genera as *Acrostichum* and *Palaeothrinax* point toward such a conclusion, as has long been recognized.

It seems to me that Holarctic would have been a better term than East Asian-American, for certainly the evidence is clear that other parts of Asia shared in the growing cosmopolitanism of the Tertiary floras of the Northern Hemisphere. Furthermore, although in hearty agreement with most of the author's conclusions, I can not believe that the Tertiary floristic history was as simple as it has been visualized. In Provence, at Haering, and elsewhere in Europe, we see plain evidence of immigrants from Africa, and the dispersal of Tertiary mammals offers some corroborative evidence, as well as of repeated westward spreads from Asiatic instead of northern sources.

Here in America the most distinctive elements in the early Tertiary floras appear to me to have been derived from the south, and I believe that the same is true of the warmer climate plants of the English Oligocene. I suspect that we will eventually demonstrate many latitudinal swings back and forth, rather than waves of southward dispersal urged by a single progressive cooling in high latitudes.

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SPECIAL ARTICLES

BLUEBERRY CHROMOSOMES

FOR sixteen years the writer has been making experiments in the hybridization and selection of native American blueberries, species of the genus *Vaccinium.* The practical outcome of these experiments has been the development of valuable horticultural varieties producing berries of very large size. Some of the hybrids now in commercial cultivation, Pioneer, Katharine, Cabot and Rancocas, have yielded berries three-quarters of an inch in diameter, and last year the berries of two unnamed hybrids, 1257A and 1443A, reached a diameter slightly in excess of seven-eighths of an inch.

In the course of these experiments it was found that certain species, some of them very different in general appearance and in technical characters, hybridize readily. Other species, some of them very closely related, are sterile to each other's pollen and yield no hybrids.

The lowbush blueberry, *Vaccinium angustifolium,* of the northeastern United States, hybridizes easily with the highbush blueberry of the same region, *V. corymbosum.* The horticultural variety Greenfield is a second-generation hybrid between these two species, containing two quarter-strains of each. The horticultural variety Rancocas is another second-generation hybrid of the same ancestry, containing one quarter-strain of lowbush blueberry and three quarter-strains of highbush blueberry. Natural hybrids between these two species are of frequent occurrence in New England pastures. The plant named in Gray's Manual *Vaccinium corymbosum amoenum* is one of these natural hybrids.

The dryland blueberry (*Vaccinium vacillans*), the Canada blueberry (*V. canadense*), and the bigbush blueberry (*V. atrococcum*) could not be crossed with either the lowbush or the highbush blueberry. That the highbush and the bigbush blueberry did not hybridize was to me very surprising, for the two species are closely related, so closely indeed that Asa Gray regarded one as a variety of the other.

Two southern species, the hairy blueberry, *Vaccinium hirsutum,* and the myrtle blueberry, *V. myrsinites,* hybridize freely in the greenhouse with both the highbush and the lowbush blueberry, notwithstanding the great structural differences between the species thus hybridized. One, *Vaccinium hirsutum,* a species of the southern mountains, has a bristly-hairy fruit, inconspicuous winter flowering buds, an extraordinarily large stigma, and almost woolly leaves. The other, *V. myrsinites,* a species of the southern coastal plain, has very small evergreen leaves, and hardly looks as though it belonged to the same genus as the highbush and the lowbush blueberry of the north. That these strikingly different southern species hybridize easily with the two northern species surprised me greatly.

Desiring to learn the reason for this curious grouping of blueberry species, with reference to hybridization, I tried for several years to induce some one of the plant cytologists to make a study of blueberry chromosomes, but without success. Cytologists are scarce and busy. At last, through the mediation of G. N. Collins, Dr. A. E. Longley undertook the sport of hunting the blueberry chromosome. He began the work in the spring of 1924 and continued it in the years following, as material became available. Dr. Longley's results up to this time are presented in a paper accompanying this paper of mine.

Dr. Longley has made the discovery, important and significant in blueberry breeding, and fascinating in the facility with which it removes obstacles to this pursuit, that certain species of blueberry have twelve chromosomes, others twenty-four, and still others thirty-six.

The highbush and lowbush blueberry, which hybridize freely, both in nature and artificially, have twenty-four chromosomes. In the dryland blueberry, the Canada blueberry, and the bigbush blueberry, no one of which has hybridized with either the highbush or the lowbush blueberry, the number of chromosomes is twelve.

The question naturally arose whether the 12-chromosome species would not hybridize with each other. It happened that these crosses had never been attempted, because in these three species no plants had been found whose characteristics were desirable for combination. With the new incentive, however, numerous cross-pollinations were made in 1926 between the Canada blueberry and the dryland blueberry and between the dryland blueberry and the bigbush blueberry. Fruit set promptly, the berries contained an abundance of seeds, and the seeds have now produced vigorous young plants, some of them ready to flower next spring.

From still another cross, not yet mentioned, curious results had been obtained. This was a cross, made in 1922, between the rabbiteye blueberry of Florida, *Vaccinium virgatum*, and one of the large-berried northern hybrids. Many of the pollinations failed, but berries containing seeds were obtained in sufficient number to produce several hundred seedlings. They grew with great vigor and flowered freely, but although hundreds of pollinations were made on them with pollen of known virility, not a single well-developed berry resulted, and the occasional small and late berries they bore contained no seed possessing an embryo. In the production of offspring this cross, therefore, has proved completely sterile.

Upon examining the rabbiteye blueberry, Dr. Longley found that this species has thirty-six chromosomes. The plant with which it was crossed has twenty-four chromosomes. The resulting sterile hybrids usually have thirty chromosomes.

Since many who read this paper are doubtless unfamiliar with the action of the chromosomes, the minute bodies that are reputed to carry to the offspring the characteristics about to be inherited from the two parents, the following brief statement is presented regarding them. It represents the ideas current among geneticists. When the first cross-pollination in this series was made, the thirty-six chromosomes from the pollen grain of one parent were poured into the egg cell of the other parent, which already contained twenty-four chromosomes. The total of sixty chromosomes was carried through each cell of the resulting hybrid, in the ordinary process of cell division, until the plant was nearly ready to flower. Then ensued a phenomenon known as the reduction of the chromosomes, in the cells that produce the pollen grains and the egg cells. Presumably twenty-four of the sixty chromosomes, representing those derived from the 24-chromosome parent, combined with twenty-four of the thirty-six chromosomes representing the other parent. The remaining twelve chromosomes from the second parent, having no chromosomes with which to pair normally, paired abnormally with each other or remained unpaired. This abnormal pairing of the chromosomes, according to the current view, caused a derangement of the normal activities of the plant, which resulted in sterility of fruit production.

The rabbiteye blueberry has come into cultivation extensively in the South by the transplanting of the wild bushes. It is of great importance that this species be improved by hybridization. The first attempt to do this failed, seemingly because the rabbiteye blueberry stood alone in the number of its chromosomes. The possibility of improvement appeared to depend on the finding of another species having thirty-six chromosomes, and possessing also desirable characteristics that could be transmitted to a hybrid.

In the higher Appalachian mountains of western North Carolina and eastern Tennessee occurs a native species, *Vaccinium pallidum,* the Blueridge blueberry, which has large, beautiful and delicious fruit. As early as 1911, attempts were made to cross this with the highbush blueberry and the lowbush blueberry; but all the pollinations failed, and the Blueridge blueberry was therefore abandoned as a breeding stock.

In the hope that this blueberry might be a 36-chromosome species, because it had failed to hybridize with the 24-chromosome species, plans were made, for the spring of 1927, to determine its chromosome number. Material was obtained from western North Carolina through the courtesy of George E. Murrell, horticulturist of the Southern railway. On critical study of the material Dr. Longley found, to the great delight of all of us, that the Blueridge blueberry has thirty-six chromosomes.

If future experience confirms the view that the number of the chromosomes in blueberry species is a true index of the facility of their interbreeding, as the experiments indicate thus far, we shall be able next spring to hybridize the rabbiteye blueberry with the Blueridge blueberry, and thus add one more item to our knowledge of the means by which wild species become plastic in the hands of science.

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CHROMOSOMES IN VACCINIUM

A CYTOLOGICAL investigation of the number of chromosomes in a dozen *Vaccinium* species and hybrids has revealed three diploid, six tetraploid, one pentaploid and two hexaploid forms.

The material used for this study of the chromosome in microspore-mother-cells was collected early in the springs of 1924, 1925, 1926 and 1927 from *Vaccinium* plants grown under the direction of Dr. Frederick V. Coville at the greenhouses of the Bureau of Plant