

# Perspectives

## Anecdotal, Historical and Critical Commentaries on Genetics

*Edited by James F. Crow and William F. Dove*

### **Plant Breeding Giants: Burbank, the Artist; Vavilov, the Scientist**

**James F. Crow**

*Genetics Department, University of Wisconsin, Madison, Wisconsin 53706*

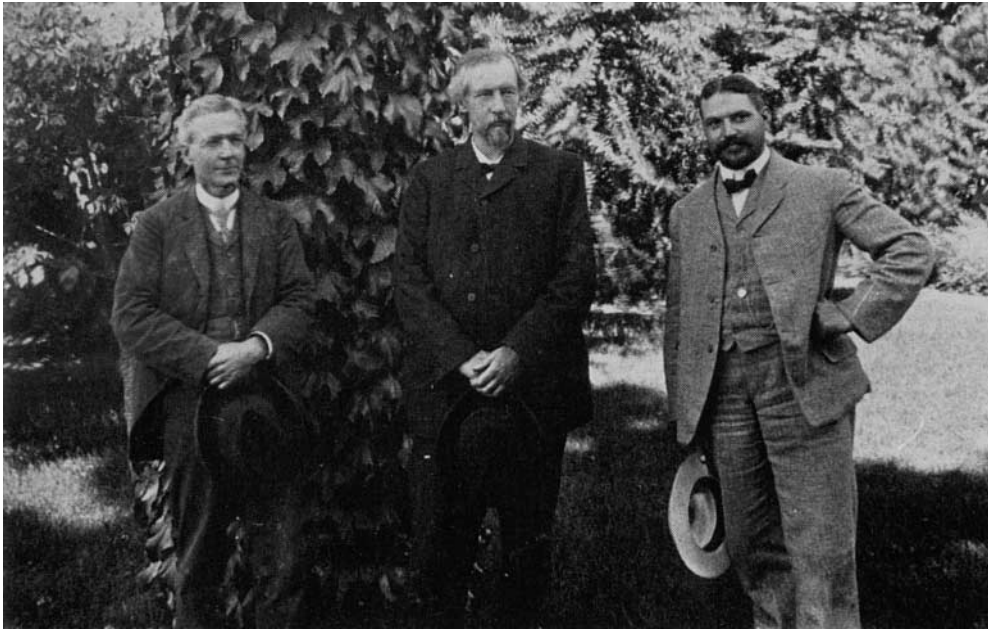
LUTHER Burbank was a curious mixture: part gardener, part artist, part P. T. Barnum. He was responsible for a plethora of improved fruits, vegetables, and ornamentals. Some of these were of lasting significance, such as the Burbank potato, the Santa Rosa plum, the Phenomenal blackberry, and the Shasta daisy. His successes depended on judicious employment of several techniques: he selected the best seedlings from large fields with enormous numbers of plants, he imported promising strains from around the world, he made crosses between distantly related varieties and even species, he exploited skillful grafting, and he astutely utilized vegetative propagation of superior recombinants, thereby preserving their genotypes. Probably his greatest contribution to science was discovering nonsegregating, true-breeding hybrids, such as from a cross between a raspberry and blackberry, that were later understood to be amphidiploids. He pioneered in regarding these as another mode of species formation. He was a popular hero, far and away the most highly publicized plant breeder of his time (BURBANK 1914–1915; HOWARD 1945–1946; DREYER 1993). He died in 1926, a rich man.

Nikolai Vavilov was Russia's greatest geneticist. His energy was prodigious; he slept only 4 or 5 hours per night. He had a remarkably retentive memory, and his knowledge was encyclopedic. He was a charming companion and could converse in any of the European languages. He traveled over the globe collecting enormous numbers of wild relatives of domestic plants and developed a widely respected theory about the centers of origin of domestic plants. By 1940 he had collected more than 250,000 specimens. Many of these were preserved as living plants and were tested in various environments at 400 different stations. On an unprecedented scale, he carried out the kind of program that is now standard in experiment stations. He headed the All-Union Institute of Plant Breeding, which at one time had 20,000 workers. In 1939 he was elected President of the Seventh International Genetics Congress in Edinburgh. Unfortunately, he was not permitted to attend. He had already become a victim of Lysenko, who had

Stalin's ear. He was arrested in 1940 while on a collecting trip and was sentenced to death, but this was rescinded in June 1942. He died in prison in 1943. Had he been able to continue his program, he would surely have greatly improved Soviet agriculture. Instead, under Lysenko, it was a fiasco.

In addition to their different fates, these two men were at opposite poles in their views of genetics. Burbank, who did much of his work in the nineteenth century before Mendel's work was rediscovered, noted and exploited the great variability of  $F_2$  populations. Nevertheless, he later downplayed the significance of Mendelism and held to Lamarckian ideas throughout his life. He relied on his memory and kept no systematic records. He played by ear, not from the score. But what a sensitive, discerning ear! Yet geneticists were dubious. In contrast, Vavilov was an early student of Bateson and was thoroughly grounded in genetics and cytology. Geneticists throughout the world held him in the highest regard. Since Vavilov has been the subject of an earlier *Perspectives* (CROW 1993), I devote more space to Burbank in this one.

For several years, Burbank was supported by the Carnegie Institution of Washington. To assess what he was doing, the Carnegie directors commissioned G. H. Shull to study Burbank's methods and report on his accomplishments. Shull spent a large part of 5 years, starting in 1906, on this endeavor. He found this frustrating, for he was unable to discover the full history of most of Burbank's creations and was impatient with the absence of careful records, to say nothing of Burbank's unorthodox views of heredity. Shull tried for several years to prepare a full report and wrote thousands of words, but finally abandoned the project (GLASS 1980). Burbank disliked having his methods observed and he was impatient with Shull's verbose lecturing on genetics. He preferred to work alone in the fields with no one looking over his shoulder. Undoubtedly Burbank found Shull's persistent questions irritating. It is hard to imagine two less compatible people. Nevertheless, they remained on friendly terms, perhaps only on the surface.



From left to right, Burbank, de Vries, and Shull. The photo was probably taken in 1906 (from DREYER 1993).

The Carnegie support of Burbank, \$10,000 per year, was one of its largest grants, and the whole episode was an embarrassment to the Institution. Burbank had understood that the grant was to last 10 years, but it was cut off after 5. He was clearly disappointed and made no secret of his annoyance; this may have carried over to animosity toward Shull. In this context it is perhaps significant that in 1906 a photograph was made of Burbank, along with Hugo de Vries and G. H. Shull (DREYER 1993, p. 146). Yet, when a colored photo was printed in the definitive 12-volume set (BURBANK 1914–1915, Vol. 12, p. 148), Shull had been cut out (compare the two photographs). Burbank had the last word! Alternatively, Burbank may simply have preferred to be pictured with a celebrity. In the early part of the century, de Vries was world famous, whereas Shull was unknown; his fame would come much later, after the great success of hybrid maize (MANGELSDORF 1955; CROW 1998).

The number of new forms of fruit, vegetables, and ornamentals produced by Burbank is truly astonishing—more than 200 varieties of fruit alone. Walter L. Howard, long-time pomologist at the University of California, spent 10 years compiling Burbank's creations cataloged in a bulletin of the University of California Agricultural Experiment Station (HOWARD 1945; DREYER 1993).

Burbank's 12-volume report bears the title, "Luther Burbank. His methods and discoveries and their practical value. Prepared from his original field notes covering more than 100,000 experiments made during forty years devoted to plant improvement. ... Under the editorial supervision of John Whitson and Robert John and Henry Smith Williams, M.D., LL.D." (BURBANK 1914–1915). It is a hodge-podge of biography, descriptions of new varieties, color pictures (some 1500 of them, unusual for the time), and hagiography. I do not know

how much was ghost-written. Some of the words appear to have come directly from Shull's notes (DREYER 1993). Although the book makes interesting reading and the pictures are colorful, it is frustratingly lacking in breeding details.

Although Burbank was involved in a large number of disputes and controversies, his popularity continued to rise. His headquarters were visited by hordes of tourists. His birthday was designated by the California legislature as Burbank Day, and children came annually on this date to felicitate him (BURBANK 1914–1915, Vol. 12, frontispiece). In 1940 he was honored by having his picture on a 3-cent postage stamp (the cost of a letter in those days), the only biologist among five scientists so honored. His popularity continued throughout his life.

Plant breeders and geneticists were less impressed. Not all his varieties lived up to their billing, especially in Europe, where growing conditions were not those of the California coast. There were objections to his exaggeration. His followers were even more grandiose, especially those selling his creations. As HOWARD (1945–1946) wrote, Burbank was a victim of hero worship. Scientists in the U.S. Department of Agriculture were especially annoyed, for they were obligated to answer countless questions and offer advice about the comparative value of different varieties. Their conclusions often differed from statements in the advertising claims. Geneticists were critical of Burbank's unorthodox views of heredity, especially his Lamarckism.

Some of the strongest scientific criticism came from D. F. Jones, who later became prominent for his work on hybrid maize (NELSON 1993). Jones wrote a book-length manuscript that was never accepted for publication, probably because of the severity of his criticisms.



The same photograph after coloring and trimming (BURBANK 1914–1915). I am indebted to Dr. Ishkren Asmanov for calling my attention to Burbank's procrustean processing of the picture.

Only a much-shortened version has been published (JONES 1937).

Here is a sample from Jones, which he took from one of Burbank's publications: "The spines were bred out of the desert cactus, producing a better cattle food than alfalfa, which, on even poor land, outdoes alfalfa five to one." But, Jones writes, "Having recently come from southern Arizona, I knew that no thornless cacti were being planted there. Other thornless plants of this species, more hardy than Burbank's, were injured by frost in winter. All cactus plants have proved to be so slow in growth that there was little incentive to plant them and so poor in food value that no animals would eat them when other forage was available."

Clearly, Burbank's career is one that will remain controversial. The contrast between his great practical accomplishments, even if oversold, and his genetic naiveté is a puzzle for historians. Now comes the big question: What did Vavilov think of Burbank? DREYER (1993,

pp. 206–207) says: "Too little noticed was the most significant visitor Burbank had that year [1921], the great Russian scientist Nikolai Ivanovich Vavilov. ... What transpired at their meeting is not recorded. Vavilov's work was to be of great importance in tracing the origins of cultivated plants, and he was well aware that much of Burbank's success was owed to canny importations. ... Vavilov would almost certainly have disagreed with his host's views on heredity."

Fortunately, we now can learn what Vavilov thought, for at the time of Burbank's death in 1926 he wrote an obituary. I am greatly indebted to Dr. Iskren Azmanov for calling this obituary to my attention and for supplying a great deal of additional information. He also provided a translation, by himself and Carl Moody.

The obituary is highly laudatory, a testimony of praise for a creative artist. But at the same time Vavilov, with his deep scientific insights, clearly perceived Burbank's weaknesses in his study of genetics. It was Lysenko, whose unorthodox views were not unlike those of Burbank, who was responsible for Vavilov's downfall and eventual imprisonment and death. Ironically, Vavilov had provided strong support for Lysenko in the beginning (CROW 1993).

Vavilov's obituary of Burbank, written in 1926, follows. I have made a number of changes in Azmanov and Moody's translation; if any of these misconstrue Vavilov's intention, the fault is mine.

#### Luther Burbank (1849–1926)

*Nikolai Ivanovitch Vavilov*

Luther Burbank died on April 11, 1926, in Santa Rosa, California. During the last half of the nineteenth century and the first quarter of the twentieth, no other name has so clearly focused public attention on the role of selection and geographical origin in the creation of new plant forms.

In the autumn of 1921 I had the opportunity to become acquainted with the activities and personality of Luther Burbank. My recollections carry me involuntarily to the shores of the Pacific Ocean in California, to the little town of Santa Rosa, tangled in sweetbrier and twining roses. Here, in the midst of the town, behind a low picket fence, in a space of about two and a half acres the curious eye could peer into the Holy of Holies of the creation of plant forms.

A humble, inviting, little ivy-covered house was Burbank's home. The garden office, which faced the street, called attention to itself by means of an inscription that read: "Mr. Burbank is no less occupied than are the officials of Washington, and therefore he most humbly requests that the public not disturb him with visitations." A ferocious female secretary would sternly confront anyone who disregarded this announcement, observing that Mr. Burbank was extremely busy and cautioning the intruder against a long visit.

To my astonishment, despite a warning from a Washington official, I received a most favorable reply to my letter from Dakota, requesting permission to visit the celebrated plant breeder, and, already rather well acquainted through published data with the activities of the California creator



of new plant forms, I obtained an audience of several hours.

As in a fairy tale, the visitor found himself in a magical garden. There were huge cactuses without thorns but with delicious fruits covered with fine needles, completely original asters, chrysanthemums, bright late-blooming poppies (*Eschscholtzia*), gladioli, an enormous number of cultivated varieties of fruit trees, and mighty walnut trees, including an interspecific hybrid with sharply displayed heterosis in height. There were unique varieties of maize of various types: sweet, dent, reminiscent somehow of hybrids of maize and sorghum; bush phlox with unusual flowers; in short, an entire living museum in which everything was full of meaning. There were marvelous roses, strange dahlias, unique cannas. The autumnal season had not diminished their colors.

A unique, very recently produced, low-growing sunflower attracts one's unwitting attention by a huge corolla on a short stem and a pendant head deliberately selected to grow in this orientation for protection from birds.

Many beautiful gardens can be seen in any advanced country. The uniqueness of Burbank's garden is that everything in it that meets the eye is the result of creativity. Everything in the garden has been subjected to the influence of the plant breeder.

I recall the moment when, standing with my camera before Burbank amidst his flowers, I comprehended this living fairy tale—the story of the force of individuality in this beautiful old man with the face of an actor, of an artist among his creations.

Let us now shift from fairy tale to reality.

It is difficult to enumerate all that was accomplished by the great plant breeder, to calculate the material and intellectual balance sheet of this remarkable life. The essence of his intellectual legacy, in my opinion, comes down to broad selection of worldwide varietal material, to large-scale research into seedlings from fruit trees, and to the application of distant interspecies hybridization and creating methods to promote reproduction.

The first principle lies in Burbank's personality, bequeathed and embodied in word and deed. It consists of his gathering of plant riches on a broad scale from around the world, his mobilization of the Earth's plant capital. South American flora, Tibetan and Himalayan mountain species, plants from China, Japan, and the entire Old World—all passed before the eyes of the great observer. The idea of the wide use of the world's plant resources found reflection in the creation in Washington, D. C., of the Bureau of Plant Industry within the U. S. Department of Agriculture, which endowed the Bureau with a systematic, powerful organization. In the last several years the activities of this institution have radically changed the varietal composition of the cultured vegetation of the United States and Canada.

The second principle is the usefulness of the collection of seeds from plants that had been reproduced asexually. Burbank showed that in practice in the field of pomology, when practiced on a wide scale, rather frequently the selection of seeds produces very valuable new forms with new combinations of characteristics—the result of the recombination of genes among hybrids. These characteristics are then perpetuated in our fruit trees that are reproduced asexually.

The third principle is broad, bold, persistent interspecies hybridization. In the area of horticulture and pomology, the ability to use asexual reproduction after crossing opens a broad prospect in the application of distant hybridization. Aborted seeds and disharmonies in the devel-

opment of reproductive organs, all difficulties to be overcome in field crops reproduced by seeds, can be ignored in asexual reproduction. Intuitively the mind of the ingenious plant breeder grasped, with American quickness, the practicality of this new path of asexual plant reproduction, and in an extremely short time he realized its broad possibilities. The very infertility of the hybrids thus propagated was cleverly used to create seedless fruits, which in and of themselves are interesting in practical pomology. In a period dominated by discussion and theoretical elucidation of the limits of the possibility of distant hybridization, Burbank, with American persistence, blazed new trails.

Burbank's activities are described in the 12 volumes of an excellent publication entitled *Luther Burbank, His Methods and Discoveries (1914-1915)*. The image of a great artist emerges virtually alive from this luxurious publication. A total of 1500 beautifully produced color plates illustrate all the stages of the life and activities of the California toiler. Here are the condensed details of his autobiographical data. Luther Burbank was the 13th child. He was born in a farm family in a little village near Lancaster, Massachusetts.

Through both personal acquaintance and study of his 12-volume work, one is struck first and foremost by the huge number and variety of his objects of selection. Indisputably his greatest practical achievements were made in the field of pomology. Plum hybrids, crosses of plums and apricots, new varieties of apples, plums, pears, and grapes, diverse blackberries and raspberries with gigantic fruits all attracted Burbank's attention in the bloom of his creative activity. His practical achievements in the selection of plums and blackberries were especially great and provided the market with new varieties of exceptional value.

Burbank's first experiments were with the potato. The variety produced from seedlings that he brought out in the 1870s, famous under the name "Burbank," until recently occupied significant acreage in the potato cultivation in the United States. The Burbank potato, like other varieties, is distinctive for its cosmopolitanism. The Burbank was cultivated until recent times, when it was supplanted by new varieties. Burbank's potato had already increased the material well-being of the United States. Along the Pacific Coast, in a single year (1906) more than 8-million bushels of the Burbank potato were harvested.

Of the 12-volume compilation, the fifth volume, devoted to Burbank's work with plums, is a masterpiece of the breeder's art. Marvelous color illustrations, achievable only in American publications, speak without words about Burbank's remarkable studies. Broad hybridization made it possible for the artist-breeder to mold forms at will. Burbank had collected a huge, worldwide assortment of the genus *Prunus*. Crosses of a series of wild varieties among themselves and with cultured types displayed, as a result of hybridization, gigantic fruits. The largest plum in the world was created. There were plums that dried out on the tree, producing tree-borne prunes. Old Chinese and Japanese varieties were crossed with diverse European forms, and to them were added the qualities of small-fruited Persian plums. To the tender qualities of the Old-World races was added the hardness of the American plum. Burbank found a small French plum with sour, astringent fruits, but lacking a stone. By crossing this plant with a cultured plum and repeated crossings with various plums, hybrids that combined the absence of a stone with the desirable qualities of cultured plums were developed. The entire volume with 105 colored plates deserves the most attentive study by pomologists.

Unfortunately, descriptions in this volume, as in the entire work, have a belletristic character and lack scientific documentation. Only the illustrations and occasional passages and references to initial varieties allow one to grasp the essence of the creative work.

The endless variety of new forms of chrysanthemums, Amaryllis, lilies, Watsonia, Crinum, Cactolalia, and every conceivable new type and kind of monoecious and dioecious horticultural object were subjected to the influence of the methods of selection and hybridization. There seems to be an original approach to each object. Among ordinary roses a blue color must exist, and Burbank almost found it. A blackberry without thorns was created and a daisy of a previously unseen shape and size, and so on without end. "How does your work in selection begin?" a visitor asks Burbank. "First, you establish an ideal. Then you seek the ideal," answered Burbank.

In his last decade, Burbank devoted much attention to the selection of maize, sorghum, beans, peas, flax, wheat, and sunflowers. His interests changed noticeably from garden items to field crops, and, to our astonishment, 5 years ago we were able to observe a great number of field plants in Burbank's garden. Cactuses without thorns, a large number of vegetable-garden plants, starting with artichokes and ending with beets, and finally tree and forest species—none escaped Burbank's sphere of attention.

More intuitive than others, Burbank apprehended the practical significance of heterosis in silviculture for creating wood pulp in a short time. With no theoretical investigation, Burbank correctly discerned the prospects for making use of the intensification and acceleration that are the results of hybridization.

Contrary to our expectations of encountering a profoundly old man resting from his work and reaping the harvest of past labors, we found a vital researcher in his 70s still engaged in endlessly seeking new discoveries and bemoaning the thanklessness of the task of plant selection, the profits from which accrue to commercial firms, while the portion that remains to those who created the new products is at best empty glory. Despite information that we happened to hear in Washington, reinforced by a widespread rumor about Burbank's primarily commercial inclinations, we were witnesses to great work and untiring labor under the humblest of circumstances in his eighth decade.

Like every great personality to whom errors are not unknown, Burbank concentrated the attention of both friend and foe. His intuitive creativity as an artist-breeder not infrequently ran counter to the precise genetic perspective of the contemporary establishment. Not being a theoretician in plant breeding, Burbank reached not a few mistaken conclusions in the explanation of his work. The theoretical side and the explication of the results of his work do not always find Burbank at the level of

contemporary science. When Dr. George Harrison Shull (1874-1954), a representative of the Carnegie Institute, was assigned the task of providing a scientific description of the results of Burbank's research, he was obliged to give up the job with disappointment because of the lack of strict and objective documentary data.

It is difficult to learn from Burbank. One needs a good theoretical grounding to be able to separate the substantial from the insubstantial, to find the explanations of the exceptional successes Burbank achieved. A good textbook on plant selection would be more useful for a beginner than Burbank's 12-volume artistic work. In studying Burbank's creations, it is always necessary to bear in mind that the artist's intuition overwhelms his research. Because of the great amount of practical work in constant pursuit of ever newer and newer objects, Burbank was unable to follow the rapid developments in the field of genetics. One can imagine that the large number of critics was engendered by the mistakes of the great plant breeder, especially in his own country. As the proverb says, "No man is a prophet in his own country." Nevertheless, objectively, it is impossible to deny the results of the immense creative work that this plant breeder left to posterity.

Plant selection can be understood as a scientific discipline that studies the principles and methods for the elaboration and creation of new varieties. Selection can be an art as well as a craft. To his grave has gone a great artist-breeder who intuitively and correctly chose the path to solving problems of plant selection and who undoubtedly accomplished a huge amount of practical work, especially in the areas of pomology and horticulture.

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