basis of his own very wide knowledge of plant distribution and his intensive consideration of the subject of cultivated plants, dismissed the Old World versus the New World species, as to universal distribution of the cultivated forms, with this very striking observation: "In the history of cultivated plants, I have noticed no trace of communication between the peoples of the old and the new worlds before the discovery of America by Columbus ***** Between America and Asia two transports of useful plants perhaps took place, the one by man (the Batata, or sweet potato) the other by the agency of man or of the sea (the cocoanut palm)." The evidence was so strong against any universal distribution of cultivated food plants as between the two hemispheres in pre-Columbian and pre-Magellan times that he did not consider it necessary or desirable to pursue this phase of the subject further. All dependable evidence available nearly seventy years later (the statement first appears in the French edition of his work in 1883) supports the correctness of his conclusion.

INCONSISTENT THEORISTS

It is indeed very curious to note how little attention certain theorists on the origins and distribution of agriculture and the civilizations based on agriculture have given to this manifestly true statement. It seems to be clear that in the popular mind, and I am afraid in the minds of some of the non-biological theorists in ethnology and other fields, and a few biological theorists, that cultivated plants and domesticated

animals, as such, were more or less universally distributed as between the two hemispheres at an early date in human history. It cannot now be proved that a single basic cultivated food plant was universally distributed in both hemispheres before the era of modern exploration commenced with the epoch-making voyage of Columbus in 1492. And among all the animals domesticated by man, the same statement is true with one exception. Early man entering North America over a northern route via northeastern Asia and Alaska did bring with him his ancient companion in hunting, the common dog.

OCCASIONAL EXCEPTIONS

In the plant field there is an occasional exception or rather partial exception to the statement that all cultivated plants were confined to the Eastern or the Western hemisphere until the last decade in the fifteenth century and the early decades of the succeeding one. Thus it is now clear that the Polynesians did transport the sweet potato *(Ipomoea batatas* Poir.) from western South America to the Pacific Islands a few centuries before Magellan circumnavigated the globe in 1521. They disseminated the American name (Kechua Indians of Chile) *Kumara* with the plant itself all over the islands within their culture area, even as far to the southwest as New Zealand. Doctor Buck[2] is authority for the statement that the species was in Hawaii by the middle of the 12th century. They did not discover New Zealand until the 10th century, and their settlement there came somewhat later. Its later introduction into the Philippines and the Indo-Malaysian region did not take place until later when it was consummated by the early Portuguese and Spanish explorers or settlers. This pre-Magellan occurrence of the sweet potato in Polynesia I would accept as proof that the Polynesians in their remarkable expansion over the Pacific Islands, actually did reach the western coast of America, and that some of these early voyagers did succeed in returning to their island homes. Consider merely the fact that the Polynesians were not

[2] **Buck, P. H.** Vikings of the Sunrise. i-xiii. 1-335, illus., 1938.

grain or seed eating peoples, for they had no cereals, not even rice, that standard staff of life of the warmer parts of the Old World, and that basically their chief source of carbohydrates was from tubers and corms. They cultivated on an extensive scale such tuber bearing plants as several kinds of the true yam *(Dioscorea)*, the aka *(Pueraria)*, and the pia *(Tacca leontopetaloides* O. Kuntze), and among the corm bearing species, the distinctly important taro *(Colocasia esculenta* Schott), and the less important pula *(Cyrtosperma chamissonis* Merr.), teve *(Amorphophallus campanulatus* Blume), and ape or kape *(Alocasia macrorrhiza* Schott); and of course the breadfruit *(Artocarpus altilis* Fosb.) was a most important food plant to them although it is little used in the islands to the west from whence it came. Thus the sweet potato encountered by them in cultivation in South America would be a "natural" for them with which to replenish their food supply for the return voyage to their island homes. The pre-Magellan Polynesian food plants were all, with the exception of the sweet potato, of oriental origin.

REPLACEMENT OF INFERIOR BY SUPERIOR SPECIES IN CULTIVATION

But the superior sweet potato, once introduced into Polynesia, replaced to a remarkable degree the actual cultivation of such distinctly inferior food plants as the *Amorphophallus*, *Tacca*, and *Pueraria*, and apparently greatly reduced the importance of the *Cyrtosperma* as a plant cultivated for food. Today, some of these, such as the *Amorphophallus*, *Tacca*, and *Pueraria* still persist in Polynesia and elsewhere in the Old World as wild plants, and in times of famine their tubers or corms are still used as food. *Tacca* has an interesting history, for it was in earlier times rather extensively cultivated for food not only in Polynesia, but also in the Indo-Malaysian region and in Africa. Its tubers are poisonous and cannot be used for food until after a special treatment to eliminate the poisonous principle. It occurs naturally immediately back of sandy beaches both in Malaysia and in Polynesia; and it still persists here and there at inland stations, probably a survival from

earlier cultivation. One can only consider that originally it was sea distributed through its floating seeds, but its wider distribution, especially inland, was aided and abetted by man. It may still be cultivated here and there, but as a cultivated plant it is nowhere of any great importance.

One other case that occurs to me is the relatively unimportant gourd *(Lagenaria siceraria* Standl.), for it is clear that this cultivated plant did occur in both hemispheres before Magellan's time. As a food plant it is very unimportant, and in some countries its fruits are scarcely eaten; its dry gourds are important for use as vessels of one sort or another. Such evidence as is available points to tropical Africa as its original home, but when and how it attained its more or less universal pan-tropic distribution is not clear. It may owe its presence in pre-Columbian America to the Polynesian voyagers, as may also be the case with the coconut.

The fact that certain formerly cultivated food plants are now no longer found in cultivation, or are only occasionally planted, where in earlier times they were important in the economy of the natives of this or that region, merely emphasizes the fact that when a superior food-producing plant is once introduced into a new region, it often replaces the inferior plants there in cultivation at the time. The sweet potato in Polynesia is an excellent illustration of this. It is again illustrated in various parts of Latin America, where, in early times, quinoa *(Chenopodium quinoa* Willd.), and certain species of *Amaranthus* were widely cultivated for their small seeds. They are still planted here and there but apparently nowhere on a large scale as formerly was the case. They were replaced in cultivation by the small grains of Europe when once these superior cereals were introduced, with wheat, barley, and rye, of Eurasian origin, in those places where climatic conditions were favorable, and at low altitudes by that tropical staff of life, rice, of Asiatic origin. But these small grains were all introduced by the early Spanish colonists, and were unknown to the American peoples until the beginning of the sixteenth century.

EARLY AMERICAN VERSUS EURASIAN CIVILIZATIONS

I have elsewhere noted that a considerable number of theorists argue that the beginnings of civilizations in America were somehow derived from what they have assumed to be the older civilizations of the Old World. This would mean contacts across the Pacific and the Atlantic oceans at a time when seaborne traffic was exceedingly primitive. True, the Polynesians themselves did solve the problem of distance in their remarkable migrations which resulted in their occupation of the widely scattered islands of the Pacific basin, but this expansion occurred late in history, certainly within the past 1,500 years. The number of species of food plants cultivated by them was very small, and with the exception of the sweet potato that they acquired in the twelfth century were all developed in the Old World. To those who would bring civilized man across the Pacific from Asia to initiate the development of civilization in America the apparent absence of highly skilled seafaring men in the Micronesian-Polynesian regions in pre-Polynesian days should give them pause for thought. If this ever did happen, the voyagers must have encountered an American agriculture reasonably well developed, otherwise they could scarcely have established themselves in the New World, any more than could the Pilgrims have survived at Plymouth in 1620 but for their fortunate (to them) discovery of maize stored by the Indians; if there were early trips across the Pacific those who may have made such an almost impossible voyage definitely brought with them none of their cultivated plants. We may admit that there may have been early accidental contacts across one or both oceans, but generally speaking there is no reason to surmise that the pre-Columbian civilizations in America were derived from those of the Old World.

The precursor of the diffusionist group is that peculiar cult that supports the idea of Atlantis. That mythical country or island group was supposed to have existed in the Atlantic Ocean between the Mediterranean region and the West Indies, and the extremists who accept its former existence argue that both the civilizations of the Mediterranean region and of what

is now Latin America were derived from this hypothetical Atlantis. They claim for the theoretical Atlanteans a highly developed civilization, which incidentally would involve a very highly developed agriculture. I merely observe that had Atlantis ever existed, and had its people colonized both Europe and America, they, like our own ancestors who colonized the Americas following the close of the fifteenth century, would have taken with them the cultivated plants and domesticated animals on which their home agriculture was based. The result would have been an early universal distribution, as between the eastern and the western hemispheres, of both the domesticated animals and cultivated plants, which definitely was not the case. We can hence dismiss the Atlantis idea, even as we can dismiss the ideas of certain of the modern diffusionists among the ethnologists.

The modern diffusionists, those who would derive all advances in civilization from a common source, are the lineal descendants of supporters of the Atlantis idea. They see resemblances as between the Old and the New World civilizations in architecture, in sculpture, in hieroglyphics, in textiles, in implements, and in ecclesiastic, political and social organizations and practices, and on the basis of these resemblances or assumed resemblances they can only derive this or that advance in pre-Columbian America from Europe or Asia. If this were the case is it indeed not strange that the pre-Columbian civilized peoples of America had no knowledge of iron and that the wheel was unknown to them? Basically it should be clear even to those who read as they run, that the story from agriculture, and the enormous differences as between the cultivated food plants and domestic animals in America and Eurasia, is utterly opposed to assumed early contacts either across the Atlantic or the Pacific that in any way effected the advance of early agriculture or civilizations in the new world. The only conclusion that one can logically draw, on the basis of the information now available in the fields of general biology and agriculture, is that agriculture in America was a growth from the soil, in that it was based entirely on animals and plants native of and confined to North and South America; and that not one of these was known in Eu-

rope or Asia until after the Columbus-Magellan period, the last decade of the fifteenth century and the early decades of the sixteenth century. If such an agriculture could be so developed in America, and it certainly was so developed, what reason is there even to suppose that these highly skilled agriculturists could not develop their own types of civilization on the basis of their own agriculture? This would be a process merely paralleling what occurred here and there in Eurasia. It is unnecessary even to postulate trans-Atlantic or trans-Pacific contacts.

ILLOGICAL BOTANICAL IDEAS

The diffusionists, but not the conservative ethnologists, have, to a limited extent, been aided and abetted by certain biologists, but without conspicuous success. Perhaps for those who will theorize on the basis of utterly insufficient data, and who do not consider the manifest facts which are opposed to their theories, it is here pertinent to quote Lord Acton's pithy saying: "The worst use of theory is to make man insensible to fact."

Thus consider Cook's[3] papers in which he proved to his entire satisfaction that the coconut was native of tropical America and that it had been introduced into the Old World tropics across the Pacific long before Columbus discovered America. As I see the picture his basic assumptions were erroneous, although when his papers were first published, I for a time accepted his conclusions. In any case, he definitely has been shown to be in error, for the real facts in the case clearly indicate that this important plant originated in the Old World tropics; that from East Africa to the easternmost limits of Polynesia and Micronesia it was essentially a man-distributed species; and while there is a possibility that it had reached the Cocos Islands off the coast of Panama before the Europeans arrived, perhaps through the agency of the Poly-

[3] **Cook, O. F.** The Origin and Distribution of the Cocoa Palm. Contr. U. S. Nat. Herb. **7**: 257-293. 1901.

————History of the Coconut Palm in America. Op. cit. **14**: 271-342. 1910.

nesians, its effective introduction and distribution in tropical America was first accomplished by the Portuguese in Brazil, followed a little later by the Spaniards in Mexico.[4] But the adventuresome young men who very recently sponsored the cruise of the balsa raft Tonkiki, from the coast of Chile to the small islands of the southestern Pacific actually took with them ripe coconuts to help "prove," it is assumed, that such voyages may have been made in pre-Columbian days; and that perhaps Cook was correct in his strange conclusions. And yet, as far as the coconut is concerned, all they did was to reintroduce into the small islands of the eastern Pacific a species which the Polynesians themselves had originally introduced from islands farther to the west.

ANDERSON ON MAIZE

Within the past few years one of our geneticists has suggested in print, that, of all places in the world, Upper Burma may have been the original home of that strictly American plant species, maize or Indian corn. The basis of this idea is apparently the fact that the type of maize now cultivated in Upper Burma is a very variable form, as are some of the American types.

All this means is that the type, there introduced, was a variable one as contrasted with the fixed West Indian type that Columbus introduced into Spain and which, in a remarkably short period, had reached western China.

Let us assume then, for only a moment, that maize did originate in Upper Burma. Had this been the case it is certain that this important food plant would have extended its range, through the agency of man, to all parts of Eurasia and Africa, where it can be grown, long before the beginning of the sixteenth century. But there is no evidence to indicate that maize occurred in either Europe or Asia until after its introduction into Spain from the West Indies by Columbus. Once introduced in the Old World, however, it was disseminated with remarkable rapidity, and in certain region quick-

[4] **Chiovenda, E.** La culla del Cocco. Contributio alla ricerca della patria originaria della Palma de Cocco. Webbia **5:** 199-294, 359-449. 1923.

ly became a basic food plant, as it was and is in North, Central, and South America; and incidentally it may be noted that in prehistoric times this most important food plant together with the common bean, had been distributed all over South, Central, and North America, and the West Indies, wherever favorable climatic conditions prevailed, from eastern Canada and New England to southern Argentina. This is a striking illustration of how widely an important food plant was distributed in America at an early date, as is the case for wheat, barley, and rye in Eurasia; yet none of these basic cereals transcended the limits of the eastern or the western hemispheres until within the past four and a half centuries.

"One of our geneticists" mentioned in a previous paragraph is Dr. Edgar Anderson, for after the original manuscript of this paper had been submitted there appeared the joint Stonor-Anderson[5] paper which available space permits me to discuss only very briefly. The thesis that they attempt to prove, without conspicuous success, is that: "The ethnological and linguistic evidence suggested that these varieties (in Assam) had been in that area for a very long time and probably must have arrived there in pre-Columbian times." They further state (p. 356):

"To the authors the conclusion seems inescapable, that there are now two races of maize in Asia and that one of these must have crossed the Pacific in pre-Columbian time. The direction (or directions) in which it travelled, however, is still uncertain."

And not to be outdone in setting up hypotheses which can scarcely be proved at this late date in human history, Anderson (p. 391) states:

"If we admit (with a growing minority of anthropologists [which God forbid!]) the possibility of trans-Pacific contact in very early pre-Columbian times, then race A might have crossed the Pacific at an early date when maize was still an unaggressive little popcorn, to be carried across the Pacific again when the dominant world crop which we now know to have been developed in the New World, or *vice versa****

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[5] **Stonor, C. R.**, and **Anderson, E.** Maize Among the Hill Tribes of Assam. Ann. Missouri Bot. Gard. **36:** 355-396. **pl.18-23.** 1949.

From the generally accepted facts as to the relationships of maize a good case could be made out of either Asia or the New World as a primary center. There can be no doubt that the New World was certainly the secondary center, or rather a whole set of secondary centers."

Here we have an echo of the author's apparent belief that maize may actually have originated in the Old World, which impresses me as pure nonsense; it really ought to sting the other maize specialists into action! In my opinion all that it is necessary to postulate, in reference to special strains or varieties of maize in tropical Asia, is that the original post-Columbian introductions from the New World into tropical continental Asia were certainly of the variable American types; and that after these were introduced they still continued to vary. This introduction was almost certainly made by the Portuguese who first colonized Brazil, as well as parts of India, Ceylon, and in the Malayan region Malacca and Amboina, among other places, in the early decades of the sixteenth century. If this idea be correct then the early maize introductions into India would have been Brazilian or at least South American types, and not the fixed West Indian type that was introduced into Spain by Columbus, and later into the Philippines by the Spaniards. There is every reason to believe that the first maize introductions into the Philippines by the Spaniards, after 1550, were certain of the Mexican varieties, characteristic of relatively dry areas, which naturally were not adapted to the hot humid low altitude Philippine climate, and that these varieties failed to persist. The ultimately successful and somewhat later introduction was the fixed Cuban or West Indian type, for this is the dominant, and often the only type of maize now grown in Guam and in the Philippines today.

I have elsewhere in this paper paid my respects to the extreme diffusionists on the basis of our present knowledge of the origin and dissemination of the basic cultivated food plants and domestic animals. It is, however, rather sad to note that the geneticists in their ignorance of modern findings cite various cases to support their diffusionist ideas, where earlier taxonomists have erred in this or that conclusion. Thus Hutchinson, *et al.*, discussed below, cite the *Cucurbita* case follow-

ing Cogniaux's erroneous conclusions of 1881. Cogniaux would bring all of the cultivated species of the genus out of Asia, *Cucurbita maxima* Duch., *C. pepo* Linn., *C. moschata* Duch., and *C. ficifolia* Bouché, for these stating: "Indigena verisimiliter in Asia meridionali; colitur in regionibus calidis totius orbis." Here we may thank him for including the modifying word *verisimiliter*. At the same time he stated (correctly) that all of the wild species which he recognized were natives of North America. What a remarkable conclusion when one considers that there were no native (wild) species of the genus in the Old World, for if the four cultivated species did originate in Asia, from what could they have been derived? As we know from the archeological record that these cultivated species were widely known in America in pre-Columbian times, and that they were very widely cultivated in North, Central, and South America at the time the western continents were first explored by the Europeans, Cogniaux's conclusion was utterly illogical. If he were correct, and if we accept his strange conclusions, then there must have been contacts across the Pacific long before the time of Columbus and Magellan; I reject his conclusions, and accept the post-Magellan introductions of these variable species of *Cucurbita* in tropical Asia, which, as did maize, continued to vary once established in cultivation in the Old World.

Anderson also cites the conclusions of Hutchinson *et al.*, regarding cotton, to bolster up his thesis, and mentions the need of work on the various strains of *Bixa orellana* Linn. (strictly American and of post-Magellan introduction in Asia), *Coix lachryma-jobi* Linn. (strictly Old World and of post-Magellan introduction into America), and *Pachyrrhizus* (strictly American until post-Magellan times), for the early Polynesian records of the yam bean are now known to have been based on erroneously identified material representing the Old World genus *Pueraria*. The surprising thing, perhaps, is that they did not cite the Cookian ideas regarding the coconut —but perhaps here his erroneous interpretations and deductions were too evident to fool even a geneticist. To cite *Chenopodium*, *Amaranthus*, and even *Canavalia*, is beside the point as these genera have native species in both hemispheres, and the utilization of this or that species as food developed inde-

pendently in this or that region. It is true that a few of the species of *Amaranthus* are now pantropic in distribution but this does not mean that this was the case in pre-Magellan times. I merely cite the case of one of the weedy species of *Amaranthus* in the Philippines, there commonly known as *colitis*, this local name being merely a slight variant of its Aztec or Nahuatl one and one introduced with the plant by the Spaniards from Mexico.

VARIATION CONTINUOUS WITHOUT REGARD TO ORIGINAL PLACE OF ORIGIN

To point up the manifest fact that distinct varieties or forms of cultivated species do originate in regions widely removed from the original homes of their ancestral types, anyone who is at all familiar with the facts and is not blinded by a preconceived theory must admit that hundreds of varieties of cereals, tubers, vegetables, and fruits have been developed in America, on the basis of what were originally Old World species, in modern times. Just how certain improved forms originated in earlier times, is not always clear, but we do know that the so-called California navel orange came from Brazil, and that the so-called grapefruit originated in Jamaica yet all the *Citrus* and *Citrus* relatives are of the Old World. Relatively speaking, are the varieties of any of the cereals, even including maize, really more distinct among themselves than are the myriads of varieties of the common apple and other open pollinated species that have been developed in North America within the past century or so? It is obvious to anyone who will really think through on this subject that new or improved varieties of scores and scores of cultivated species are constantly being developed. The same statement is true regarding domestic animals, even including the South American development (probably accidental) of a race of our domestic hen which produces not eggs with white or brown shells, but pale blue ones; and our domestic hen originated in Asia and was of post-Magellan introduction into America. To produce eggs with pale blue shells I judge involved some alteration in the chromosomes or genes.

REALISTIC VERSUS UNREALISTIC APPROACH TO THE SUBJECT OF VARIATION

We may as well be realistic in our approach to this problem of variation in cultivated plants. What reason is there for even thinking that a variable type of maize or the strikingly variable cultivated species of *Cucurbita*, and other species as well, once introduced into the Old World, would not continue to vary, and to produce new forms, once established in a new environment? This is exactly what has happened in North and South America with the various crop plants of Eurasian origin introduced into the New World in post-Columbian times. In criticizing some of the illogical theories set up by the diffusionists and by a few modern geneticists, one is tempted to exclaim: Oh for the pen of a Fernald! This in reference to his often caustic, but in general thoroughly well deserved criticisms of some of the findings of certain of our taxonomists which, no doubt, have caused a great deal of squirming and soul searching on the part of those criticized.

The conclusions reached, are utterly incompatible with the bulk of the evidence now available regarding the places of origin and the actual time of wide distribution (i. e., as between the two hemispheres) of the cultivated plants and domestic animals. Here apparently is a case where a more or less preconceived theory was set up, bolstered by such scant evidence as the authors could assemble, but without proper consideration of the great mass of evidence that is opposed to the theory they so easily "prove." To quote Anderson again I suspect that he will sum up my brief criticism of his conclusions as "acrimonious quibblings." They are nothing of the sort, for all I have attempted to do is to paint the other side of the picture.

In a recent publication on the basis of an intensive investigation of the cultivated cottons[6] its authors can explain how two diploid parents could be brought together so that hybridization could take place in pre-Columbian America only

[6] **Hutchinson, J. B., Silow, R. A., and Stephens, S. G.** The Evolution of Gossypium and the Differentiation of the Cultivated Cottons. i-xi. 1 - 160. fig. 1-10. 1947 (p. 138, 139).

on the basis of transmission across the Pacific of an Asiatic species, and they conclude that this introduction must have been accomplished by man. Consider the following statements in connection with the long lists of domesticated animals and cultivated plants given below, one series of strictly American, the other of strictly Eurasian origin, not one of which had extended its range across either the Pacific or the Atlantic in either direction before 1492:

"All the available evidence supports the view here put forward that the domestication and distribution of crop plants, and the development and conservation of variability within them, are intimately bound up with the origin and spread of civilizations, and that the whole interrelated complex, including civilized man, his domestic animals and his crop plants, has grown from a single root and spread to the New World by trans-Pacific migration."

"Since none of the Indo-Malaysian plants —not even the coconut— have been established in centres of variability, it is evident that the trans-Pacific migration was carried out by people with direct contact with India and not by a race long established in Indo-Malaysia. In particular, the migrants cannot have been of the Polynesian stock."

This conclusion will doubtless be highly acceptable to the diffusionists, as it represents diffusionism to the *n*th degree. No exception can be taken to the first part of the statement in the first paragraph, but one may legitimately take violent exception to the last part of it, and to all of the second paragraph. If someone could only prove that even a few of the basic crop plants of manifestly American origin, and only a few of the more numerous ones of Eurasian origin, were universally distributed in cultivation in both hemispheres in pre-Columbian times, one might be more lenient in judging the matter. The universal distribution of cultivated food plants and domestic animals took place only within the past 450 years. After all, if cultivated species were introduced into America from Asia over the long trans-Pacific route, would the people involved, dependent as they were in large part on certain basic food plants, take with them only cotton seeds? I think not. As I see the picture the whole thesis rests squarely

on an attempt to explain the presence in pre-Columbian America of an assumed Asiatic species of *Gossypium*, a very tenuous basis on which to set up a theory, much less to prove it. This is a beautiful illustration of basing a theory and drawing utterly untenable conclusions on the basis of one apparent or possible fact, essentially the genes of certain American forms of cotton. The authors absolutely ignore the historical aspects of the distribution of cultivated plants, wherein all trustworthy information is opposed to the theory they so easily "prove." One wonders, had Lord Acton been a botanist or a geneticist, what his reactions might have been. It is a beautiful illustration of the pointedness of his apt saying: "The worst use of theory is to make man insensible to fact."

DOMESTIC ANIMALS OF EURASIAN AND AMERICAN ORIGINS

Consider the apparent facts in the case of American versus Eurasian species of both domestic animals and cultivated plants. Not a single domestic animal, other than the common dog, was common to the two hemispheres in pre-Columbian times. The American species were peculiarly few as compared with the more numerous and more important Eurasian ones, being practically limited to those beasts of burden, the llama and alpaca, derived from the guanaco, the Guinea pig, the Muscovy duck, and the turkey. The Eurasian list is very much longer and vastly more important, including all breeds of cattle, horses, sheep, goats, swine, water buffalo, yak, camel, and in the poultry field the hen, goose, duck, guinea hen, and pigeon.

As to the second paragraph, above quoted, one suspects that the authors accepted, without question, the strange illusions and even stranger conclusions of that romantic school of diffusionists whose fictional rather than factual writings are well characterized in the published works of W. J. Perry, G. Elliot Smith, and perhaps the even more erratic J. Churchward. But can one imagine *direct* contacts between the peoples of India and tropical America, that left no traces in the widely scattered Pacific islands? Or is it that these early hypothetical voyagers in their hypothetical journeys back and

forth succeeded in skipping the Pacific islands? It is no wonder that Spinden, without citing names, as I do, concluded that we might just as well have diffusion of culture by telepathy and intellectual osmosis!

AMERICAN CULTIVATED PLANTS

In the field of crop or cultivated plants the contrast is just as great. Thus in America, the plants of American origin —and it should be emphasized that not one of these was known in the Old World until after the voyages of Columbus and Magellan, the late fifteenth and early sixteenth centuries— include such basic and secondary food producing species as maize or Indian corn, the potato and sweet potato, cassava or tapioca, yautia, all forms of garden and field beans *(Phaseolus vulgaris* Linn.), the lima beans, scarlet runner, tepary, and yam beans, tomato, garden pepper, sunflower, Jerusalem artichoke, squash, summer squash, pumpkin, peanut, chayote, arrowroot, papaya, avocado, pineapple, custard apple, soursop, cherimoya, guava, cocao or chocolate, cashew, white sapote, black sapote, sapodilla, mamei, star apple, and others. Cultivated for food locally, especially in parts of South America, are ulluco *(Ullucus)*, oca *(Oxalis)*, anyu *(Tropaeolum)*, llacou *(Polymnia)*, arracacha *(Arracacia)*, achira *(Canna)*, and we should not forget the formerly very widely cultivated quinoa *(Chenopodium quinoa* Willd.), and jataco *(Amaranthus)* whose small seeds were, and to a limited degree, still are utilized for food.

EURASIAN CULTIVATED PLANTS

The Eurasian list is not only much longer but it is also of greater importance in spite of the significant contributions to the world food supply originating in America, to mention only maize, the garden and lima beans, the potato and the sweet potato. It includes all of the cereals, other than maize, the important ones being wheat, rye, barley, oats, rice, millet, Italian millet, pearl millet, sorghum, teff, ragi, and Job's tears *(Coix)*, and for convenience buckwheat may be so

placed, although it is not a cereal. Outside of the important cereal field, the Old World contributions include the turnip, rutabaga, cabbage, kohlrabi, cauliflower, broccoli, radish, Brussels sprouts, rape, Chinese cabbage, mustard, beet, chard, parsnip, carrot, asparagus, onion, leek, garlic, shallot, spinach, eggplant, lettuce, endive, okra, salsify, globe artichoke, rhubarb, garden and field peas, soybeans, cowpea, chickpea, pigeonpea, lentil, broad or horse bean, hyacinth bean *(Dolichos lablab* Linn.), Goa bean *(Psophocarpus tetragonolobus* DC.), taro, yam *(Dioscorea* spp.), sugar cane, and sesame. Then there is that most remarkable list of cultivated fruit trees, shrubs and vines, all Eurasian, such as all varieties of the apple, pear, plum, cherry, apricot, peach, almond, wine grape, quince, olive, fig, date, English walnut, pomegranate, all of the citrus fruits (orange, lemon, lime, pomelo, kumquat), melon, water melon, cucumber, banana, coconut, breadfruit, jackfruit, jujube, rambutan, rose apple, Japanese persimmon, litchi, longan, mangosteen, durian, lansone *(Lansium)*, and various others. For emphasis I again repeat the statement that not one of these was known to occur in America until after they had been introduced by the European colonists; and for good measure it is perhaps worth adding that all of our important cultivated forage plants used for making hay, are Eurasian in origin, such as the clovers, alfalfa and the cultivated hay grasses, including even the so-called Kentucky blue grass which is not native of Kentucky or even of America, but is an introduction from Europe.

ECONOMIC BUT NOT FOOD PRODUCING PLANTS, ORNAMENTALS AND WEEDS

The above are impressive lists, although neither is complete. One might prepare corresponding American and Eurasian lists of economic, but not food producing plants, now widely cultivated in both hemispheres, such as tobacco, coca, *Cinchona*, rubber *(Hevea)*, maguey *(Agave)*, allspice, and others of America origin and coffee, tea, black pepper, cubebs, clove, nutmeg, cardamon, flax, hemp, ginger, and numerous others of Eurasian origin, but the story would be exactly the same.

When one considers the very numerous trees, shrubs, vines, and herbs now universally planted for ornamental purposes in the tropics of both hemispheres the story as to their distribution repeats itself —all disseminated in the past 450 years. And if one desires still more confirmation consider the great number of now universally distributed pantropic weeds, for here again the story is the same. These, as between the eastern and western hemispheres, are man distributed, and again their distribution came late, not early, in man's peregrinations, i. e., like the cultivated plants, within the past 450 years.

ORIGINAL LIMITED DISTRIBUTION OF CULTIVATED PLANTS

Any theory advanced to explain possible pre-Columbian contacts between the two hemispheres that in any way affected the early American civilizations should square with these lists. On the basis of merely the above listed food plants the odds against the possibility of a man-introduced Asiatic cotton in pre-Columbian America is about 90 to 1! Until some one can prove definitely that the limited distribution of this or that species is erroneous —that is, limited to the eastern or the western hemisphere up to the time of Columbus— one may feel justified in looking askance at a theory to explain diploid cottons in America that does not take into consideration this limited distribution of basic food and other cultivated plants. For emphasis, I repeat, that up to the time of the voyages of Columbus and Magellan, i. e., the close of the fifteenth and the beginning of the sixteenth century, there was no distribution of basic cultivated food plants and domesticated animals as between the New and Old Worlds. The great period of dissemination, of economic plants and animals, as between the two hemispheres, as well as the weeds, came as a result of the exploring and colonizing activities in the period of European expansion following the beginning of the sixteenth century.