



United States Department of Agriculture

Agricultural
Research
Service

June 2013

150 Years of Research at the United States Department of Agriculture: Plant Introduction and Breeding





Cover photo: The stately building that once housed the U.S. Department of Agriculture in Washington, D.C., ca. 1890. (This photo is preserved in the USDA History Collection, Special Collections, National Agricultural Library.)

Abstract

Griesbach, R.J. 2013. 150 Years of Research at the United States Department of Agriculture: Plant Introduction and Breeding. U.S. Department of Agriculture, Agricultural Research Service, Washington, DC.

The U.S. Department of Agriculture celebrated its 150th anniversary in 2012. One of the primary functions of the USDA when it was established in 1862 was “to procure, propagate, and distribute among the people new and valuable seeds and plants.” The U.S. Government first became involved in new plant introductions in 1825 when President John Quincy Adams directed U.S. Consuls to forward rare plants and seeds to the State Department for propagation and distribution. This publication describes highlights from 150 years of the USDA’s program in introducing and breeding new plants. Many of the “new” plants have now become standard crops, such as soybeans and blueberries.

Keywords: Frederick Coville, Palemon Dorsett, Beverly Galloway, genetics, William Morse, plant collection, William Saunders, seeds, Herbert Webber, James Wilson.

ARS Mission

The Agricultural Research Service conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to—

- ensure high-quality, safe food and other agricultural products;
- assess the nutritional needs of Americans;
- sustain a competitive agricultural economy;
- enhance the natural resource base and the environment; and
- provide economic opportunities for rural citizens, communities, and society as a whole.

While supplies last, single copies of this publication can be obtained at no cost from Robert J. Griesbach, USDA-ARS, Office of Technology Transfer, 5601 Sunnyside Avenue, Room 4-1159, Beltsville, MD 20705; or by email at Robert.Griesbach@ars.usda.gov.

Copies of this publication may be purchased in various formats (microfiche, photocopy, CD, print on demand) from the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161, (800) 553-6847, www.ntis.gov.

The U.S. Department of Agriculture (USDA) prohibits discrimination in all its programs and activities on the basis of race, color, national origin, age, disability, and where applicable, sex, marital status, familial status, parental status, religion, sexual orientation, genetic information, political beliefs, reprisal, or because all or part of an individual’s income is derived from any public assistance program. (Not all prohibited bases apply to all programs.) Persons with disabilities who require alternative means for communication of program information (Braille, large print, audiotape, etc.) should contact USDA’s TARGET Center at (202) 720-2600 (voice and TDD). To file a complaint of discrimination, write to USDA, Director, Office of Civil Rights, 1400 Independence Avenue, SW, Washington, D.C. 20250-9410, or call (800) 795-3272 (voice) or (202) 720-6382 (TDD). USDA is an equal opportunity provider and employer.

Contents

Introduction	1
Early U.S. Government Support for Agriculture 1820-1862.....	2
Establishing the U.S. Department of Agriculture 1862-1872.....	4
Seed Distribution 1862-1900	12
Beginning of Plant Breeding and Genetics 1895-1905	14
Development of Quantitative Genetics for Animal and Plant Breeding 1905-1925.....	16
The Role of the Agricultural Research Service in Plant Introduction 1953-2012.....	17
Introduction and Development of Soybean Cultivars	18
Introduction and Development of Blueberry Cultivars	20
References	23



Figure 1. View looking north on 13th Street from the stairs of the Agriculture Building. This photograph was taken about 1880 (J.F. Jarvis' Stereoscopic Views, View from Agricultural Department, author's collection).

Introduction

"The greatest service which can be rendered any country is to add a useful plant to its culture."
Thomas Jefferson, Memorandum of Services to My Country, September 2, 1800.

The United States began as a nation of farmers. The first four presidents called for the establishment of a department of agriculture; however, Congress did not act on their recommendations. At the time, most Americans were economically independent farmers who had just fought the Revolutionary War to guarantee their self-determination. The challenge in creating the new nation was how strong to build the central government. Bitter debates ensued on this issue. Many farmers believed that a central department of agriculture would become too powerful and control their lives (Hagenstein et al. 2011).



Early U.S. Government Support for Agriculture 1820-1862

By 1820, significant agricultural problems were developing in the United States. Because of the standard farming practices of the time, a significant amount of the farmland in the Eastern United States was no longer productive due to the lack of fertilization, pests, diseases, etc. In addition, greater access to more efficient railroad and canal transportation was creating new market economies for agricultural products. These factors created tensions between Americans who wanted to maintain subsistence farming as a way of life and those who wanted to use farming as a means for generating income (Hagenstein et al. 2011).

In order to improve agriculture, there was a need for the systematic collection and distribution to all U.S. farmers the latest information on new farming practices as well as new and improved cultivars. At that time, most of the agricultural practices and crops grown in the United States were derived from Europe and implemented through connections between individuals from the two continents. To begin to address these needs, as well as other science-based needs, Congress chartered in 1818 the Columbian Institute for the Promotion of Arts and Sciences (Rathbun 1917). Details for establishing a botanic garden within the Columbian Institute were elucidated in Public Statute I, Chapter CXXV, Section 4:

“Corporation may procure, by purchase or otherwise, a suitable building for the sittings of the said institution, and for the preservation and safekeeping of a library and museum; and, also, a tract or parcel of land, for a botanic garden, not exceeding five acres.”

Two years later, Congress furthered the effort to develop a national botanic garden by passing Public Statute I, Chapter LXXXI, which—

“Granted, during the pleasure of Congress, to the Columbian Institute for the Promotion of Arts and Sciences, the use and improvement of a tract of public land in the city of Washington, not exceeding five acres, to be located under the direction of the President of the United States, for the purpose of enabling the said Columbian Institute to effect the object of their incorporation.”

President James Monroe immediately set aside land just west of the Capitol Building for the U.S. Botanic Garden. The Garden was bordered on the north by Pennsylvania Avenue, the west by the Canal (now Independence Avenue), and the south by Maryland Avenue (Rathbun 1917).

The first formal collection of seed by the U.S. Government began in 1825, when President John Quincy Adams directed U.S. Consuls to forward rare plants and seeds to the State Department. To further this effort, the Treasury Department issued Circular 8 in 1827. In this circular, specific cultural information as well as shipping instructions were requested. In addition, the circular requested that the U.S. Navy facilitate the shipments. As seeds began to accumulate, Congress authorized Secretary of Treasury Richard Rush to distribute the seeds at his discretion. Using the Columbian Institute for distribution, Rush placed an advertisement in city newspapers in 1828 (Rathbun 1917):

“The Columbian Institute has just received from Tangier, in Morocco, some wheat and barley, which it is supposed, may form a useful addition to the stock of those grains already in the United States, particularly in the States and territories south and southwest of Washington. The Institute has also received some seeds and fruit of the date, which have been sent under a belief that they may be successfully cultivated in the most southern part of the Union. Tangier, whence these grains and seeds are brought, is in the latitude of 35 North; though black frosts are rare, white frosts are frequent there in January, February, and March. Those members of Congress who may desire to obtain a portion of either or all of these objects will please make known their wishes to Mr. Dickins, the Secretary of the Institute.”

Because of the limited funds and human resources available, seed distribution was restricted to members of Congress. It was expected that the Congress members would further distribute the seeds to their constituents.

In 1836, Congress established under the State Department the Patent Office and appointed Henry L. Ellsworth as the first Commissioner of Patents. On his own initiative, he immediately began distributing the seeds that were sent to the State Department. He used the land around the Patent Office Building to grow and propagate the plants. In 1838, the Columbian Institute closed, and the following year Congress established the

Agricultural Section within the Patent Office. This section was responsible for procuring and distributing seeds and cuttings, as well as collecting agricultural statistics and promoting the agricultural and rural economy (Weber 1924).



Figure 2. The Patent Office Building. This photograph was taken by John Plumbe about 1846 (Library of Congress, DAG No. 1229).

The next major effort on new plant introduction occurred during the U.S. Exploring Expedition. From 1838 to 1842, Lieutenant Charles Wilkes led an expedition around the world. The expedition returned with seeds of approximately 500 different species and over 1,000 plants of 254 different species. A 50-foot-long, two-section greenhouse was constructed behind the Patent Office Building to house the collection. In 1843, a second greenhouse was constructed, and in 1844, the first greenhouse was enlarged by 78 feet square feet (Weber 1924).

Another expedition was led by Commodore Matthew Perry to Japan in 1852. The main purpose of this expedition was to establish trade with Japan; however, James Morrow accompanied the trip as the botanist. Morrow returned with 17 cases of plants containing over 1,500 specimens of both dried and living plants. These plants were housed in the Patent Office greenhouses (Cole 1947).

Additional foreign collection trips occurred in 1856 and 1857. In 1856, the U.S.S. Release was turned over to the U.S. Department of Interior to collect cold-tolerant sugarcane in Demerara, British Guiana. Sugarcane was a major crop grown in Louisiana. Early spring frosts in 1841 destroyed nearly one-third of the crop. There was a need to discover more cold-tolerant types.

In 1857, a special agent was sent to Japan to collect tea seed. It was hoped that tea could be grown as a commercial crop in the United States. Large numbers of plants were distributed for evaluation throughout the United States. For example, 45,750 plants were distributed in 1878. After 30 years of evaluation, it was determined that there was not a suitable location in the United States for tea production (Ryerson 1933).

When the Patent Office Building was expanded in 1849, new plans were made for the land on which the greenhouses and the garden stood. Therefore, Congress appropriated \$5,000 to relocate the greenhouses and garden to the old Columbian Institute's botanic garden site. This new and improved garden opened in 1856 and was known as the U.S. Propagation Garden (Holt 1858, Swank 1872).



Figure 3. View looking west from the steps of the U.S. Capitol across the U.S. Propagation Garden. This photograph was taken in 1863 (Library of Congress, LOT 13070, No. 5).

By 1860, the Agricultural Section of the Patent Office was annually distributing over 2.4 million packages of seed (Kloppenborg 1988). However, there were a number of complaints that the seed and plants being distributed were untested for pests, diseases, quality, and attributes. For example, an editorial in DeBow's Review (DeBow 1857) refuted the claim that the sorghum distributed by the Patent Office could be used as a substitute for sugarcane. The editorial reported on two independent studies finding that sorghum was not a substitute for sugarcane because it produces "*glucose in a semi-fluid form... and is unable to obtain any crystals of sugar.*" In order to address these types of issues, the Agricultural Section employed, besides a statistician, a chemist and an entomologist for testing and experimentation.

Establishing the U.S. Department of Agriculture 1862-1872

By 1850, it was becoming clear that foreign agriculture could not be directly transplanted to the United States. There was a need to develop agricultural methods and crops specific to the country. Congress was still divided on how significant a role the Federal Government should play in developing a specific U.S. agriculture. There still was a significant congressional contingent that was opposed to creating a stronger Federal Government, including establishing a department of agriculture (Hagenstein 2011).

During the U.S. Civil War, Congress was able to establish the U.S. Department of Agriculture (USDA) because of the loss of the Congress members in opposition. In 1862, the Agricultural Section of the Patent Office became the USDA. The Congressional Act (Chapter 72, 12 Statute 387 stated that the USDA was—

“To acquire and to diffuse among the people of the United States useful information on subjects connected with agriculture in the most general and comprehensive sense of the word, and to procure, propagate, and distribute among the people new and valuable seeds and plants.... The Commissioner shall receive and have charge of all property of the Agricultural Division of the Patent Office including fixtures and property of Propagating Garden.”

Isaac Newton was the first Commissioner of the USDA. Newton was a Pennsylvania farmer who was not well known and became a controversial political figure. A controversy arose over the issue of the Annual Reports of the Commissioner of Agriculture. Over 120,000 of the 1863 Reports were distributed free of charge by Congress members. These reports directly competed with the agricultural newspapers, journals, and books that were very popular at the time. One of the leading agricultural newspapers, the *American Agriculturalist*, commented on the reports (Judd 1864):

“We protest against the whole system of making books of this kind at public expense; against collecting a lot of essays from ready writers and calling them a report ... publishing them at public expense for the benefit of a few, is a flagrant outrage ... we call upon Congress to put and to end to this cheat.”

Despite being called “*more skilled in the art of congressional wire-pulling than in the science of agriculture*” (Ross 1929), Newton succeeded by recruiting skilled scientists. Congress authorized the Commissioner to appoint a statistician, a chemist, an entomologist, and a botanist. The statistician, chemist, and entomologist in the Agriculture Section of the Patent Office were retained and became employees of the USDA.

William Saunders was recruited as the USDA’s botanist. The duties of the botanist were outlined in H.R. Bill 734, Section 4:

“(1) To take charge of the experimental garden and such other public grounds as may be placed under his direction; (2) to procure and encourage the transmission of seeds, cuttings, bulbs, and plants from sources, both foreign and domestic, for the purpose of testing their merits and adaptation in general, or for particular localities of this country; (3) to procure by hybridizing and special culture products of a superior character to any now existing; (4) to ascertain by experiment the influences of varied culture in products, and the modifications affected by the operations of pruning and other manipulations on trees and fruits; (5) to investigate more thoroughly the various maladies and diseases of plants, and the insects which destroy them; (6) to provide ample means for thoroughly testing all seeds and other contributions which may be received; (7) to cultivate specimens of the various hedge plants and exhibit their availability for that purpose; (8) to cultivate a collection of the best fruit trees and plants, such as grapes, apples, pears, peaches, strawberries, raspberries, currants, and so forth, as to compare their respective merits; (9) to plant a collection of choice shrubs adapted for decorating gardens and landscape scenery; and (10) to erect glass structures for the twofold purpose of affording the necessary facilities for cultivating exotic fruits and plants, and to furnish examples of the best and most economical modes of constructing, heating, and managing such buildings.”

Unlike Newton, Saunders was highly regarded. Liberty Hyde Bailey called him “the ablest and most influential [man] the Department has ever had” (Bailey 1917). Saunders’ first assignment as Superintendent of the U.S. Propagation Garden was producing a “Catalogue of the Plants, Bulbs, Tuber, etc. for Distribution from the U.S. Propagating Garden.” In this publication, Saunders also elaborated on the 10 duties assigned to him by Congress. Abraham Lincoln referred to this catalogue in his December 1, 1862, State of the Union Address:

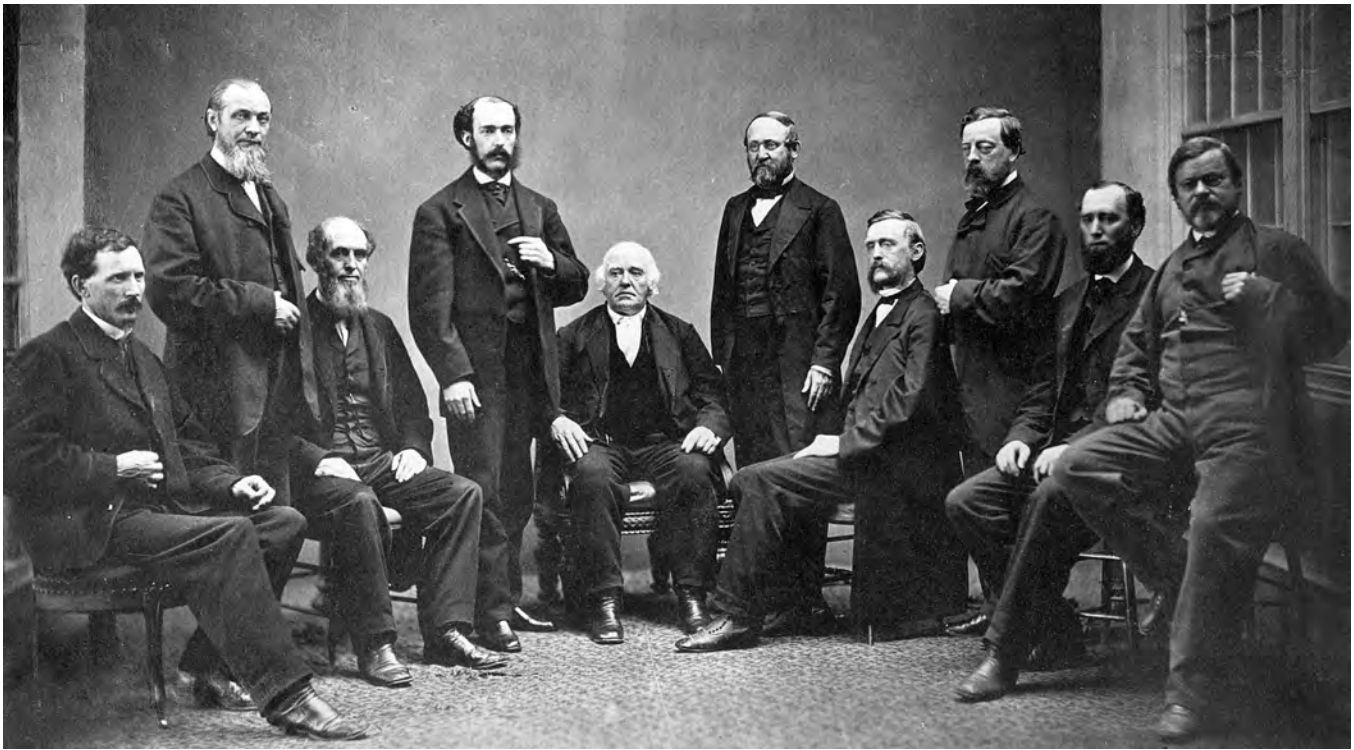


Figure 4. Employees of the U.S. Department of Agriculture in 1867. From left to right: Superintendent Seed Department Major H.A. Meyers, Superintendent of Gardens William Saunders, Chief of Correspondence Col. E.M. Whitaker, Chief Clerk Major G.B. Newton, Agriculture Commissioner Isaac Newton, Private Secretary W.E. Gardner, Statistician J.R. Dodge, Chemist Thomas Antisell, M.D., Superintendent Experimental Farm Isaac Newton Jr., and Entomologist Townsend Glover (USDA photograph #20111110-OC-AMW-0167).

“The Commissioner informs me that within the period of a few months this Department has established an extensive system of correspondence and exchanges, both at home and abroad, which promises to effect highly beneficial results in the development of a correct knowledge of recent improvements in agriculture, in the introduction of new products, and in the collection of the agricultural statistics of the different States.

Also, that it will soon be prepared to distribute largely seeds, cereals, plants, and cuttings, and has already published and liberally diffused much valuable information in anticipation of a more elaborate report, which will in due time be furnished, embracing some valuable tests in chemical science now in progress in the laboratory.

The creation of this Department was for the more immediate benefit of a large class of our most valuable citizens, and I trust that the liberal basis upon which it has been organized will not only meet your approbation, but that it will realize at no distant day all the fondest anticipations of its most sanguine friends and become the fruitful source of advantage to all our people.”

It is noteworthy that Lincoln took the time to discuss plant introduction in the same address in which he provided details on his Emancipation Proclamation plan and formally announced his Compensated Emancipation plan.

Saunders made several improvements to the U.S. Propagation Garden. In 1863 and 1865, a second and third greenhouse was added for growing and propagating fruits. In 1864, an 80-by-20-foot propagation house was constructed to provide a warm and humid atmosphere. Finally, a small brick office building was constructed in the northeast corner of the Garden (True 1937).

The U.S. Propagation Garden was described by a USDA Clerk, Lois Adams (1863):

“Across the street in front of the west Capitol grounds is one of the public gardens. The garden is a broad, barren looking tract of land, anything but inviting to the passerby. The large greenhouse standing in the center, however, attracts many visitors, and it is well worth a visit to see the perfection to which tropical plants and trees are brought here ... [Adjacent to the large greenhouse are] two greenhouses filled with plants from almost every part of the world ... each [greenhouse is] 100-feet long and 25-feet wide.... This piece of ground, comprising only 5 acres, [is] scarcely more than a common grass plot, with winding gravelled walks cutting the sod here and there... without the relief of shrub or tree, producing no artistic effect whatever... Here are to be made experiments whose results are to be published in the annual reports, and here are to be grown all the varieties of flowers, fruits, shrubs, etc., that can be obtained, or may be thought-worthy either for beauty or utility.”

Besides the U.S. Propagation Garden, the USDA also occupied a portion of the basement in the Patent Office Building. Adams described the seed processing area in the basement of the Patent Office Building (Adams 1864):

“Before us is a room 50-feet long by 25-feet wide; down the center nearly the whole length extends a table, on each side of which sit women and girls, 40 in number, gray-haired, middle-aged, and youth scarcely past childhood, all closely crowded together, and bent over the work of filling and stitching up the piles of little seed bags before them. Between these busy workers and the wall, on either side, in rows three deep, stand casks and barrels, and piled upon these are other barrels, sacks, and boxes, containing seed prepared, or to be prepared, for distribution by mail or express to country homes far away.”

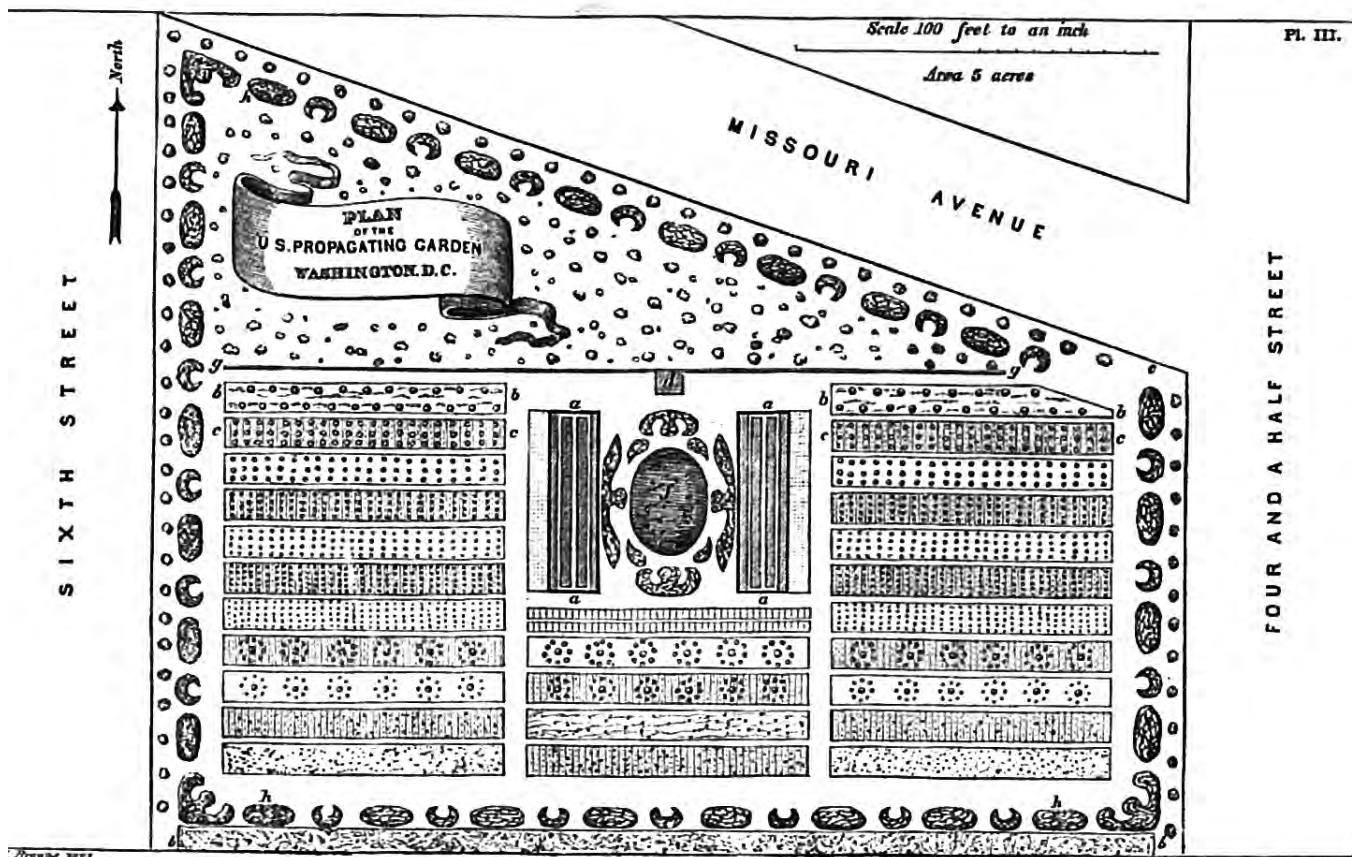


Figure 5. Plans for the U.S. Propagation Garden (Plate III in Holt 1858).



Figure 6. View looking east across the U.S. Propagation Garden. This photograph was taken in 1861 (Matthew Brady photograph).

In Commissioner Newton's 1863 Report to Congress, he requested more land and building space. The following year, Congress granted the USDA access to Government Reservation No. 2. Reservation No. 2 was located on 35 acres between 12th and 14th Streets and the Canal (now Independence Avenue) and B Street (now Constitution Avenue). Despite the transfer, Reservation No. 2 remained a cattle-holding yard for the Army until the end of the Civil War (Newton 1864).



Figure 7. View looking west-northwest from the Smithsonian Castle across from U.S. Government Reservation No. 2. This photograph was taken by Titian Peale in 1863 (University of Rochester Library).

After the War, the Reservation became the USDA's Experimental Farm, under the leadership of George Reid. From 1865 to 1867, the Experimental Farm was used to evaluate and propagate over 120 wheat, 167 rye, 17 oat, 70 pea, 30 bean, 32 sorghum, 18 cabbage, 14 lettuce, 13 onion, 43 potato, and 230 melon culti-

vars. In addition, 50 grass species for hay production; 17 shrub species for living hedges; and over 500 strawberry, grape, apple, and pear cultivars were evaluated (Saunders 1889). In 1868, the U.S. Propagation Garden and the Experimental Farm merged with the new Experimental Gardens and Grounds Division under the leadership of William Saunders (Powell 1927).

One of the results of the Experimental Farm's evaluation program was the identification of a superior wheat cultivar ('Tappahannock') from Virginia. 'Tappahannock' was noted for its high yields, early maturity, disease resistance, and flour quality. One of the highlights in the Commissioner's 1870 Report was the extensive correspondence received concerning the distribution of this wheat. The correspondence demonstrated that this cultivar was also widely adapted to many regions of the country from New England to the Lower South through the Midwest. For example, Elisha Angell from Rhode Island reported (Capron 1870):

"He has for 2 years sown the 'Tappahannock' wheat, received from the Department through the Rhode Island Agricultural Society, and finds it an excellent grain, well-adapted to the Northern States, hardy and free from blast or rust. He exhibited some of it at the New England and New Hampshire fair and received the first premium."



The Patent Office needed the space that was occupied by the USDA; therefore, Congress authorized in 1867 the construction of an Agriculture building on the south side of Reservation No. 2. The Agriculture building was designed by Adolf Cluss and was constructed by Francis Gibbons, Jr. The building's offices and laboratories were described in detail by John Ellis (Ellis 1869):

Figure 8. Agriculture Building, ca. 1890 (USDA photograph #20120105-OC-AMW-0304).

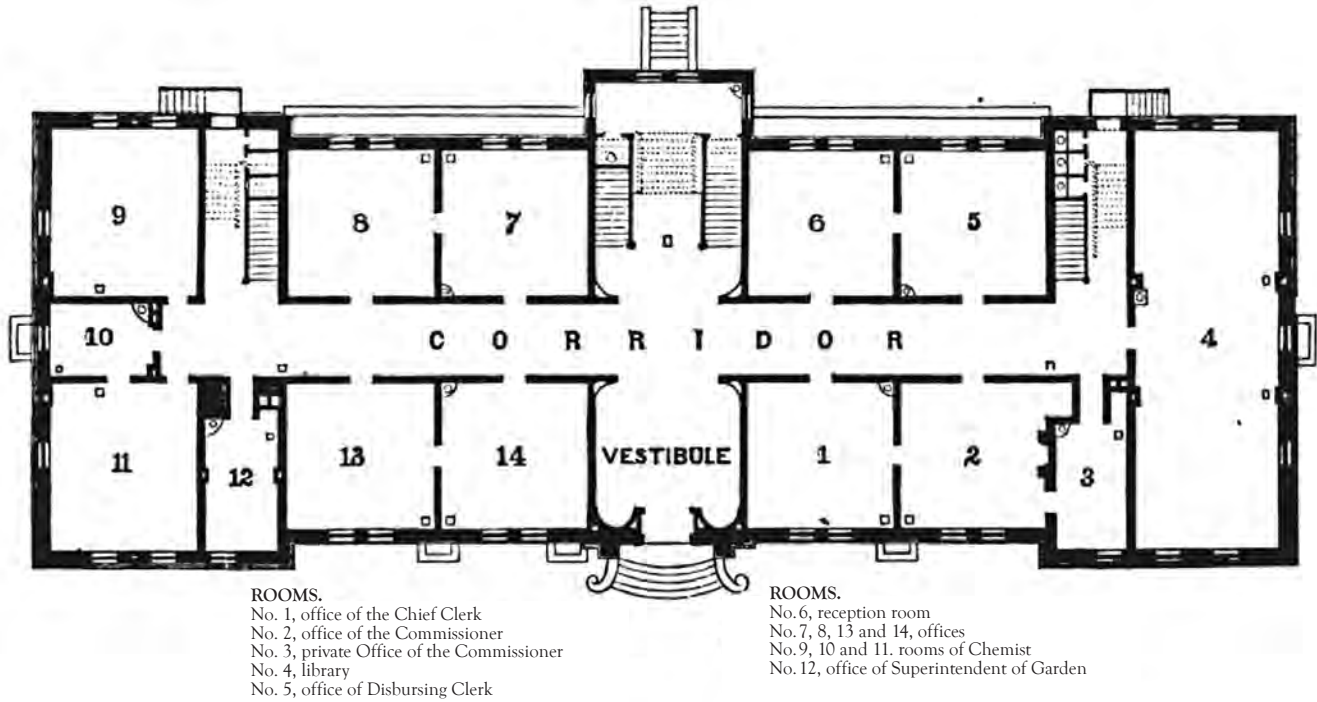


Figure 9. First floor layout of the Agriculture Building (Plate II in Dodge 1869).

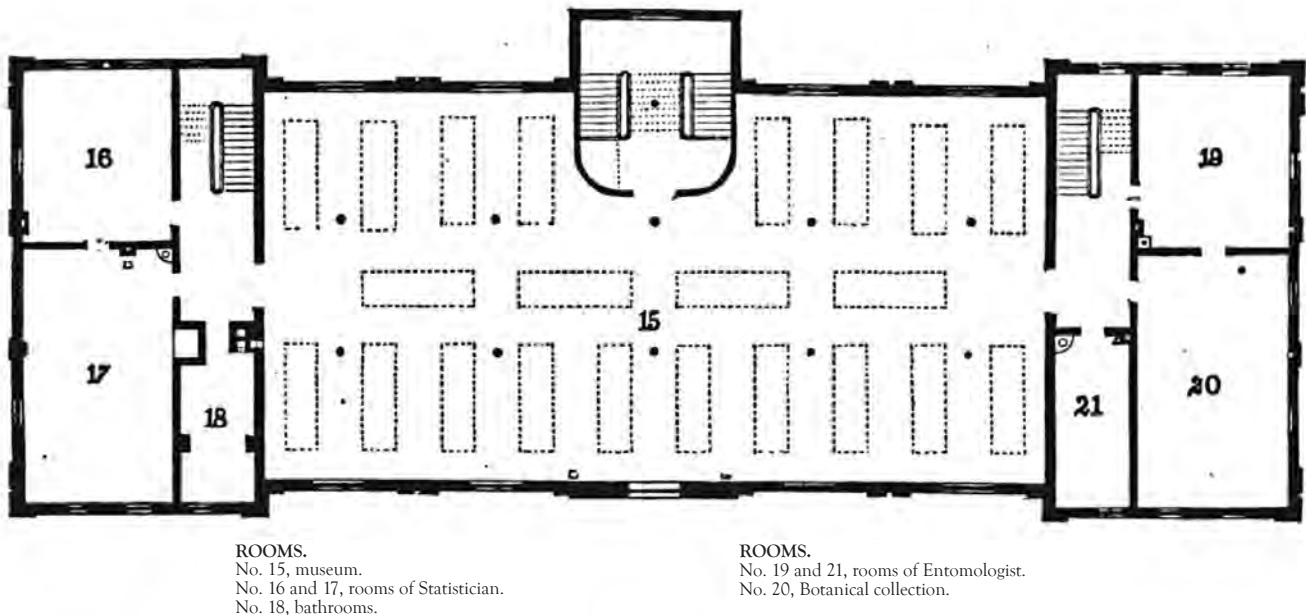


Figure 10. Second floor layout of the Agriculture Building (Plate III in Dodge 1869).

“The basement is well-lighted and contains, besides furnace and stove rooms, a laboratory and folding rooms. Upon the first floors are the offices, the library, and a second laboratory for the lighter work. The rooms of the Commissioner, three in number, are finished with the patent wood-paper, lately coming into use. The paper was cut for the purpose from the most beautiful woods the country affords, and the panels, inlaid with rare varieties, are by far the richest, and more beautiful than any panel-work in the Capitol. The halls are laid with imported tiles, and the walls and ceilings are tastefully preserved. Upon the second floor is the main hall, fitted up with massive walnut cases, made airtight, for the specimens which compose the museum ... The fourth floor, which is immediately under the roof, extends over the whole building, and resembles in all respects a great grain warehouse. An elevating platform connects it with the basement and gives an easy method of raising the supplies of seed-grain, which are kept in this thoroughly dry and well-ventilated space.”



Figure 11. Museum within the Agriculture Building displaying in one of the cabinets hand-painted, papier-mâché fruit highlighting cultivar differences and specific diseases symptom. This photograph was taken about 1875 (J.F. Jarvis' Stereoscopic Views, author's collection).

In 1870, a Victorian-style Conservatory was constructed just west of the Agriculture building. The 320-foot-long Conservatory was designed by Adolf Cluss with significant input from Saunders. The purpose of the Conservatory was to display economically valuable tropical plants such as pineapple, tea, and cinnamon. Many of these plants were also evaluated as new crops for warm areas of the country. The center section of the Conservatory (60 ft x 30 ft) was taller to accommodate tall-growing tropical fruit, nut, and palm trees. The shorter end sections (30 ft x 30 ft) were mainly devoted to citrus; while the connecting sections were for the general collection (Capron 1870).



Figure 12. Conservatory of the Department of Agriculture for growing and evaluating tropical plants of economic value. This photograph was taken in 1898 (author's collection).

The Conservatory was used to evaluate, propagate, and distribute tropical fruit for potential commercial production. One of the early successes was the release of the ‘Washington’ navel orange. In 1871, the U.S. Consul to Brazil, Richard Edes, sent the Secretary of Agriculture several orange tree cuttings from a superior seedless type known as the navel orange. Saunders grafted the cuttings onto standard root stocks and sent plants to Florida and California for evaluation. The plants did not do well under Florida conditions but thrived in California (Roistacher 2000). By 1882, there were more than half a million ‘Washington’ orange trees in California, making it one of the most successful fruit introductions in U.S. history. Keystone Company (1903) commented that:

“Two trees were sent to Riverside, California, and from these have been propagated millions of trees. By reason of the cooperative effort demanded, the orange has done far more for the permanent development of the State than gold or other mining ever did.”

As the Department expanded, the depth and sophistication of the research grew. In 1890, Edwin Willets, Assistant Secretary of Agriculture, established the policy that all research by the Department would be mission-oriented to a practical objective, and he encouraged employees to look beyond the seed and plant distribution program (Willets 1890). To reach these goals, the USDA's plant science activities became more diversified and additional Divisions were spun out of the Experimental Gardens and Grounds Division—Seed in 1868, Botany in 1869, Forestry in 1880, Pomology in 1886, Fiber Crops in 1890, Vegetable Pathology in 1890, and Agrostology in 1895 (Bennett 1908).



Figure 13. Geometrically arranged display and evaluation garden of annual plants. This photograph was taken about 1875 (C.S. Cudlip & Company stereoview, author's collection).



Figure 14. Planting a display garden of flowering annual, perennial, and tropical plants. This photograph was taken about 1930 (author's collection).



Figure 15. Tourists visiting the grounds of the Department of Agriculture (unknown stereoview, author's collection).



Figure 16. View looking west-northwest from the Smithsonian Castle across the grounds of the U.S. Department of Agriculture. This photograph was taken by Francis Hacker in 1879 (Library of Congress, LOT 12361, No. 1).

Because of the expanded research program, Secretary James Wilson proposed to Congress in 1899 that it provide funds to construct a modern laboratory building on the Department's grounds. In 1903, limited funds were obtained for a single administration building with two wings for laboratories. The new building was designed by Rankin, Kellogg, and Crane of Philadelphia, PA, and was constructed in two phases. The first phase was begun in 1904 and completed in 1907 and consisted of the east and west laboratory wings. The central administrative wing was not completed until 1930, after the original Agriculture building was torn down (Caemmerer 1932).

In 1900, new research fields were established across the Potomac River in Virginia. Over 400 acres of the Arlington Military Reservation (now Fort Myer, the

Pentagon, and Arlington National Cemetery) in Rosslyn, VA, were temporarily assigned to the USDA. Because the land contained a Potomac River channel, springs, streams, drainage ditches, and marshes, it took nearly 3 years to prepare it for use as Arlington Experimental Farm. By 1928, there were 68 buildings and greenhouses on the Farm (Avery 1928, Greathouse 1907, and Powell 1927).



Figure 17. View looking east towards the newly finished East Laboratory (left), Seed Building (center), and Agriculture Building (right). This photograph was taken about 1916. The unfinished building in the background is the Smithsonian's Freer Gallery of Art (author's collection).



Figure 18. The central administration building was completed in 1930, and it connected the East and West Laboratories into one building. This photograph was taken about 1934. The building is now known as the Jamie L. Whitten Federal Building (USDA History Collection, Special Collections, National Agricultural Library).



Figure 19. View looking north of the newly constructed Arlington Memorial Bridge directly connecting Arlington Experimental Farm with the National Mall. This photograph was taken about 1932 (author's collection).



Figure 20. Rose evaluation garden at Arlington Experimental Farm. This photograph was taken about 1930 (Library of Congress, LC-F82-714).



Figure 21. Turf grass experimental plots at Arlington Experimental Farm. This photograph was taken in 1929 (Library of Congress, LC-F8-42975).

Seed Distribution 1862-1900

Expanded activities resulted in additional divisions branching out of the Experimental Gardens and Grounds Division—Seed Division in 1868 and a Botany Division in 1869. The Botany Division's primary role was to organize the Government's plant herbarium specimens that were housed at the Smithsonian and the U.S. Patent Office (Parry 1870). The Seed Division was responsible for procuring and distributing seeds of superior and new plants, as well as collecting from the recipients of seeds evaluation reports and other information that could be used to improve the seed distribution program. The early Annual Reports of the Commissioner of Agriculture had an extensive section discussing these evaluation reports.

At this time, the United States did not have a major commercial seed industry. The Patent Office and the Department of Agriculture filled that void by distributing small quantities of free seed. To ensure the widest distribution and efficiency, nearly all of the seed was sent to members of Congress for distribution directly to the farmers. During the Congressional debate in 1880 on the appropriation bill for the seed distribution program, Representative D. Wyatt Aiken from South Carolina stated (Fagan 1895):

“The law establishing the Agricultural Department required the Commissioner to purchase rare and valuable seeds and distribute them among agriculturists. But no sooner did that law become effective than every Congressman became a genuine animated seed distributor, and, “bulldozing” the successive Commissioners into submission, without a vestige of right assumed the prerogative of scattering the seeds broadcast over the land. For 25 years this system prevailed, converting the Department into a wholesale seed store conducted on a cooperative principle, at once political and eleemosynary.”

Because of this debate, the distribution of seed was expanded from members of Congress to include the Department's regular statistical correspondents, experiment stations, agricultural societies, farmers, and miscellaneous applicants. However, the appropriation bill stated that at least three-fourths of all the seed be supplied to Congress members or their delegates.

The seed that was initially distributed was of new and improved plants. As the demand for seeds increased,

the USDA had to supplement its distribution by purchasing seed of common varieties. In 1895, the USDA expended \$48,830.30 for the purchase of seeds, bulbs, and cuttings from 32 companies. For example, 481 bushels of 5 varieties of sweet corn were purchased from the Cleveland Seed Company in New York (Harden 1895). The purchased material accounted for most of the 9,901,153 packages of seed that were distributed. The distribution included 8,963,059 packages of 162 varieties of vegetables, 771,780 packages of 73 varieties of flowers, 32,847 packages of 7 varieties of corn, and 18,752 packages of 4 varieties of cotton (Fagan 1895).



Figure 22. Seed storage in the Seed Building. This photograph was taken about 1916 (Library of Congress, LC-F82-1722).



Figure 23. Seed sorting in the Seed Building. This photograph was taken about 1916 (Library of Congress, LC-F82-1730).



Figure 24. Seed packaging in the Seed Building. This photograph was taken about 1916 (Library of Congress, LC-F82-1725).



Figure 25. Seed package distribution in the U.S. Capitol. This photograph was taken about 1916 (Library of Congress, LC-F82-3650).

As the commercial seed industry developed, the USDA's Seed Distribution Program became a major competitor (Ebel 1912). In 1902, Secretary Wilson succeeded in convincing Congress to modify the Seed Distribution Program. Under the new program, "common" seed would no longer be distributed. The USDA would focus on supplying seed of new varieties that it developed and new germplasm that it collected. In addition, the USDA would distribute seed of new or little-known varieties purchased in the open market. The purchased seed



Figure 26. Mailing seed from Pennsylvania Senator Boies Penrose's office at the U.S. Capitol. This photograph was taken about 1916 (Library of Congress, LC-F82-3649).

would only be distributed for a year, allowing further demand to be met by the seed industry. Wilson stated (Wilson 1902):

"As the plant-breeding work of the Department increases, opportunities for securing seed of this nature will accumulate.... The Department has a well-organized force of scientists who are thoroughly familiar with the general conditions of soil and climate in nearly all parts of the country. Special crops could be selected for special purposes, and with the advice and cooperation of members of Congress, such crops could be placed where they would do the most good. This is a line of work that would result in very much more value to individual districts throughout the country than the distribution of a large quantity of common varieties of garden seed, which have no particular merits so far as newness or promise are concerned."

In order to improve foreign plant collection, Secretary Wilson created the Seed and Plant Introduction Section. The Superintendent of this Section, David Fairchild, organized plant exploration teams that were sent abroad for specific collection purposes. Niels Hansen and Mark Carleton were sent to Russia, Seaton Knapp to Japan, Walter Swingle to southern Europe and northern Africa, and David Fairchild and Barbour Lathrop to South America (Fairchild 1938).

Beginning of Plant Breeding and Genetics 1895-1905

Towards the end of the century, the work of the USDA became more specialized and more Divisions were established—Forestry in 1880, Pomology in 1886, Fiber Crops in 1890, Vegetable Pathology in 1890, and Agronomy in 1895. In addition, the number of plant science employees increased from 41 in 1881 to 159 in 1899 (Bennett 1938).

During the 1890s, the focus on plant introduction began to change. Prior to that time, the USDA had conducted large-scale evaluation programs to identify germplasm that was resistant to pest and diseases, as well as plants adapted for environmental stress. The Superintendent of the Vegetable Pathology and Physiology Division, Beverly Galloway, started a new program to breed plants resistant to specific pests, diseases, and stresses. His goal was to “enable the grower to not only modify his conditions to suit the plants, but to modify the plants to suit the conditions.” (Galloway 1897).



Figure 27. Dr. Galloway and six of nine scientists within the Section of Vegetable Pathology. This photograph was taken in 1893. (L-R, standing) Joseph James, Theo Holm, Merton B. Waite, and P.H. Dorsett. (L-R, seated) David Fairchild, Beverly T. Galloway, and Walter T. Swingle. (USDA History Collection, Special Collections, National Agricultural Library.)

Galloway’s Division established breeding programs for developing (1) disease resistance in cotton, melon, and grape vine; (2) cold tolerance in citrus; (3) alkali soils and drought resistance in alfalfa and wheat; and (4) greater productivity and quality in pineapple, tobacco, cotton, and maize. The USDA’s first plant breeders were William Orton, Walter Swingle, Jesse Norton,

Mark Carleton, and Herbert Webber, as well as Webber’s assistants C.P. Hartley and Archibald Shamel (Smith 1907).

In the 1896, 1897, and 1898 Yearbook of Agriculture, Herbert Webber published a series of review articles on plant breeding principles with practical examples: Influence of Environment in the Origination of Plant Varieties (Webber 1897), Hybrids and their Utilization in Plant Breeding (Swingle and Webber 1898), and Improvement of Plants by Selection (Webber 1898). Webber (1898) concluded:

“Hybridization and changing the environment artificially are the principal means of securing desired variations, and selection is the means by which a variation, when secured, is augmented and fixed.”



Figure 28. Herbert Webber at the Sub-Tropical Laboratory in Eustis, Florida. This photograph was taken in June 1895 (USDA History Collection, Special Collections, National Agricultural Library).

In 1899 in London, an International Conference on Hybridization was held (Wilks 1900). Webber and Swingle attended the meeting and presented the USDA’s results on breeding citrus, cotton, pineapple, and corn, using lantern slides for illustrations. In addition to Webber, the USDA sent Willet Hays as an envoy. At the time, Hays was a wheat breeder, as well as the Director of the University of Minnesota’s State Experiment Station. Two years later, he was appointed Assistant Secretary of Agriculture.

In 1902, the USDA sponsored the 2nd Conference on Plant Breeding and Hybridization (Unanimous 1904). Between the 1st and 2nd Conferences, Gregor Mendel's principles of inheritance were rediscovered. During this meeting, several talks and discussions centered on Mendel's principles. One of the resolutions of this conference stated:

"Whereas, this conference recognizes the invaluable services which the United States Department of Agriculture is rendering to the breeders of plants and animals... be it resolved, that a committee of three be appointed by the Chair empowered and directed to confer with the Honorable Secretary of Agriculture with a view to the formation of plans for the more intimate cooperation in [the] future between individual workers and the Department in question and publishing data relative to plant and animal improvement."

The work of this committee (Liberty Hyde Bailey of Cornell University, Thomas Hunt of Cornell University, Dean Curtiss of Iowa Agricultural College, and Herbert Webber of the USDA) resulted in the establishment of the American Breeders Association (ABA) with Secretary Wilson as President and Assistant Secretary Willet Hays as Secretary. At the first annual meeting of the ABA, Secretary Wilson (Wilson 1905) stated:

"The organization of the plant and animal breeders of the country is wise. Little progress has been made in our country along the line of animal breeding, while the study of the plant has had much more attention. Many of the principles controlling breeding are alike in both cases. The breeder of one should be familiar with the breeding of the other. The adaptation of plants and animals to our several climatic areas and life zones is an imperative necessity. The agricultural development of our country waits for this."

The ABA began publishing the *American Breeders Magazine* in 1910. In 1914, the ABA became the American Genetics Association and the *American Breeders Magazine* became the *Journal of Heredity* (Crow 2003). The USDA and its association with the ABA transformed breeding from an art into a science (Allen 2000).

Two months after the 2nd Conference, Webber taught the first class in the United States on Mendelian inheritance through the USDA Graduate School. Seventy-five students attended, 58 of whom were either faculty or their assistants at agricultural colleges and experiment stations. According to Liberty Hyde Bailey of Cornell University, Webber's class was instrumental in

the dissemination of the Mendelian ideas in the United States (Paul and Kimmelman 1988).

The USDA inaugurated a program with the State Experiment Stations to further the breeding of new and improved varieties. Secretary Wilson, in his 1908 annual report to Congress, stated:

"With a view to bringing the results of the breeding investigations of the Department home to the farmer in such a way that he can adopt the practices which the Department has been perfecting, extensive cooperative work has been inaugurated in a number of Southern States. Cooperative breeding work, with several types of cotton and corn, was conducted with a number of farmers where the conditions were favorable for the development of new and improved varieties of these crops."

The USDA and the State Experiment Stations began research programs to study the effects of inbreeding on plant and animal breeding (Shamel 1905). Because of this coordinated effort, the USDA and the State Experiment Stations led the world in the systematic breeding of new varieties (Kingsbury 2009). Secretary Wilson (1910) noted that scientific advances in breeding would have a great economic impact. He stated (Wilson 1910):

"Improvements by breeding are unlike those secured by adding new acres to the cultivated areas of the country, by deeper plowing, by more frequently cultivating the crop, by adding to the soil larger supplies of fertilizers, or by giving a more expensive ration to farm animals. These improvements, though they greatly increase the farmers' profits, are secured at a cost which sometimes equals the value of the added produce. But the cost of improvements through breeding usually represents only a small fraction of the added values. The increase of product secured by breeding pays the cost in a short time, and, since there is no further expense, the annual increase afterward is clear profit. The farmer will be able to retain a part of the larger production in the form of added profit, and part will help to reduce the cost of living to those in our cities. Larger production on the farm will also give increased business for the transportation company, the manufacturer, and the merchant, and will provide the Nation with a larger product with which to hold our balance of trade."

Development of Quantitative Genetics for Animal and Plant Breeding 1905-1925

At the turn of the century, there were two schools of thought on inheritance—discontinuous or continuous inheritance of traits. William Bateman of Cambridge University in London, England, led the group that believed in discontinuous inheritance, where traits were the result of single elements with discrete variation. This group advocated a pedigree breeding approach where one individual was selected and inbred to create a superior individual. Discontinuous inheritance was easily explained by Mendelian genetics. The discontinuous inheritance group included Hugo de Vries (1901) of the University of Amsterdam, The Netherlands, who developed the mutation theory to explain how new Mendelian factors or genes were created; Theodor Boveri (1902) of the University of Munich, Germany, and Walter Sutton (1902) of the University of Kansas, who independently developed the chromosome theory of inheritance that postulated that the Mendelian factors (genes) were located on chromosomes; and Thomas Morgan (1911) of Columbia University, NY, who demonstrated how chromosome “crossing-over” explained the physical mechanism of Mendelian inheritance.

The continuous group was led by Francis Galton who believed that traits were the result of multiple elements with continuous variation. This group advocated a mass breeding approach where multiple individuals were selected and outcrossed to create a superior population. Mendelian genetics could not explain continuous inheritance. The continuous inheritance group included Karl Pearson (1900) of the University of London, England, who developed and applied several mathematical concepts (correlation coefficients, linear regression, P-value, and Chi distribution) to explain continuous inheritance; and Wilhelm Weinberg (1908), a medical doctor from Stuttgart, Germany, and Godfrey Hardy (1908) of Cambridge University in London, England, who independently developed the Hardy-Weinberg equilibrium theory to estimate the frequency of genes in a population.

In 1909, Wilhelm Johannsen of the University of Copenhagen, Denmark, coined the terms “genotype” and “phenotype” to distinguish the difference between the physical trait and the gene(s) controlling that trait. The dilemma was that the genotype behaved in a

discontinuous manner, while the phenotype behaved in a continuous manner. This dilemma led Spillman (1912) of the USDA to state:

“The question whether the more fundamental characters of the organism are inherited in Mendelian fashion is purely academic and of no practical importance either to the theory of heredity or the practice of the breeder.”

In 1906, George Rommel of the USDA started a project to determine the long-term effects of in-breeding on animals using guinea pigs as a model. Rommel began with 23 different brother-sister matings. In 1915, Sewall Wright took over the USDA’s inbreeding project on animals. At this time, over 40,000 inbred guinea pigs were born from the continued brother-sister matings of 17 of the original 23 families (Wright 1922a, b, and c). In addition, a practical inbreeding experiment was started in 1912 with dairy cattle to determine if the continuous use of improved sires could increase the level of milk and butterfat production (Woodward and Graves 1933). To explain the guinea pig and cattle data, Wright developed a new mathematical method (path coefficients). Wright’s approach was described in 1921 in a series of papers on systems of mating (Wright 1921a, b, c, d, and e).



Figure 29. Sewall Green Wright was an American geneticist known for his influential work on evolutionary theory. Wright, Ronald A. Fisher, and John B.S. Haldane were the founders of theoretical population genetics. This photograph was taken in 1928 (American Philosophical Society, Mss.Ms.Coll.60).

Wright, together with Ronald Fisher (1924), who also developed a new mathematical method for analyzing genetic data (analysis of variance), created the field of “quantitative genetics.” Fisher worked at the Rothamsted Experiment Station in England. The new field of quantitative genetics was able to bridge the differences between continuous and discontinuous inheritance.

The Role of the Agricultural Research Service in Plant Introduction 1953-2012

Today, the USDA plant improvement program is conducted by numerous laboratories within the USDA's Agricultural Research Service (ARS). The ARS is the USDA's chief scientific research agency. It conducts research to develop and transfer solutions to agricultural problems of high national priority and provides information access and dissemination to (1) ensure high-quality, safe food and other agricultural products; (2) assess the nutritional needs of Americans; (3) sustain a competitive agricultural economy; (4) enhance the natural resource base and the environment; and (5) provide economic opportunities for rural citizens, communities, and society as a whole.

ARS has maintained a long-term commitment to conserving and managing a broad spectrum of plant genetic resources and information associated with that germplasm. It has also vigorously encouraged use of these genetic resources in research, breeding, education, and production. Today, the plant genetic resource management efforts are conducted by the U.S. National Plant Germplasm System (NPGS), a network of Federal, State, and private organizations and research units coordinated by ARS. Since 2006, NPGS's total plant germplasm holdings have expanded by about 14 percent—from 474,000 accessions of 11,800 species to more than 540,000 accessions of 13,642 species in 2011. Over 200,000 accessions were distributed in 2010.

Between 2006 and 2011, USDA supported 84 plant explorations and exchanges. Thirty-eight of the explorations took place within the United States, and 46 occurred in 21 other countries—Albania, Armenia, Australia, Azerbaijan, Canada, China, Dominican Republic, England, Italy, Japan, Kazakhstan, Kyrgyzstan, Morocco, Paraguay, Republic of Georgia, Russia, Scotland, Tunisia, Turkmenistan, Ukraine, and Vietnam. The targeted taxa included a wide range of crop species and their wild relatives—*Actinidia*, *Allium*, *Arachis*, *Beta*, *Carya*, *Chenopodium*, *Corylus*, *Daucus*, *Ficus*, *Fragaria*, *Glycine*, *Helianthus*, *Humulus*, *Juglans*, *Lactuca*, *Malus*, *Medicago*, *Mentha*, *Morus*, *Olea*, *Panicum*, *Parthenium*, *Phaseolus*, *Pistacia*, *Pisum*, *Prunus*, *Punica*, *Pyrus*, *Ribes*,

Rubus, *Solanum*, *Trifolium*, *Triticum*, *Vaccinium*, *Vitis*, many forage and range grasses and legumes, landscape trees and shrubs, and florist plants.

The NPGS delivers germplasm-associated information through its Web-based Germplasm Resources Information Network (GRIN). In 2010, nearly 2 million unique computers accessed and consulted data from the GRIN Web site. In conjunction with the Global Crop Diversity Trust, GRIN is being revamped into a new version, dubbed GRIN-Global (www.grin-global.org/index.php/Main_Page). The Global Crop Diversity Trust was founded by the United Nations Food and Agriculture Organization (FAO) and Bioversity International to promote the rescue, understanding, use, and long-term conservation of valuable plant genetic resources (www.croptrust.org/main).

ARS is also committed to developing innovative approaches for breeding plants more efficiently and effectively. As plant breeders searched for ways to develop varieties more quickly, the need for methods to reduce the number of generations by identifying genes without visual observation in the field became a top priority in most breeding programs. This triggered a need for ARS researchers to develop techniques to assess genes at the molecular level before flowering takes place, providing information that allowed a shift in breeding programs from a purely applied mode to marker-assisted breeding.

ARS researchers also maintain and deliver huge volumes of crop genome sequence and genomic map data in state-of-the-art genome databases. New bioinformatic analytical tools are devised and applied. Crop genome structures are elucidated, key agricultural traits are mapped in crop genomes, and their underlying genetic bases are determined. Crop breeding has benefited from ARS strategic investments in genetic resources, the ready availability of genome sequences, and the development of analytical tools to understand how gene sequence variation determines variation in crop traits.

The U.S. Government has played a central role in developing several standard agricultural and horticultural crops. The first example will demonstrate the role USDA plant exploration had in the development of the soybean industry. The second example will demonstrate the role USDA plant breeding played in creating the commercial blueberry.

Introduction and Development of Soybean Cultivars

Soybean was first introduced in the United States from China via England in 1765 by Samuel Bowen of Georgia. From the soybeans that Bowen grew, he manufactured and exported to England soy sauce, noodles, and powder. Bowen developed a novel manufacturing process that received a patent. Unfortunately, when Bowen died, his soybean enterprise was not continued.

The next significant introduction of soybean occurred in 1851. Benjamin Franklin Edwards received a package of seeds from Japan and gave them to John Lea of Illinois. Lea propagated the plants and sent seed to Andrew Ernst of Ohio. Ernst further propagated the plants and sent seed to the Commissioner of Patents in 1852 for distribution. Because of the Patent Office's widespread distribution of seed and the testimonials in their annual reports, soybeans became a valuable forage plant. In a Patent Office Report, Ernst (1854) stated:

“The stalks appear to be too woody for fodder in a dried state, though they may be used as such, together with the large thick leaves, when green. The excellency of the seed, at maturity when properly cooked, for winter food, for both man and animal, has been fully tested.”

The first U.S. plant exploration trip that collected soybeans occurred in 1854 during Commodore Matthew Perry's Expedition to Japan. James Morrow obtained soybean seed and sent it to the Patent Office for distribution. Two of the cultivars that were distributed from the Perry Expedition were named 'Mammoth' and 'Adsuki' (Hymowitz 1990).

By 1900, nearly every Agriculture Experiment Station was growing and evaluating soybeans with positive results. One of the problems was the limited germplasm that was available. There were less than a dozen cultivars in cultivation ('Ito San', 'Samarow', 'Mammoth', 'Butterball', 'Buckshot', 'Kingston', 'Eda', 'Ogemaw', 'Guelph', and 'Adsuki'). In order to increase the gene pool, the USDA's Office of Foreign Seed and Plant Introduction sent Frank Meyer to China in 1905 on the first of several plant exploration trips. Soybean was one of the priority plants of the exploration trips. Between 1906 and 1908, Meyer introduced 18 new cultivars into the United States.



Figure 30. Frank N. Meyer was a USDA explorer who traveled to Asia to collect new plant species. He introduced 2,500 plants into the United States. This photograph was taken about 1909 (USDA History Collection, Special Collections, National Agricultural Library).

In 1907, the USDA started a large-scale soybean evaluation and introduction program. Charles Piper and William Morse of USDA's Division of Forage Crops and Diseases directed the program at USDA's Arlington Farm Experiment Station in Virginia. In order to expand the gene pool, Piper went to India in 1911 and returned with 108 new varieties of soybean. By 1915, over 500 different cultivars were being evaluated by Piper and Morse. Because of these evaluations and the extensive literature published by Piper and Morse, soybean was beginning to be recognized as a value food crop for humans, instead of just a green forage crop. Morse (1918) separated soybeans into two types with the following cultivar recommendations:

“The yellow-seeded sorts are preferred for food and the production of oil and meal and include the following: Mammoth (late) ... Mikado (medium) ... Ito San (early). For forage, the black-seeded varieties are most suitable and include Biloxi (late) ... Peking (medium) ... Black Eyebrow (early).”

Cultivar recommendations were based on the flowering behavior of the cultivar. While studying flowering at the Arlington Farm Experiment Station, Garner and Allard (1920) recognized the significance of the daylength in controlling flowering named the response “photoperiodism.” They found that in ‘Biloxi’ soybean, a succession of at least two relatively short light periods, each followed by a relatively long dark period, was necessary for flowering. While in ‘Mandarin’ soybean, a long dark period was not required for flowering. They further discovered that temperature, as well as photoperiod, influenced flowering in soybean (Garner and Allard 1930). Further studies by Borthwick and Parker of the USDA started classifying soybean varieties into different flowering classes based on their photoperiodic response (1939) and night temperature (1941). Today, soybeans are classified into 13 maturity groups based on their response to photoperiod and temperature (Hymowitz 1990).

Before World War I, soybean was mostly grown as a forage crop. World War I created a shortage of oil that resulted in a significant importation of soybean oil from Manchuria into the United States. It became clear that there was a need to find (1) earlier maturing soybeans that could be grown in the cornbelt, (2) higher oil types for industrial use, and (3) lower oil types for animal feed. Therefore, Palemon Dorsett and his son, James Dorsett, went to northeastern China and Manchuria and returned in 1927 with nearly 1,500 new soybeans.



Figure 31. Palemon H. Dorsett and his Chinese interpreter, Peter Liu, on the trail near Pa Ta Chu, Western Hills, to the west of Peiping, China. This photograph was taken about 1909 (Palemon Howard Dorsett Collection, Special Collections, National Agricultural Library).

Dorsett returned to China with Morse in 1929. The goal of the soybean portion of this trip was more than plant collection. They were to obtain data and photographs of field operations and of practices and methods

of the soybean utilization for food and industrial uses in China, Korea, and Japan. In 1931, they returned with over 6,000 pages of official, typewritten notes, 3,369 photographs, over 4,500 different soybeans representing approximately 2,000 varieties and/or types, and over 250 different food products (Hymowitz 1984).

In 1907, Piper and Morse noticed off-colored seed in their variety increases. Most of the soybean lines that they obtained were not genetically uniform and contained similar but not identical plants. Therefore, many of the soybeans that they released were the result of selection from the original imported line. Because soybean flowers are very small and easily damaged, it is very difficult to create artificial hybrids. Only 20 percent of attempted crosses by Piper and Morse resulted in seed (Morse and Cartter 1937). Before 1940, very few of the varieties released were the result of artificial hybridization. A few of the artificially created hybrids include ‘Mamloxi’, ‘Mamotan’, ‘Mamredo’, ‘Ogden’, ‘Volstate’, ‘Tennessee Non-pop’, ‘Oloxi’, ‘Pee Dee’, and ‘Yelredo’ (Probst 1970).

An increase in the effort to create artificial hybrids occurred with the establishment of the U.S. Regional Soybean Industrial Products Laboratory at the University of Illinois. In 1936, Jackson Cartter of the USDA helped to organize the Laboratory and became its first director. As director, Cartter organized and coordinated the soybean breeding program for 12 Midwestern States. He served as director until he retired in 1965.

In collaboration with its university colleagues, the USDA continues to play a major role in developing improved soybean germplasm. For example, in 2007, the first drought-tolerant soybean germplasm was jointly released. This germplasm was developed by “Team Drought” led by Thomas Carter at the USDA-ARS Sandhill Research Station in Jackson Springs, NC. Members of “Team Drought” include researchers at universities in Arkansas, Minnesota, Missouri, Georgia, Nebraska, and North Carolina, as well as USDA Research Leader Perry Cregan and Geneticist David Hyten of the Soybean Genomics and Improvement Laboratory in Beltsville, MD, and Research Leader Randy Nelson of the USDA Soybean Germplasm Collection in Urbana, IL. Two genes that control soybean wilting were discovered. Knowledge of these genes provided a shortcut for accelerating the incorporation of drought-tolerant germplasm in breeding stock without resorting to extensive field testing in drought sites (Hufstetler et al. 2007).



Figure 32. ARS is releasing new advanced soybean breeding lines that have slow-wilting traits, which are important to thriving during drought. (Photo by Scott Bauer, Agricultural Research Service, image K4390-31.)

Molecular technologies have been recently developed for soybean improvement. In 2010, USDA scientists, together with the Department of Energy's (DOE) Joint Genome Institute, the Hudson-Alpha Genome Sequencing Center, and 15 other institutions, assembled and annotated the first whole genome sequence for soybean (Schmutz et al. 2010). To utilize these technologies, Plant Geneticist David Grant at the USDA-ARS Corn Insect and Crop Genetics Research Laboratory, Ames, IA, led a team to develop a knowledge-based system called "SoyBase" and the "Soybean Breeder's Toolbox." These tools link historical and contemporary genetic and trait information with DNA sequence data (Grant et al. 2010). The Toolbox (<http://soybeanbreederstoolbox.org>) provides an easy-to-use single point of access to multiple databases, software, and data analysis tools. It serves as the central repository for genetic and genomic data and related resources for soybean, as well as an initial access point for laboratory-specific Web pages and specialized data sets. In 2010, approximately 28,000 computers accessed the Toolbox.

Introduction and Development of Blueberry Cultivars

Blueberries are one of the most recently domesticated food crops. Prior to 1911, all blueberries grown and sold in the United States were harvested from the wild. All that changed in 1906, when Frederick V. Coville began a program to domesticate blueberries.

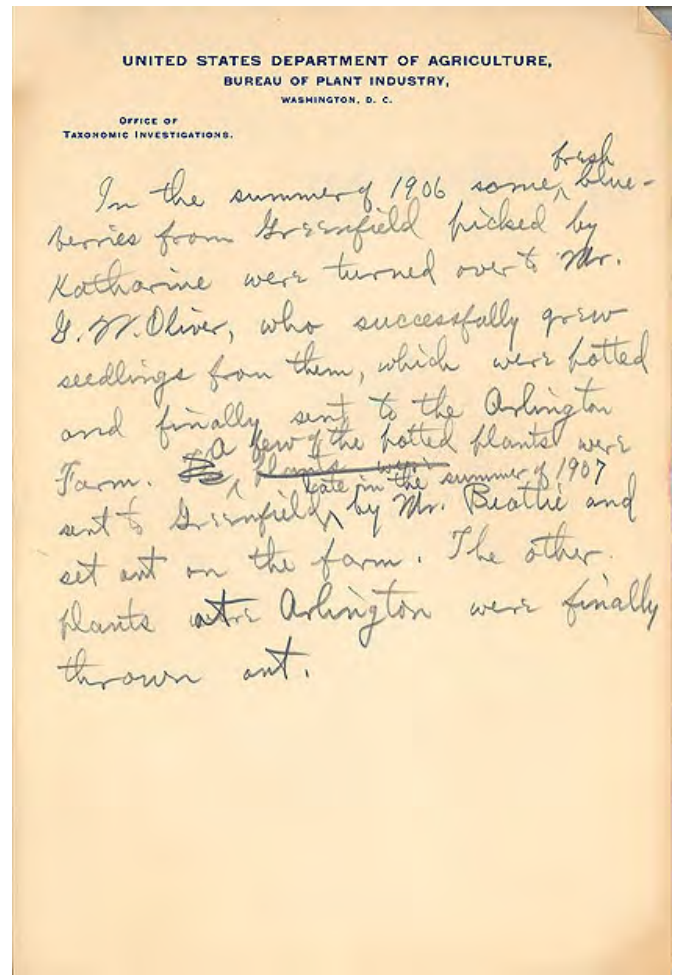


Figure 33. A note by USDA botanist Frederick Coville describing his pioneering research on domesticating blueberries. (Special Collections, National Agricultural Library.)

The first breakthrough occurred when Coville discovered why most transplanted wild blueberry plants declined and eventually perished after several years. Through a series of experiments from 1906 to 1910, Coville and his assistant George W. Oliver determined that blueberry plants required a very acidic soil. In addition, they discovered that a fungal mycorrhizal relationship was essential for the vigorous growth of the plants. They further determined that conventional methods of

fertilization and fertilizer that relied on manure were not successful for blueberries. Coville (1921) described the fundamental requirements for blueberry culture:

“(1) An acid soil, especially one composed of peat and sand; (2) good drainage and thorough aeration of the surface soil; and (3) permanent with moderate soil moisture. Under such conditions, the beneficial root fungus, which is believed to be essential to the nutrition of the plant, need give the cultivator no concern.”

This information was widely distributed as a USDA Bulletin (Coville 1910) and an article in *National Geographic* (Coville 1911). Elizabeth White, the daughter of a cranberry farmer in New Jersey, read about Coville’s work and in 1911 approached him with an offer to use their farm as a site for his research. Coville collaborated with White to identify superior wild germplasm. Local wild blueberry commercial pickers were used to locate wild plants with large fruit. White also collaborated with Coville in developing a commercial blueberry production system. In 1912, they planted the first commercial blueberry field by placing wild selections in alternate rows to allow for cross-pollination. The first commercial harvest occurred in 1916. The results of these studies resulted in another widely distributed USDA Bulletin, Number 974, on Directions for Blueberry Culture (Coville 1921). This bulletin became the manual for commercial blueberry production.

Coville began artificially breeding blueberries in 1908. The first wild blueberry selected for breeding was a highbush type (*Vaccinium corymbosum* L.) named ‘Brooks’ after the owner of the pasture at Greenfield, NH, where Coville discovered it. This plant was selected because of its large fruit and exceptional flavor. Coville (1937) noted:

“The delicious flavor of this wild blueberry from New Hampshire appears in all the crossbred-named varieties of blueberries, except ‘Jersey’ and ‘Wareham’, and the flavor of those two varieties would be more delicious if ‘Brooks’ had been included in their ancestry.”

Coville was unsuccessful in self-pollinating ‘Brooks’ and discovered that blueberries were self-sterile. He began intercrossing ‘Brooks’ with cultivars identified by White and her team of local pickers. One of the most important wild plants that were used in breeding was discovered in Browns Mills, NJ, by Exekiel Sooy. However, this cultivar, ‘Sooy’, itself had very little commercial value. In 1915, White (2011) describes it in her notes:

“Tried on the table these berries have a really disagreeable flavor, which lingers some time after eating them. They also leave a very heavy residue of skins in the mouth. Stock no good, shall dig out all but two or three plants.”

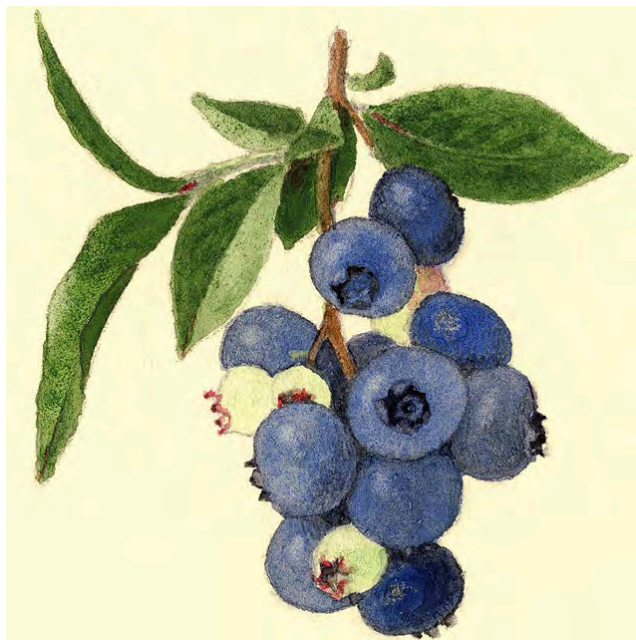


Figure 34. In 1908, USDA botanist Frederick Coville selected this wild highbush plant with berries of superior size and flavor as one of the foundation parents of his breeding program. He named it “Brooks” after Fred Brooks, a neighbor on whose New Hampshire land the bush was growing. (Watercolor by James Marion Shull, 1940, Special Collections, National Agricultural Library.)

In 1912, Coville crossed ‘Sooy’ with ‘Brooks’. From this cross, about 3,000 seedlings were obtained, which resulted in the release of two cultivars in 1920—‘Pioneer’ and ‘Katherine’. These cultivars became the foundation of the commercial blueberry industry (Moore 1994). By 2010, over 75 percent of the current blueberry acreage was still composed of USDA hybrids, most notably ‘Bluecrop’, ‘Jersey’, ‘Weymouth’, and ‘Blueray’ (Hancock 2009).

After Coville’s death in 1937, George M. Darrow assumed leadership of USDA blueberry breeding. Darrow, working with USDA taxonomist W.H. Camp, made advances on the crossibility and phylogeny of the native *Vaccinium* species. In addition, he formed a large collaboration network for evaluating germplasm under a wide range of conditions. His network consisted of private growers and Agricultural Experiment Station scientists in Connecticut, Florida, Georgia, Maine,

Massachusetts, Michigan, New Jersey, and North Carolina. From 1945 to 1961, he sent out almost 200,000 hybrids to his cooperators for evaluation (Hancock 2009). These cooperative agreements helped in the development of cultivars that adapted to differing environmental conditions. The most notable cultivar Darrow released was 'Bluecrop'. Even though it was released in 1952, it is still the leading blueberry cultivar in the world.



Figure 35. Bluecrop, released by USDA botanist Frederick Coville in 1941, is easy to grow and easy to eat. It remains one of the country's most popular mid- to late-season varieties. (Photo by Mark Longstroth, Michigan State University.)

Donald H. Scott took over the program after Darrow's retirement in 1957. Scott focused on seed germination. In 1965, Arlen D. Draper joined the team. Draper is best known for introducing genes from most of the wild species into the commercial highbush blueberry. Working with Scott and Gene J. Galletta, Draper employed various strategies to incorporate desirable traits found in wild blueberries into the cultivated blueberry, such as low chilling requirement (for Southern growers) and improved fruit quality. A number of cultivars being grown today were developed and/or selected by Draper. Notable cultivars include 'Duke', one of the first large-fruited, early-season cultivars widely planted throughout the United States; 'Legacy', a popular, high-yielding cultivar; and 'Elliott', a late-ripening cultivar that produces large fruit (Hancock and Galletta 1995).

Blueberry research at USDA's Agricultural Research Service is summarized in the May/June 2011 issue of *Agricultural Research Magazine* (volume 59, number 5). Geneticist Mark Ehlenfeldt, at Philip E. Marucci Center for Blueberry and Cranberry Research, Chatsworth, NJ,

coordinates the breeding efforts for the Northeastern United States. Plant Pathologist James Polashock, also at the Marucci Center, oversees disease-resistance screening. Breeding efforts for the Southeastern United States are coordinated by Geneticist Steve Stringer, working at the Thad Cochran Southern Horticultural Laboratory in Poplarville, MS. Finally, breeding efforts for the Northwestern United States are coordinated in the Horticultural Crops Research Unit in Corvallis, OR, by Geneticist Chad Finn.

Working with the breeders are Molecular Geneticists Jeannie Rowland and Nahla Bassil. Rowland is in Beltsville, MD, at the Genetics Improvement of Fruits and Vegetables Laboratory. Bassil is at the ARS National Clonal Germplasm Repository in Corvallis, OR. Rowland is currently leading an extensive team of U.S. and foreign university researchers to generate genomic tools for blueberry improvement. Specific traits targeted for molecular analysis and breeding are those associated with cold tolerance and chilling requirements.

Besides the genetic improvement of blueberry, ARS is also studying blueberries' effects on health and nutrition. Wallace Yokoyama at the Western Regional Research Center in Albany, CA, Xianlin Wu at the Arkansas Children's Nutrition Center in Little Rock, AR, and Agnes Rimando at the Natural Products Utilization Research Unit in Oxford, MS, are investigating the cholesterol-lowering and associated atherosclerosis-lowering effects of blueberry (Kim et al. 2010, Wu et al. 2010).

References

- Adams, L. 1864. The Government propagating garden. *Detroit Advertiser and Tribune*, February 5, 1864, p. 4.
- Allen, G.E. 2000. The reception of Mendelism in the United States, 1900–1930. *Comptes Rendus de l'Académie des Sciences Paris, Sciences de la Vie/Life Sciences* 323:1081–1088.
- Ames, M.C. 1873. *Life and Scenes in the National Capitol*. A.D. Worthington & Co., Chicago, IL.
- Anonymous. 1904. Proceedings of the International Conference on Plant Breeding and Hybridization, New York, 1902. *Memoirs of the Horticultural Society of New York* 1:193.
- Avery, E.V.A. 1928. *The Arlington Experimental Farm: A Handbook of Information for Visitors*. Government Printing Office, Washington, DC.
- Bailey, L.H. 1917. *The Standard Cyclopedia of Horticulture*. The MacMillan Company, New York, NY, 3:1595.
- Bennett, J.B. 1908. Report of the Appointment Clerk. *Annual Reports of the Department of Agriculture for Year Ending June 30, 1907*, p. 751.
- Boerma, R., T.E. Carter, Jr., and H.J. Earl. 2007. Genotypic variation for three physiological traits affecting drought tolerance in soybean. *Crop Science* 47:25–35.
- Borthwick, H.A., and M.W. Parker. 1939. Photoperiodic responses of several varieties of soybean. *Botanical Gazette* 101:341–365.
- Borthwick, H.A., M.W. Parker, and P.H. Heinze. 1941. Influence of localized low temperature on Biloxi soybean during photoperiodic induction. *Botanical Gazette* 102:792–800.
- Boveri, T. 1902. Über Mehrpolige Mitosen als Mittel zur Analyse des Zellkerns. *Verhandlungen der physikalisch-medizinischen Gessellschaft zu Würzburg*. Neu Folge 35:67–90.
- Caemmerer, H.P. 1932. Washington, the National Capital. Senate Doc. 332, 71st Congress, 3rd Session, pp. 431–435.
- Capron, H. 1870. Report of the Commissioner of Agriculture, pp. 13–15, 156.
- Cole, A.B. 1947. *A Scientist With Perry in Japan, the Journal of Dr. James Morrow*. University of North Carolina Press, Chapel Hill, NC.
- Coville, F. 1910. Experiments in Blueberry Culture. *USDA Bureau of Plant Industry Bulletin* 193.
- Coville, F. 1911. Taming the wild blueberry. *National Geographic Magazine* 22:137–147.
- Coville, F. 1921. Directions for Blueberry Culture. *USDA Bureau of Plant Industry Bulletin* 974.
- Coville, F. 1937. Improving the Wild Blueberry. *Yearbook of Agriculture*, pp. 559–574.
- Crow, J.F. 2003. Genetics: Alive and well. *Journal of Heredity* 95:365–374.
- DeBow, J. 1857. Editorial, *DeBow's Review* 23:77–85.
- Dodge, J.R. 1868. Department Building and Grounds. *Report of the Commissioner of Agriculture*, pp. 190–193.
- Ebel, M.C. 1912. The Congressional free seed distribution. *Gardeners Chronicle of America* 16:473–474.
- Eck, P., and N.F. Childers. 1966. The blueberry industry. In P. Eck and N.F. Childers, eds., *Blueberry Culture*, pp. 3–13. Rutgers University Press, New Brunswick, NJ.
- Ellis, J. 1869. *The Sights and Secrets of the National Capitol*. U.S. Publishing Co., New York, NY, pp. 351–357.
- Fagan, M.E. 1895. Report of the Chief of the Seed Division. *Report of the Secretary of Agriculture for the Year 1895*, pp. 202, 208.
- Fairchild, D. 1938. *The World Was My Garden*. Charles Scribner & Sons, New York, NY.
- Fisher, R. 1924. On a distribution yielding the error functions of several well-known statistics. *Proceedings of the International Congress of Mathematics, Toronto, Canada* 2:805–813.
- Galloway, B.T. 1897. Division of vegetable physiology and pathology. *Yearbook of the U.S. Department of Agriculture*, p. 106.

- Garner, W., and H.A. Allard. 1920. Effect of length of day on plant growth. *Journal of Agricultural Research* 18:553–606.
- Garner, W., and H.A. Allard. 1930. Photoperiodic response of soybeans in relation to temperature and other environmental factors. *Journal of Agricultural Research* 41:719–735.
- Grant, D.M., R. Nelson, S.B. Cannon, and R.C. Shoemaker. 2010. SoyBase, the USDA-ARS soybean genetics and genomics database. *Nucleic Acids Research* 38:D843–D846.
- Hagenstein, E.C., S.M. Gregg, and B. Donahue. 2011. *American Georgics*. Yale University Press, New Haven, CT.
- Hancock, J.F., and G.J. Galletta. 1995. Dedication: Arlen D. Draper: Blueberry Wizard. *Plant Breeding Reviews* 13:1–10.
- Hancock, J.F. 2009. Highbush blueberry breeding. *Proceedings of the 10th Conference of the Latvian University of Agriculture*, pp. 35–38.
- Hardy, G. 1908. Mendelian proportions in a mixed population. *Science* 28:49–50.
- Harnden, E.S. 1895. Report of the Special Agent for the purchase of seeds. Report of the Secretary of Agriculture, p. 213.
- Holt, J. 1858. Report of the Commissioner of Patents, Agriculture Section.
- Hymowitz, T. 1984. Dorsett-Morse soybean collection trip to East Asia: 50-year retrospective. *Economic Botany* 38:378–388.
- Hymowitz, T. 1990. Soybeans: The success story. *In* J. Janick and J. Simon, eds., *Proceedings of the 1st National Symposium on Research, Development, and Economics*. Timber Press, Portland, OR.
- Johannsen, W. 1909. *Elemente der exakten Erblichkeitslehre*. Gustav Fischer, Jena, Germany.
- Judd, O. 1864. Editorial, *American Agriculturalist* 25:1–7.
- Kim, H., G.E. Bartley, A.M. Rimando, and W.H. Yokoyama. 2010. Hepatic gene expression related to lower plasma cholesterol in hamsters fed high-fat diets supplemented with blueberry pomace and extract. *Journal of Agricultural and Food Chemistry* 58:3984–3991.
- Kingsbury, N. 2009. *Hybrid*. University of Chicago Press, Chicago, IL, pp. 144–186.
- Kloppenborg, J.R. 1988. *First Seed: The Political Economy of Plant Biotechnology*. Cambridge University Press, New York, NY.
- Moore, J. 1994. The blueberry industry of North America. *HortTechnology* 4:96–102.
- Morgan, T. 1911. Random segregation versus coupling in Mendelian inheritance. *Science* 34:384.
- Morse, W.J. 1918. The soybean industry in the United States. *Yearbook of Agriculture*, pp. 101–111.
- Morse, W.J., and J.L. Cartter. 1937. Improvement in soybean. *Yearbook of Agriculture*, pp. 1154–1189.
- Parry, C.C. 1870. Report of the Botanist. Report of the Commissioner of Agriculture, pp. 108–113.
- Paul, D.B., and B.A. Kimmelman. 1988. Mendel in America: Theory and practice. *In* K.R. Benson and J. Maienschein, eds., *American Development of Biology*, pp. 281–310. Rutgers University Press, New Brunswick, NJ.
- Pearson, K. 1900. On the criterion that a given system of deviations from the probable in the case of a correlated system of variables is such that it can be reasonably supposed to have arisen from random sampling. *Philosophical Magazine Series 5*, 50:157–175.
- Powell, F.W. 1927. *The Bureau of Plant Industry—Its History, Activities, and Organization*. John Hopkins Press, Baltimore, MD.
- Probst, A.H. 1970. Fifty years of soybean variety improvement. *Soybean Digest*, pp. 66–70.
- Rathbun, R. 1917. The Columbian Institute for the Promotion of Arts and Sciences. *Bulletin of the United States National Museum* 101:4–5, 10–14, 48.
- Roistacher, C.N. 2000. A history of the Washington Navel Orange Tree. *Proceedings of the Global Citrus Germplasm Network*, December 2000. Appendix 6.
- Ross, E.D. 1929. Lincoln and Agriculture. *Agricultural History* 3:60.
- Ryerson, K.A. 1933. History and significance of the foreign plant introduction work of the United States Department of Agriculture. *Agricultural History* 7:110–128.

- Saunders, W. 1876. Report of Superintendent of the Gardens. Report of the Commissioner of Agriculture, pp. 62–63.
- Schmutz, J., S.B. Cannon, J. Schlueter, et al. 2010. Genome sequence of the paleopolyploid soybean (*Glycine max* (L.) Merr.). *Nature* 463:178–183.
- Shamel, A. 1905. The effect of inbreeding in plants. *Yearbook of the U.S. Department of Agriculture*, pp. 377–392.
- Smith, E.F. 1907. Plant breeding in the United States Department of Agriculture. Report of the 3rd International Conference 1906 on Genetics. Royal Horticultural Society, pp. 301–309.
- Spillman, W. 1911. Application of some of the principles of heredity to plant breeding. *USDA Bureau of Plant Industry Bulletin* 165.
- Stokes, J.W. 1867. Report of the Commissioner of Agriculture, pp. 15–19.
- Sutton, W. 1902. On the morphology of the chromosome group in *Brachystola magna*. *Biological Bulletin* 4:24–39.
- Swingle, W.T., and H.J. Webber. 1898. Hybrids and their utilization in plant breeding. *Yearbook of the U.S. Department of Agriculture*, pp. 383–420.
- True, A.C. 1937. A history of agriculture experimentation and research in the United States. *USDA Miscellaneous Publication* 251:42–43.
- Webber, H.J. 1897. Influence of environment in the origination of plant varieties. *Yearbook of the U.S. Department of Agriculture*, pp. 89–106.
- Webber, H.J. 1898. Improvement of plants by selection. *Yearbook of the U.S. Department of Agriculture*, pp. 355–376.
- Weber, G.A. 1924. The Patent Office: Its history, activities, and organization. Johns Hopkins Press, Baltimore, MD.
- Weinberg, W. 1908. Über den Nachweis der Vererbung beim Menschen. *Jahreshefte des Vereins für Vaterländische Naturkunde in Württemberg* 64:369–382.
- White, E. 2011. Blueberry Centennial 2011–2016. Whitesbog Preservation Trust Newsletter for the 1st Quarter.
- Wilks, W. 1900. Report of the International Conference on Hybridization, London, 1899. *Journal of Royal Horticultural Society* 24:106–117.
- Willets, E. 1890. Report of the Secretary of Agriculture, p. 59–73.
- Wilson, J. 1902. Report of the Secretary of Agriculture, p. 20.
- Wilson, J. 1905. Proceedings of the First Meeting. *American Breeders Association* 1:15.
- Wilson, J. 1908. Report of the Secretary of Agriculture, p. 52.
- Wilson, J. 1910. The new magazine has a place. *American Breeders Magazine* 1:3–5.
- Woodward, T., and R. Graves. 1933. Some Results of Inbreeding Grade Guernsey and Grade Holstein-Friesian Cattle. *USDA Technical Bulletin* 339.
- Wright, S. 1921a. Systems of mating. I. The biometric relation between parent and offspring. *Genetics* 6:111–123.
- Wright, S. 1921b. Systems of mating. II. The effects of inbreeding on the genetic composition of a population. *Genetics* 6:124–143.
- Wright, S. 1921c. Systems of mating. III. Assortative mating based on somatic resemblance. *Genetics* 6:144–161.
- Wright, S. 1921d. Systems of mating. IV. The effects of selection. *Genetics* 6:162–166.
- Wright, S. 1921e. Systems of mating. V. General considerations. *Genetics* 6:167–178.
- Wright, S. 1922a. The effects of inbreeding and crossbreeding on guinea pigs. I. Decline in vigor. *USDA Bulletin* 1090:1–36.
- Wright, S. 1922b. The effects of inbreeding and crossbreeding on guinea pigs. II. Differentiation among inbred families. *USDA Bulletin* 1090:37–63.
- Wright, S. 1922c. The effects of inbreeding and crossbreeding on guinea pigs. III. Crosses between highly inbred families. *USDA Bulletin* 1121:1–60.
- Wu, X., J. Kang, C. Xie, et al. 2010. Dietary blueberries attenuate atherosclerosis in apolipoprotein E-deficient mice by upregulating antioxidant enzyme expression. *Journal of Nutrition* 140:1628–1632.