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American Fruit Explorers:

Frank Nicholas Meyer: An Emigrant's Lifelong Search for Plant Immigrants

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Abstract

Rarely sedentary, Frank N. Meyer (1875-1918) labored and studied plants diligently in Europe to earn passage to the United States. After holding several jobs briefly in the U.S. to fund his botanical explorations, Meyer was hired by the Foreign Plant Introduction Section of the U.S. Department of Agriculture (USDA). During his four expeditions to Asia (1905 to 1918), Meyer collected more than 2,500 plant specimens and exchanged germplasm with botanical gardens worldwide. Traveling thousands of miles by foot, Meyer endured harsh weather, scarce food, vermin-infested lodgings, sickness, bandits, revolutionaries, and multiple bureaucracies, but he was content when collecting economically useful plants. During these expeditions, Meyer collected specimens adapted to extreme temperatures, drought, and alkaline soils for testing in the U.S., introducing about 115 fruit- and nut-bearing species. Cultural practices, rootstocks, post-harvest methods for fruit crops, and translated Chinese plant names were recorded in his field notes, herbarium specimens, 1,740 photographs, and letters. Meyer also perfected packing methods for live plant specimens to ensure their survival during shipment. Many of the genetically-useful traits in pomological crops today originated from germplasm introduced to the U.S. by this dauntless plant collector.

Frank N. Meyer was an intrepid plant collector, traveling primarily in Europe and Asia, under perilous conditions. Always in search of an economically useful plant, Meyer recognized many attributes of fruit- and nut-bearing species that had potential in U.S. breeding programs as scion cultivars or rootstock. Establishing a network of priests, missionaries, government officials, and other plant collectors to assist him, Meyer often collected in remote locations and shipped over 2,500 plant specimens to the U.S. during four expeditions (Cunningham, 1984a). Many herbarium specimens, ornamentals, and 1,344 photographs were sent to the Arnold Arboretum in Boston, but most plants were sent to the USDA for distribution to the plant introduction garden at Chico, California, and to Experiment Stations in California, Arizona, Texas, Louisiana, and Florida and commercial entities (Table 1). Although Meyer was an assiduous plant collector and a prolific letter writer during his expeditions, he published few scientific articles during his lifetime (Meyer, 1911a,1911b,1915,1916).

Early years and education. Frans Nicolas Meijer was born on 29 Nov.1875 in Houthaven, The Netherlands. As a youngster, he was a good student who loved nature, enjoyed long walks, and read stories about traveling. While at home, he tended the family garden. After completing the sixth grade, Meijer worked briefly for an instrument maker, but was unhappy confined inside the shop all day. At age fourteen, he began working as a gardener's assistant at the Amsterdam Botanical Garden, where he was mentored by Hugo de Vries, distinguished botanist and faculty member at the University of Amsterdam. Under de Vries' tutelage, Meijer studied French, English, botany, plant propagation, math, physics, and drawing. In his spare

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Table 1. Fruit- and nut-bearing species and their hybrids collected by Frank N. Meyer from 1905 to1918.

Plant name[z]	Plant name
Actinidia chinensis Planch.	*Juglans regia* L. [*J. regia sinensis*]
Actinidia kolomikta (Rupr. & Maxim.)	*Litchi chinensis* Sonn. [*Nephelium litchi*]
Carya cathayensis Sarg.	*Malus baccata* (L.) Borkh.
Castanea crenata Siebold & Zucc.	*Malus dasyphylla* Borkh. [*M. pumila* var. *paradisiaca*]
Castanea mollissima Blume	
Castanea sativa Mill.	*Malus halliana* Koehne
Castanea seguinii Dode	*Malus* × *prunifolia* (Willd.) Borkh. [*M. prunifolia*]
Castanopsis tibetana Hance	*Malus* × *spectabilis* (Sol.) Borkh. [*M. spectabilis*]
Chaenomeles cathayensis (Hemsl.) C.K. Schneid. [*Pyrus cathayensis, C. lagenaria cathayensis, Cydonia caythayensis*]	*Malus sylvestris* (L.) Mill. [*M. malus*]
	Morus alba L. [*M. alba* var. *bungeana, M.alba* var. *latifolia, M. alba pendula*]
Chaenomeles sinensis (Dum.Cours.) Koehne [*Pyrus sinensis*]	*Morus nigra* L.
	Myrica nagi Thunb.
Citrus × *aurantium* L.	*Myrica rubra* (Lour.) Siebold & Zucc.
Citrus cavaleriei H.Lév. ex Cavalerie [*C. ichangensis*]	*Olea europaea* L.
	Phoenix dactylifera L.
Citrus limon (L.) Osbeck [*C. limonum*]	*Pistacia chinensis Bunge* [*P. vera*]
C. limon × *C. reticulata* [*C.* × *meyeri*]	*Prinsepia uniflora* Batalin
Citrus medica L.	*Prunus hybrid* (plumcot)[y]
Citrus maxima (Burm.) Merr. [*C. decumana, C. grandis*]	*Prunus armeniaca* L.
	Prunus avium (L.) L.
Citrus nobilus Lour.	*Prunus brachypoda* Batalin
Citrus reticulata Blanco [*C. nobilis deliciosa*]	*Prunus cerasus* L.
Corylus avellana L.	*Prunus davidiana* (CarriŠre) Franch. [*Amygdalus davidiana*]
Corylus chinensis Franch.	
Corylus cornuta Marshall [*C. rostrata*]	*Prunus domestica* L.
Corylus ferox Wall. [*C. tibetica*]	*Prunus dulcis* (Mill.) D.A. Webb [*Amygdalus communis*]
Corylus maxima Mill.	
Corylus sieboldiana Blume [*C. mandshurica*]	*Prunus fenzliana* Fritsch [*Amygdalus fenzliana*]
Crataegus meyeri Pojark.	*Prunus fruticosa* Pall.
Crataegus orientalis Pall. Ex M.Bieb.	*Prunus glandulosa* Thunb. [*Prunus humilis*]
Crataegus pinnatifida Bunge	*Prunus lycioides* (Spach) C.K. Schneid.
Crataegus sanguinea Pall.	*Prunus* × *meyeri* Rehder[x]
Crataegus cuneata Siebold & Zucc.	*Prunus microcarpa* C.A. Mey.
Cydonia oblonga Mill.	*Prunus mume* (Siebold) Siebold & Zucc.
Diospyros kaki L.f. [*D. sinensis*]	*Prunus padus* L. .
Diospyros lotus L.	*Prunus persica* (L.) Batsch [*Amygdalus persica*, *A. persica platycarpa*[w]]
Ducnhsnea indica (Jacks.) Focke	
Ficus carica L.	*Prunus persica potaninii* Batalin [*Amygdalus davidiana*]
Ficus repens Roxb. Ex Sm.	
Fragaria sp.	*Prunus prostrata* Labill.
Juglans cathayensis Dode	*Prunus pseudocerasus* Lindl. [*P. pseudo-cerasus*]
Juglans mandshurica Maxim.	*Prunus salicina* Lindl.

Prunus setulosa Batalin
Prunus simonii (Decne.) CarriŠre
Prunus subhirtella Miq.
Prunus spinosa L. [*P. spinosa* × *P. domestica*]
Prunus tangutica (Batal.) Koehne [*Amygdalus tangutica*]
Prunus tenella Batcsch [*Amygdalus nana* × *davidiana*]
Prunus tomentosa Thunb.
Prunus triloba Lindl.
Punica granatum L.
Pyrus betulifolia Bunge
Pyrus bretschneideri Rehder
Pyrus calleryana Decne.
Pyrus communis L.
Pyrus lindleyi Rehder
Pyrus nivalis [*P. nivalis elaeagrifolia*]
Pyrus pyrifolia (Burm.f.) Nakai [*P. pyrifolia* var. *culta*]
Pyrus salicifolia Pall.
Pyrus serrulata Rehder
Pyrus ussuriensis Maxim. Ex Rupr.
Ribes alpestre Wall. Ex Decne. [*R. alpestre giganteum*]
Ribes alpinum L.
Ribes aureum Pursh
Ribes burejense F. Schmidt [*R. macrocalyx*]
Ribes dikuscha Fusch. Ex Turcz. (unresolved name)
Ribes meyeri Maxim.
Ribes nigrum L.
Ribes petraeum Wulfen
Ribes procumbens Pall.
Ribes rubrum L.
Rubus parviflorus Nutt. [*R. articus*]
Rubus rosifolius Sm. [*Rubus rosaefolius*]
Sambucus racemosa L.
Schisandra chinensis (Turcz.) Baill., [*Shizandra chinenisis, S. sphenanthera*]
Sorbus domestica L.
Vitis amurensis Rupr.
Vitis davidii (Rom Caill.) Foëx [*V. armata*]
Vitis vinifera L.
Ziziphus jujuba Mill. [*Z. sativa*]
Ziziphus jujuba var. *spinosa* (Bunge) Hu ex H.F. Chow [*Ziziyphus sativa* var. *spinosa*]

[z] Currently accepted name (Anonymous, 2013). Name in bracket is the synonym listed on Meyer's photographs, botanical specimens, or USDA Plant Introduction lists (USDA, 1907-1922).
[y] Plumcot likely *Prunus salicin*a Lindl. or *P. cerasifera* Ehrh. x *P. armeniaca* L.
[x] An unresolved name, may be *P. maackii* Rupr.× *P. maximowiczii* Rupr.
[w] *Amygdalus persica platycarpa* used by Meyer for peento or saucer peach.

time, Meijer often collected and prepared plants for herbarium specimens, walking 80 km and sleeping outdoors. At nineteen, he spent ten months with the Grenadiers at The Hague, fulfilling his compulsory military service. During this time, de Vries arranged for Meijer to study with another botanist, Professor Fiet, at the University of Groningen. After successfully completing an exam, he was released from military service, and returned to work with de Vries. At age 23, Meijer left his position in Amsterdam, briefly working at F. Willem van Eeden's Walden commune in northern Holland as a gardener (Cunningham, 1984b; Poldervaart, 1995). In less than a year, Meijer was discontent and left the commune to satisfy his longing to travel. For several months, he explored Belgium, Germany, France, Switzerland and Italy on foot to see orange groves, vineyards, and other vegetation, which further fueled his desire to travel abroad and study plants in America. However, to earn passage to the U.S., he spent over a year working in London, growing edible crops in greenhouses and espaliering fruit trees until boarding the *S.S. Philadelphia* on 12 Oct. 1901.

Like other émigrés, Meijer changed his name to Frank Meyer after arriving in America. With letters of introduction from de Vries and van Eeden, Dr. Erwin F. Smith helped Meyer secure a position at the USDA greenhouses in Washington, D.C. However, by September 1902, Meyer yearned to see more,

traveling to California where he learned new plants while working at a USDA plant improvement garden. In April 1903, Meyer resigned from the USDA, worked briefly at Armstrong nursery, before leaving to explore Mexico where he sent apricot, ornamental cherry, and other seeds for trial at the Chico Plant Introduction Garden (Graham, 2017). Next, he traveled to Cuba and then back to New Orleans when he needed to replenish his savings. Before long, he found work as a propagator at the Missouri Botanical Garden is St. Louis, where he also enjoyed the World's Fair and was a member of the Forestry Jury. In July 1905, David G. Fairchild at the USDA Office of Seed and Plant Introduction hired Meyer ($1000 annual salary plus expenses) to explore China (Hodge and Erlanson, 1956; Hyland, 1977). For ten days, Meyer trained at the New York Botanical Garden, Henry L. Hicks Nursery, and Arnold Arboretum. At the Arboretum, he met the director, Charles S. Sargent, who would later influence Meyer's plant collections.

First expedition for USDA 1905 to 1908. Tasked with collecting economically useful plants, Meyer steamed across the Pacific Ocean and visited experiment stations in Hawaii before traveling to Japan. There he purchased sphagnum moss, which was unavailable in China. Hiring a guide, cart driver, and a coolie, Meyer left Peking (Beijing) to begin his exploration for useful plants and ornamentals when encountered as per USDA policy. Traveling in China was dangerous, with much distrust of Caucasians following the Boxer Rebellion but Meyer soon became wary of this danger and accustomed to conditions in remote locations, including filthy inns with brick beds. After the first few months of travel, he learned to avoid building a fire for warmth inside his infested lodging as the smoke increased bed bug and lice activity. Enduring dust storms and bitter cold, Meyer often walked 32 to 40 km daily, collecting plants in all seasons in isolated areas, unlike other collectors in China. Traveling by foot on narrow paths with supplies loaded in a cart was laborious and dangerous. Since there was no universal currency with which to purchase plant material, he carried Mexican, Chinese, Russian, and Hong Kong currency in brass, copper, silver (and later Manchurian and Korean war notes issued by Japan), putting him at risk for robbery.

Despite adversity, Meyer's first major discovery was *Diospyros kaki* (persimmon), some of which were 10 cm-diameter and sweeter, firmer, and more marketable than the native American species (*D. virginiana* L) (Wilson, 1909). He also found that *D. lotus* was useful as a rootstock and noted that sugar, liquor, and vinegar were made from persimmon (Meyer, 1916). He also photographed interesting cultural practices, including freestanding "dwarf" apple trees with their branches bent multiple times for size control (Fig. 1). During the 1905-1906 winter, Meyer collected a table grape, "paper-shell walnut" (*Juglans regia*), "Chinese pistache" (*Pistacia chinensis*), the famed "Peking pear" (*Pyrus pyrifolia*), early flowering Tangsi cherry (*Prunus pseudocerasus*), as well as *Prunus davidiana* for potential use as a rootstock for stone fruit trees. Sending live plant specimens was laborious during expeditions due to lack of efficient postal systems. After each collection, Meyer meticulously placed recalcitrant seeds in moistened ground charcoal or chopped sphagnum moss enclosed in oiled paper within wooden boxes to protect any that germinated during prolonged shipment to the U.S. Meyer also stored cuttings in damp moss within his own hand-stitched burlap bags until they could be shipped through diplomatic channels, consular pouches, and remote post offices.

In May 1906, Meyer set off for Manchuria, which was politically unstable during Japanese and Russian occupation and where strangers or whole towns were robbed. Undaunted, Meyer ("a foreign beast") journeyed through dust storms and was bitten by "not less than six kinds of vermin" in inns. In the mountains, he enjoyed the beautiful scenery and collected apricot, a "red blackberry"

Fig. 1. An orchard of free-standing apple trees with branches bent to devigorate for size control. (Photo courtesy of Arnold Arboretum Horticultural Library of Harvard University. ©President and Fellows of Harvard College. Arnold Arboretum Archives.)

(*Rubus* sp.), an ornamental cherry (*Prunus* × *meyeri*), and many other agronomic and landscape plants. For two weeks, he ate little else but boiled oats because canned food was too heavy to carry.

In the three months it took Meyer to reach Vladivostok, Russia, he had worn out several suits and three pairs of boots (Cunningham, 1984b). After restocking, Meyer resolutely collected nuts, pears, plums and more plants in Siberia during the many blizzards of winter 1906-1907. On his 31st birthday, Meyer wrote to Fairchild, "…the whole world is mine. I am too young to settle. First I will skim the earth in search of things good for man. Asia is so big that one can explore for a whole lifetime and not visit it all." One night, Meyer was assaulted by three men, but he escaped by stabbing one of them in the stomach with a bowie knife. Undeterred by this attack, Meyer collected five types of pears, a cold-hardy peach, and many seeds for potential use in North Dakota, often starting at 4:00 AM at temperatures below -31 °C, wearing two pairs of pants, an undercoat and overcoat, sheepskin socks, a bearskin hat, a scarf, earmuffs, and a sheepskin nose covering.

Returning to Shanghai, Meyer was gravely disappointed when Fairchild assigned him to collect seeds for Arnold Arboretum during spring 1907 in the bleak Wutai Shan region in northeastern Shanxi, while E.H. Wilson was to collect plants from the upper Yangtze River region. This change of plans required the USDA to extend Meyer's employment, allowing Meyer to bargain for a higher salary as he had received several more lucrative job offers. During this new assignment, Meyer sent parcels of ornamentals and agronomic seed in spite of fierce blizzards along the way (Fig. 2). Upon his return to Beijing, Meyer received a missive from Fairchild with a new task of identifying and sampling insects and their predators in spite of Meyer's lack of entomological training. That summer, Meyer became ill, but managed to send the USDA insect specimens and 14 kg of *Prunus davidiana* seed from Shanghai. Adding to his frustrating illness, Meyer received word that his baggage expenses were deemed excessive (more than the allowable 50 cents) by the USDA auditor, but fortunately Fairchild

Fig. 2. Frank N. Meyer after a collecting trip in the frigid Wutai Shan region in northeastern Shanxi Province. (Photo courtesy of Arnold Arboretum Horticultural Library of Harvard University. ©President and Fellows of Harvard College. Arnold Arboretum Archives.)

advanced Meyer funds to cover this cost. Traveling to Yidu (Hubei Province), Meyer found a rare, flat sweet jujube, as well as the "Shantung plumcot". From there he journeyed to Feicheng (Shandong Province) in search of the famous pound or "Fei" peach (*Prunus persica*), a highly-prized, large white-fleshed clingstone fruit. Because of the imperial order for 800,000 of these high-quality peaches, Meyer only managed to ship scion wood to the U.S. during the winter. Traveling from Feicheng, he saw orchards of hawthorn (*Crataegus pinnatifida*) with fruit selected for use as preserves or boiled into a sauce, which American missionaries used as an "agreeable" substitute for cranberry (Meyer, 1915). Continuing to Boshan, Meyer found grapes, (one cluster weighing 2.3 kg), a yellow-fruited hawthorn, and some ornamentals. Near Laoling, Meyer discovered the famed seedless or "honey" jujube, which were sun-dried and boiled three times before final drying. He wrote that jujubes were also smoked or processed with sugar and honey and considered a delicacy by the upper class. Another important species Meyer collected near Laoling was the Ussurian pear, *Pyrus ussuriensis*, which he thought would be useful as a pear rootstock in arid parts of the U.S. with alkaline soil.

From Beijing, Meyer sent numerous parcels of rare fungi, insects, pears, chestnuts, seedless persimmons, etc. to the U.S. With only six months left in this expedition, Meyer was eager to explore many more locations, in spite of Sargent's criticism that he covered too much area. In snow-covered mountains, he collected scion wood of persimmons, apricots, and yellow plums, before returning to the Wutaishan region for six days to collect rhubarb, a rare barley, and several ornamental species. On 4 Mar. 1908, Meyer reached the famed Tonchangdi pear district (in Jiangxi Province) where astonished locals climbed to rooftops to peer at the first Caucasian to visit the area and collect pear scions. As he continued the journey, he found a dwarf lemon tree (introduced as *Citrus* × *meyeri*, currently *C. limon* × *C. reticulata*) used as a common houseplant. After later testing in the U.S., 'Meyer' lemon was grown commercially and is used today as a backyard tree.

At Shanghai, Meyer packed his 20 t collection, including five ornamental lemons, ten white-fruited loquats, four dwarf plums, dwarf quinces, and many other rare plants. Along with his plant material, Meyer was also entrusted with the care of two rare monkeys (for the National Zoological Park) during the four week voyage to San Francisco.

After his U.S. arrival on 12 June, 1908, Meyer spent a year preparing for his next expedition, sorting his index cards, and completing the bulletin, *Agricultural Exploration in the Fruit and Nut Orchards of China* (Meyer, 1911a). In this publication, he provided descriptions and illustrations of edible fruit and nut crops (Table 1), their cultural practices, culinary and medicinal uses, and

climatic conditions for which each species was adapted. Among the stone fruit, Meyer classified three types of peaches (cling, honey, and peento). Other novel fruits, such as the flat Sa kua and Ly tze apples (*Malus* × *prunifolia*) from northern China were described. Lesser known species, such as Chinese nagi (*Myrica nagi*) was suggested as an orchard crop for its multi-purpose fruit, as well as *Canarium*, due to its use as a sweet or salted delicacy. Meyer viewed *Rubus*, *Ribes*, *Vaccinium*, *Schizandra*, and even *Viburnum opulus* L. as under-utilized small fruits in the regions he had explored. Meyer reported many types of citrus that were cultivated as orchard trees in southern China (Table 1). However, lemon was grown exclusively as an indoor plant. Buddha's hand lemon (*Citrus medica*) was especially valued as a gift for good luck and as a religious offering. Among the nut crops Meyer had seen during his expedition, he envisioned using *Corylus heterophylla* or *C. mandshurica* (currently *C. sieboldiana*) to improve drought tolerance of filbert grown in the U.S. Although Meyer described Chinese chestnut (*Castanea mollissima*), he was not yet aware of its disease resistance. Meyer also recognized a shrub-like *Castanea* species, *C. seguinii*. Attributes of edible seeds from apricot, *Pinus koraiensis*, *Gingko biloba*, and *Castanopsis tibetana* were also reported.

During his time in the U.S., Meyer also surveyed some of his 479 accessions growing in plant introduction gardens and experiment stations, assessed needs for future collections, and analyzed reasons for plant loss (1,397 of the 1,644 shipped plants survived). Additionally, Meyer met with Theodore Roosevelt to discuss the severe deforestation he had documented in China and later, the President used Meyer's photographs in a Congressional address to emphasize the need for forest conservation (Lewis, 2005). It was also during this time that Meyer applied for U.S. citizenship.

Second expedition for USDA 1909 to 1912. Eager to escape the confines of his office, Meyer sailed for Europe to visit with colleagues and study specimens in nurseries and botanical gardens before exploring plants in Central Asia. Arriving in Saint Petersburg, Meyer was stymied by Russian bureaucracy for eight weeks before he received permission to travel to Russian Turkestan with an assistant, interpreter, a revolver, and his camera in January 1910. Once again, Meyer faced bitter cold (-29 °C) and long nights. He managed to send olive cuttings collected in Yalta, before exploring the Caucus region for four months where he collected a dwarf Paradise apple (currently *Malus dasyphylla*), cherries, grapes, plums, apricots, filberts, and almonds. While in Russian Turkestan, Meyer wrote to Fairchild, "Robbers on the road murdered some people these last two nights, but a botanical collector is generally exempted from these annoyances" (Cunningham, 1984b). Despite frequent police harassment, thugs, and drunken guides and interpreters, Meyer collected dried citrus specimens for W.T. Swingle, apricots, fungi, scales, galls, as well as shells, beetles, and a mouse for the Smithsonian in Russian Turkestan (Peattie, 1944).

Due to a missing USDA warrant for expenses, Meyer had to use personal funds to finance his travel to Chinese Turkestan in October 1910. From this region, he sent five types of almonds to W.A. Taylor, plums for U.P. Hedrick, followed by grapes, peaches nectarines, pomegranates, apricots, etc. After collecting in the bitterly cold mountains in December, Meyer suffered from exposure and malnutrition. From Kashgar (Xinjiang Province), Meyer packed 544 kg of seeds he had collected in cans cleaned with ashes and lined them with felt. Then he stitched additional felt coverings over the containers before they were sealed and approved for shipping to the U.S. Next, Meyer crossed the treacherous Mussart Glacier, loaded with more than 500 kg of baggage, including firewood (Fig. 3). By the end of March 1911, he had collected currants, hardy apples, apricots, diseased twigs, fungi, soil samples, and more for shipment. After walking over 1600

Fig. 3. Meyer (foreground) with his two workers, three mules, a horse and cart loaded with supplies his collecting trip in Chinese Turkestan in 1911. (Photo courtesy of Arnold Arboretum Horticultural Library of Harvard University. ©President and Fellows of Harvard College. Arnold Arboretum Archives.)

km, collecting plant material in Altai Mountains, Meyer's travel plans were abruptly altered when he received a telegram from the U.S. Secretary of Agriculture to collect 227 kg of red clover and alfalfa seed. After accomplishing this task, Meyer intended to go to Shanxi Province, but political unrest (i.e., Chinese or Xinhai Revolution) made travel unsafe and Fairchild mandated his return to Washington by mid-February. Thus, Meyer ventured to Rostov, Russia, where he suffered from "typhus malaria", pausing only a week before collecting apricots, dates, walnuts, hazelnuts, and elms in November 1911. Still ill, Meyer continued collecting, reaching Saint Petersburg where his recurring malarial fever was aggravated by exposure and exhaustion. Leaving Russia, Meyer was still unwell but continued his work in Europe through April 1912, and finally steamed across the Atlantic on the *Mauretania* to New York.

Within weeks of his return to Washington, Meyer submitted plans for his next expedition and spent much of his time studying plant collections in the U.S. Also, Meyer saw the published version of Chinese Plant Names that included English, Latin, and Chinese nomenclature for plants he had collected from his first expedition to China (Meyer, 1911b). After six months, he received an appropriation and set off for his next expedition on 2 Nov.1912 with newly printed business cards in hand (Fig. 4).

Third expedition for USDA 1912 to 1915. Meyer's goal for this expedition was to explore the mountains of Kansu (Gansu Province). Traveling eastward through Siberia, collecting little but purchasing hardy types of crabapples, bird cherries (*Prunus prostrata*), currants, gooseberries, and dwarf almonds. Arriving in Harbin, China, he was bed-ridden for three weeks due to malarial fever. Finally, he arrived in Beijing on 14 Mar. 1913 and continued collecting seedless jujube and walnuts (*Juglans cathayensis* and *J. regia*) even though his reference books and supplies had not arrived. In May, his recurring illness returned, but Meyer sent bush cherry, peach, and jujube. He then received a new missive from Fairchild, tasking him to determine if the chestnut blight fungus (*Cryphonectria parasitica*), which was killing American chestnut trees, was of foreign origin. Within a month, Meyer found the blight and discovered that it infected Chinese chestnut trees to varying degrees, but did not kill them (Fig. 5). Tucked inside the letter was a 5 cm^2 piece of infected bark, confirming the introduction

Fig. 4. Meyer's business cards with his name in large characters and the the smaller ones stating, "Agricultural Explorer of the United States of America".

of this disease from Asia. After this, Meyer collected and shipped large quantities of walnuts, chestnut, peach, dwarf cherry (*Prunus humilus*), jujube, persimmon, pears, grapes, crabapples, and bush cherry (*Prunus tomentosa*) and more than 500 herbarium specimens. In mid-December 1912, Meyer left the relative comfort and safety of Beijing for the interior of China where notorious thugs terrorized travelers and wretched conditions prevailed. From Xi'an (Shaanxi Province), he collected nine types of persimmon, apricot, and four jujube specimens. Due to an injury sustained by his interpreter, Meyer postponed his plan to explore Kansu Province. Instead, he continued collecting persimmon and the Li jujube, which was "as large as hen's eggs." Next he wanted to obtain budded Fei peach trees. Refusing to pay over $40 per tree, Meyer purchased a plot of land containing eight trees and expeditiously removed them before unconsulted relatives of the landowner could find him. Meyer shipped the Fei peach trees, budded quinces, and large-fruited haws but unfortunately, these trees were detained in Japan for fumigation and did not survive. Undeterred by this loss, Meyer mailed 63 packages of chestnuts, haw fruits, Fei peach seed, a large "saucer" peach, and many jujubes to America on May 13, another ten parcels of pears, quince, and persimmon later in May, followed by 15 cases of *Prunus tomentosa* and eight boxes of jujube and other specimens.

By mid-June, the long-awaited journey to Kansu began. Along the way, Meyer's group saw a human head in a wooden cage suspended in an apricot tree, but more importantly, a few days later, Meyer discovered and collected 700 seeds of the "real wild Potaninii peach" (*Prunus persica potaninii*). Slogging through rain and mud, Meyer made it to Kansu where he found 155 cm-diameter pistachio trees. Fearing that they would meet certain death from roaming gangs near the Tibetan border, Meyer's four muleteers abandoned him and a heated dispute regarding the interpreter and coolie's terms of employment

Fig. 5. Meyer posing in a mature *Castanea mollissima* tree riddled with mistletoe and galls, but free of chestnut blight. (Photo courtesy of Arnold Arboretum Horticultural Library of Harvard University. ©President and Fellows of Harvard College. Arnold Arboretum Archives.)

ensued, leaving Meyer short-handed. Nevertheless, Meyer and his assistant, Johannis de Leuw collected more wild peach and late-flowering bush almond (*Prunus tangutica*) seeds, as well as peach, pear, apricot, plum, cherry, crabapple, and hazelnut (*Corylus ferox*) scions in the mountains of Kansu in November 1914. After walking over 1600 km, they finally reached Lanchow (Lanzhou) on 7 Dec. 1914 where Meyer found 120 letters, his first mail since late August. Once again Meyer was informed that his fifty cent expenditure for the advertisement for an interpreter was disallowed by the USDA auditor. He also found large government checks for $4,000 and $6,000, but had nowhere to cash them, so he had to use his own resources to fund the rest of the expedition. Unable to hire a trusted interpreter, Meyer was forced to alter his planned route and traveled along the Gansu-Shaanxi border collecting herbarium specimens in the bitter cold. In this area, Meyer and de Leuw were searched by soldiers who suspected them of smuggling opium in their loaded carts, with a fight ensuing. Although they were allowed to leave, Meyer and de Leuw were soon tracked down by more soldiers and forced against a wall for execution. Eventually, the travelers managed to extricate themselves from their predicament, and after Meyer's trunk was searched, they were released. After this, Meyer and de Leuw still had a great distance to travel before reaching a train station. In one day, they plodded 64 km through sleet and snow-covered mountains to reach their destination. In Beijing, Meyer mailed 34 parcels of photographs, inventory notes, plants, and insects. D.C. Peattie (1944) captured the essence of this expedition stating, "stout-hearted Meyer was insulted, assaulted, denied entrance, denied exit, and arrested more times, probably, than any other man in the service" (Cunningham, 1984b).

During World War 1, Meyer mourned the loss of friends and contacts from Japanese bombing raids in China, but continued the expedition, acquiring litchi seeds. In the sultry, sweltering heat near Changhua (Zhejiang Province), he found Chinese hickory (*Carya cathayensis*) groves. Sargent (1915) wrote that this discovery was "by far the most interesting thing you have accomplished in China". After mailing samples of hickory, white-barked persimmon (*Diospyros kaki,* synonym *D. sinensis*), and other specimens, Meyer left for Japan and the journey to Seattle. Upon his return, Meyer inspected his plant material growing throughout the U.S., presented lectures, and wrote, "China a Fruitful Field for Plant Exploration" (Meyer, 1915). After only a few months, he was planning his next expedition, aiming to collect pear species for potential use as fire blight-resistant rootstocks.

Fourth expedition for USDA 1916 to 1918. Meyer's original plans to visit family and colleagues in Europe were not possible due to fighting in Europe, but he still hoped to travel to Japan, Korea, Manchuria and then collect in northern and southern China before returning home in 1919. Leaving Washington D.C., Meyer traveled to Minneapolis, where he became ill for a week. As was customary, he was not paid for his time or other expenses when "unable to attend to official duties." However, Meyer persevered and left the U.S. with over 400 kg of baggage for Japan, eventually arriving in Beijing in November 1916 amidst continued political conflict. In subsequent months, Meyer collected seeds of *Pyrus ussuriensis*, *Juglans mandshurica*, *Prunus davidiana* (200,000), and dried jujubes. By January 1917, he sent F.C. Reimer in Oregon six boxes of pear roots, as well as many bundles of specimens to others. Determined to introduce the "pound peach", he returned to Feicheng to cut scion wood since the USDA had been unsuccessful in establishing these trees. Next, he headed to Ichang (Yichang) to collect *Pyrus calleryan*a. When Meyer received news of the U.S. entering WW I, he was so distressed that he was overcome by "nervous prostration". Burdened by thoughts of the war, loneliness, overwork, and vermin-infested accommodations, Mey-

er considered resigning from his duties. Additionally, the American gold dollar devalued by 65% during this time, furthering Meyer's difficulties. However, by early May, Meyer rallied and continued collecting large quantities of pears, but often had to wait for the fruit to ripen. In October, he hired local help to remove seeds from marble-sized pear fruit. Because purchased *Pyrus betulaefolia* fruit was mixed with that of *P. calleryana*, Meyer had to oversee the sorting of unwanted seed. After much effort and a bout of dysentery, Meyer had only 9 kg of useable seed.

On 26 Oct. 1917, F.C. Reimer arrived to assist Meyer in the collection of pear seeds for ten weeks, but Reimer's leg became infected, necessitating his departure from China. Thereafter, Meyer found 12 Ichang lemons (*Citrus cavaleriei* formerly *C. ichangensis*) and the prized smooth "Yang tao" Chinese gooseberry (*Actinidia chinensis*). Shortly after Meyer reached Ichang (Yichang) in late December 1917, he became trapped by fighting government troops and revolutionaries. In January, he packed plant material and managed to send 18 parcels to the American consul in Shanghai. For the next few months, Meyer helped others transplant trees, prune vineyards, etc. On May 2, Meyer and his guide, Yao-feng Ting left Ichang, walking nearly 130 km through the war-torn region to secure his purchased pear seeds and to collect his baggage. After trudging another 97 km, they were able to board a boat for Hankow (Hankou). From there he planned to continue collecting despite reports of kidnapped Americans and murdered missionaries. However, in Hankow, Meyer suffered from "stomach trouble", but he and Ting boarded the *Feng Yang Maru*, which was bound for Shanghai on the Yangtze River. On 1 June 1918, at about 2320 HR, Meyer left his cabin, but before midnight, a cabin boy reported that Meyer was missing. Eventually, Meyer's body was recovered from the Yangtze River and temporarily buried by workmen, before it was transported to Shanghai for burial at the Bubbling Well cemetery. The cause of Meyer's death was widely speculated, with some attributing it to an accidental drowning due to vertigo or nausea from his illness, while others thought he committed suicide or was murdered (Cunningham, 1984a).

Colleagues, friends, and many others wrote of Meyer's untimely death, including J. R. Smith, E.F. Smith (1918), L. H. Bailey, and W.H. Wilson, (Cunningham, 1984 b). F.C. Reimer wrote, "Mr. Meyer possessed a great brain and also a great heart. The remarkable new field that he opened up and the vast quantities of materials that he has introduced will always remain as a great epoch in American agriculture and horticulture. I am certain that future generations will appreciate his work even more than we can today" (Cunningham, 1984b). Fairchild (1919) wrote, "throughout his adopted land there will always be his plants, hundreds of them, in fields, in the backyards and orchards of little cottages, on street corners, and in arboreta of wealthy lovers of plants. And wherever they are, they will all be his."

Among Meyer's bequests, $1000 was left to the Office of Foreign Seed and Plant Introduction (OFSPI) to be used for an outing or for entertainment. Instead, they chose to create a medal in Meyer's honor, which would be awarded for meritorious contributions to plant introduction. Because OFSPI was not allowed to award such a medal, the American Genetic Association was the first organization to present the Meyer medal annually. Currently, the Crop Science Society of America has this distinction. The medal is inscribed with, "In the glorious luxuriance of the hundred plants he takes delight" and a fruiting jujube branch is depicted along with other images (Stoner and Hummer, 2007).

Legacy. Meyer contributed much to our historical knowledge of plants in his thousands of photographs, index cards, herbarium specimens, plant introductions, and publications (Fusonie, 1990). His herbarium specimens reside at the National Arboretum Herbarium, Arnold Arboretum, New York Botanical Garden, University of Califor-

nia Botanical Garden (Berkeley), California Academy of Sciences, and Philadelphia Academy of Sciences.

Among Meyer's 2,500 introductions, some of his fruit and nut germplasm exists today in repositories, experiment stations, arboreta, etc. across the U.S. (Cunningham, 1984b). Although some of Meyer's introductions were not novel, he collected at least 115 fruit- and nut-bearing species and cultivars. Meyer also determined the origin of the devastating chestnut blight fungus and found blight resistant *Castanea mollissima* trees.

Today, some of the fruit and nut species Meyer found in China are used as ornamentals (Table 1). Other introductions, such as 'Li', 'Lang', 'Mu' (Mu Shing Hong Tsao), 'Shuimen', 'So', and 'Yu' jujube are still available. The first two cultivars are the most widely propagated by nurserymen in the U.S. (Yao, 2013). 'Meyer' and 'Ponderosa' lemon (*Citrus limon* × *C. medica*) are still grown today for use in the home landscape (Crane, 2010). Although *Vitis amurensis* has not been used in the U.S., a breeding program in northeast China has released multiple hybrids of this species as wine grapes (Liu and Li, 2013).

Several fruit and nut species he collected have been used by others to develop superior rootstocks. For example, *Diospyros lotus* seedlings are commonly used as rootstock for persimmon trees due to their drought resistance and tolerance to *Armillaria*. *Diosypyros kaki* is also a recommended rootstock in California for its resistance to *Agrobacterium* (University of California, 2013). Pear is grafted onto seedling *Pyrus betulaefolia* and *P. calleryana* for tolerance to pear decline (*Candidatus* Phytoplasma pyri) (Stebbins, 1995). For high density 'Comice' pear plantings, *Cydonia oblonga* rootstock is useful. For apple, Siberian crabapple (*Malus baccata*) is a common rootstock in Alaska (*Matney*, 2018). Marubakaidou (*Malus* × *prunifolia* var. *ringo*) is a drought resistant apple rootstock used in Japan (Gao et al., 1992; Igarashi et al., 2002). 'Ottawa 8' rootstock originated from a cross of *M. baccata* x 'M.7' (Ferree and Carlson, 1987). Krymsk®1 ('VVA-1') and Krymsk® 2 ('VVA-2') rootstocks are hybrids derived from *Prunus tomentosa* for peach, nectarine, European plums, and apricots (Layne, 1987). Also, interspecific hybrids of *Prunus davidiana* have been used to produce Nemaguard, 'Cadaman', 'Barrier 1' (Empyrean® 1), Flordaguard, 'Viking', 'Hansen 536', and 'Atlas' rootstock for various stone fruit scions. Nemaguard, 'Bright's Hybrid #5' (offspring of Nemaguard), Marianna 2624 (*Prunus cerasifera* × *P. hortulana*), Myran (*Prunus cerasifera* × *P. salicina* × 'Yunnan' peach) and Krymsk® 86 (*Prunus cerasifera* × *P. persica*) rootstocks have been used for almond trees (Duncan, 2010). *Prunus mume* seedling rootstocks have also been evaluated for peach tree short life resistance and 'Rigitano' is a clonal rootstock derived from this species for low-chill peach trees in Brazil (Mayer et al., 2015). *Prunus armeniaca* has been used as a plum rootstock (Okie, 1987) and 'Alab 1', 'Druzhba', and Krymsk® 9 rootstocks are derived from interspecific crosses of this species (Browne, 2017; Eremin, 2012). *Prunus triloba* is a useful interstem for European plum (Okie, 1987). 'Colt' (*Prunus avium* × *P. pseudocerasus*) has been used as a cherry rootstock in California for its resistance to dagger nematode-transmitted virus (cherry stem pitting) (Perry, 1987).

Citrus × *aurantium* rootstock has been used worldwide where citrus tristeza virus is absent (Bitters, 1986; Castle, 1987). Swingle (1943) considered Ichang lemon a promising rootstock because of its low temperature tolerance, but it has not been used widely. However, Fallahi et al. (1991) reported that trees of 'Orlando' tangelo (*Citrus paradisi*) on Ichang lemon rootstock had a small canopy volume and performed well in Arizona, suggesting that these trees may be recommended for high density plantings. Yuzu (*Citrus cavaleriei* × *C. reticulata*) rootstock has been used in Japan and other sites where tristeza and Phytophthora are problematic (Castle,

1987)

Corylus heterophylla has been used in the breeding program of the Economic Forestry Research Institute of Liaoning Province in northeast China, resulting in the release of several cultivars such as 'Dawei', 'Liaozhen 3', 'Liaozhen 4' (Xie et al., 2014). Clonal accessions of *C. heterophylla* screened by Capik and Molnar (2012) in New Jersey were resistant to eastern filbert blight (*Anisogramma anomala*), but hybrids with *C. avellana* were susceptible to the pathogen. Oregon State University is evaluating interspecific hybrids of filberts with the dominant blight resistance gene from *C. heterophylla* 'Ogyoo' (Shawn Mehlenbacher, personal communication). *Juglans cathayensis* has some resistance to lesion nematodes (*Pratylenchus vulnus*) and crown gall (*Agrobacterium tumefaciens*) which may be useful in breeding future walnut rootstock in the U.S. (Juglans Crop Germplasm Committee, 2017).

Scientists, commercial growers, hobbyists, and consumers have been the beneficiaries of the rich germplasm that Meyer collected unremittingly during his four expeditions. Undoubtedly, researchers will continue to use his economically useful "plant immigrants" and their genes to transform and develop germplasm for future generations.

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