



Hanging Gardens of Babylon. Artistic reconstruction. Figure from the book *Zigzag Journeys in the Levant...* (1885). Public Domain



PLANT INTRODUCTION: AN ACADEMIC “CINDERELLA”?

Key words: botany, acclimatization, breeding, plant introduction, botanical gardens

Live collections: Willow Garden of the Kuzbass Botanical Garden and Irkut violet (*Viola irtutiana*) from the collection of Siberian violets at the SB RAS Central Siberian Botanical Garden.
Photo by the author and T. Elisafenko

The world of plants is enormous. In the mid-18th century, the times of Carl Linnaeus, the “father of taxonomy,” people knew only a little more than 10,000 species. At the beginning of the 19th century, the German naturalist and traveler Alexander von Humboldt counted 38,000 species, but as early as the end of this century, the German botanist Adolf Engler estimated the total number of vascular plant species alone to be 160,000. By today, only the number of described species of flowering plants has reached nearly 300,000! This floristic diversity is a genuine richness of humankind, from which it draws thousands of valuable species. A special science exists dedicated to the bringing of wild plants into cultivation and expansion of the geographical range of cultivated plants. This science is called introduction

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*Trees the like of which none of the kings,
my ancient fathers, had ever planted,
I planted them in the gardens of my land.
I took rare garden plants,
which were not found in my own land,
and caused them to flourish
in the gardens of Assyria.*

*Tiglath-Pileser I, King of Assyria
(circa 1114–1076 BC)*

Today, we can look out the window and see plants not typical of our local flora, such as a spreading *box elder*, a maple species native to North America; a green hedge formed by the Transbaikalian *Cotoneaster*; a powerful Mongolian *elm*; or even a “living fossil,” i.e., the relict *ginkgo* from China. However, we never think about how these plants ended up in completely different climatic zones, thousands of kilometers from their homeland. Neither do we think about the people who learned how to grow them.

These plants comprise not only ornamental species. It is known that *Camellia sinensis*, or the tea plant so loved by many, originates from the humid subtropics, but today the range of this species has advanced as far as the Black Sea coast. The most ordinary *potato*, which comes from Chiloe Island in Chile, is now grown almost everywhere up to the Arctic Circle, and the tropical *cotton-plant* is cultivated all over the world, including in the south of Kazakhstan.

When we grow these plants, we benefit from the labors of thousands of unknown scientists. Only a few of these trees and herbs bear the names of those who “enured” them to grow in cultivation: the fast-growing forest-forming *Robinia*, named in honor of the French gardeners the Robins, father and son; the gently blooming *Incarvillea*, named after the French Jesuit monk Le Chéron d’Incarville, who was sent to China in 1742; the popular indoor plant *Tradescantia*, named after the English naturalists and travelers the Tradescants, father and son; Georgina, the Russian name of the popular garden plant dahlia, comes from the name of Professor Johann Georgi, member of St. Petersburg Academy of Sciences.

As soon as humans began to consciously transfer plants from one environment to another, they could not but wonder how cultivation affects them. And the very term *introduction*, which was derived from the Latin *introductio*, came into use as early as in the 16th century.



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Let’s get down to terms

The concept of *introduction* has undergone many metamorphoses over its lasting life. It had long been thought to simply mean ‘growing plants outside their natural habitat’. It was mixed eclectically with *acclimatization*; parallel interpretations of it would arise... There were as many definitions of this term as there were scientists working in this field.

Thus, according to Nikolay A. Avrorin, the founder and first director of the world’s northernmost Polar Alpine Botanical Garden in Murmansk, the concept of introduction embraces all the cases of growing plants in a different natural region, regardless of whether the conditions there coincide with those habitual to the migrant.

Other scientists believed that introduction should be understood as bringing under cultivation of a plant outside its natural range. This view was shared by the Soviet Union’s first introduction theorist Vladimir P. Maleev, who studied the flora of the Crimean Peninsula; Fyodor N. Rusanov, who conducted introduction experiments at the Tashkent Botanical Garden; Nikolay V. Pavlov, who paid a lot of attention to searching for and studying useful wild plants; and Boris N. Zamyatin, a botanist and curator of the Peter-the-Great Botanical Garden.



Alexander M. Kormilitsyn, a specialist of the Nikitsky Botanical Garden, who developed the theoretical foundations for the introduction of plants in the south of the Soviet Union, viewed introduction as an integrated set of acclimatization methods. The Soviet forester and dendrologist Sergei Ya. Sokolov, a specialist of the Leningrad Botanical Garden, also understood introduction as a set of methods and techniques to facilitate and accelerate acclimatization or to force plants to acclimatize when new species are brought into cultivation. Yet another Soviet dendrologist, Pyotr I. Lapin, whose main works were devoted to the introduction and acclimatization of woody plants and to ornamental gardening, considered introduction as a targeted human activity

Of the entire genus *ginkgo*, which flourished in the mid-Jurassic period, only *Ginkgo biloba* has survived to this day. This relic plant is used in landscaping, and its leaf and fruit extracts are part of dietary supplement production.
Champs Elysees (Paris, France).
© CC-BY 2.5/Wolfgang Moroder



to bring under cultivation of plants not grown previously in a given natural historical area as well as to transfer into cultivation of those plants from local flora.

All these, however, do not provide a definition of the science but rather describe its methodology. Aggregation of the experience in growing exotic plants led to the emergence of introduction experiment as a scientific method. Today we can say that introduction is the science of development of plants under the conditions of cultivation.

The core of modern plant introduction consists of living collections that participate in the introduction experiment aimed at studying plant acclimatization processes, including changes at the cellular, physiological, and organismal levels. Botanical gardens serve as specialized research institutions working in this field of science.

Stone grain grinders, made of durable rocks, are the oldest evidence of agriculture development and introduction of grain crops. These implements came into use as early as the Late Paleolithic in both the Old and New Worlds, and starting from the Neolithic, they became a necessary household item in various cultures. © CC BY-SA 2.5/ Jose-Manuel Benito

“I BROUGHT CEDARS AND I PLANTED THEM IN THE GARDENS OF MY LAND”

The gnoseological roots of introduction should be looked for in primeval agriculture, i. e., in the search for and spontaneous cultivation of food plants. Thus, excavations at ancient pile buildings revealed that humans who lived several tens of thousands of years ago had fairly well-developed skills in growing plants.

The development of plant cultivation for gardening and ornamental purposes as well as food is also associated with the formation of the large states of the Ancient World. Thus, cuneiform writings on clay tablets have delivered to us the words spoken thirteen centuries ago by the Assyrian king Tiglath-Pileser I: “I brought cedars <...> from the countries which I have subdued, trees the like of which none of the kings, my ancient fathers, had ever planted, and I planted them in the gardens of my land. I took rare garden plants, which were not found in my own land, and caused them to flourish in the gardens of Assyria” (adapted from (Luckenbill, 1927)).

One of the Seven Wonders of the Ancient World is the legendary Hanging Gardens of Babylon, a cascade of multi-tier gardens created in Babylon presumably in the 9th or 6th centuries BC, which produced the impression of a large green mountain. Arnold Regel (1896), known as the author of the “bible” of landscape architecture, wrote that these gardens were laid out on roofs supported by basalt columns covered with asphalt and lined with bales of straw and topped with a layer of soil. The gardens were arranged in several tiers; many centuries later, exotic plants, which had turned wild, would grow on their ruins



Ancient Egyptians left a lot of archaeological evidence showing a high level of agricultural development. This evidence includes well-preserved colorful paintings on the walls of the burial chamber in the Tomb of Sennedjem, which depict scenes of plowing and harvesting. Second millennium BC. Deir el-Medina Necropolis. Public Domain

Bottom left: Ancient Egyptian bas-relief depicting a grape harvest scene. 7th–6th century BC. Louvre (Paris, France). © CC BY 3.0/ Mbzt



A cuneiform tablet found on the territory of ancient Babylon at the site of the royal garden dated to the reign of Marduk-apla-iddin II (721–710 and 703–702 BC) contains a list of cultivated plants such as the currently popular onion, garlic, cucumber, turnip, mint, watercress, thyme, coriander, etc.



Alexander von Humboldt and his colleague Aimé Bonpland near the Chimborazo volcano during their voyage to America. 1810. Painting by F. G. Weitsch. Public Domain



German naturalist and traveler Baron Alexander von Humboldt. Self-portrait. Paris. 1814. Public Domain

Beyond the limits set by nature

The founder of the introduction theory is, apparently, the famous German traveler and naturalist Alexander von Humboldt. In his book *Ideen zu einer Geografie der Pflanzen* (*Essay on the Geography of Plants*, 1807), he was the first to try to explain the changes that occur in plants due to a transfer from one climatic zone to another.

Humboldt noted that each plant has its own minimum of climatic factors limiting its distribution. He paid special attention to the sum of positive (above 0 °C) temperatures and believed that success in the transfer to a new environment hinged on a consistency of these values. It was Humboldt who first suggested that greater effectiveness could be achieved by stepwise introduction through intermediate locations. For example, in order to successfully transfer tropical plants to Europe, the planting material should be cultivated in the subtropical Canary Islands, which would make it more winter-hardy.

The subsequent development of the introduction theory is associated with the name of Augustin Pyramus de Candolle, a Swiss and French botanist, and, first and foremost, with the name of his son and successor Alphonse de Candolle, a botanist and biogeographer.



Mutisia grandiflora is a perennial flowering plant native to South America. Illustration from Humboldt and Bonpland's multivolume work under the abbreviated title *Plantae aequinoctiales* ('Equatorial Plants', 1808). © CC BY 2.0/ Mann Library

Colorless melastoma (*Tetrazygia discolor*). Illustration from Humboldt and Bonpland's *Monographie des melastomac...* ('Monograph of Melastomaceae, Including All Plants of This Order Collected Today: in Mexico; on the Island of Cuba; in the provinces of Caracas, Cumana, and Barcelona; in the Andes of New Granada, Quito, and Peru; on the Banks of the Rio Negro, Orinoco, and Amazon River', 1816–1823). Engraving by L. Bouquet based on a drawing by A. Poiteau. © CC BY 4.0/ Wellcome Collection

Charles Darwin called Alexander von Humboldt "the greatest scientific traveler who ever lived." Having received the highest permission from the Spanish king to visit Spanish territories in America and the Pacific Ocean, Humboldt and his companion Aimé Bonpland set out in the summer of 1799 on a voyage, which took almost five years and which was rightly called the second – scientific – discovery of America.

Humboldt's scientific interests were immensely diverse: geography, ethnography, history, zoology... The botanical collection alone assembled by the scientists contained nearly four 4000 species, including 1800 previously unknown ones.

Humboldt is considered to be the founder of botanical geography, which simply had not existed before him as a science. The new field rested upon the climatic principle as Humboldt was the first to notice the similarity between the gradual changes in vegetation from the equator to the pole and from the foot to top of a mountain, having characterized the relevant vegetation bands. He also made the first attempt to divide the globe into botanical regions



In his books on plant geography, de Candolle Sr. argued that in the process of natural distribution, plants could overcome most diverse obstacles (they could be carried by man, by sea currents, by wind), but they could not cope with the counteraction of climatic factors. Unlike Humboldt, he believed that positive temperatures of +5 or +10 °C were of key importance for the survival of plants. De Candolle Jr. was the first to note the existence of long- and short-day plants, with the former blooming under continuous daily illumination of more than 12 hours and the latter under less than that (Kupriyanov, 2013).



Swiss and French botanist Augustin Pyramus de Candolle. Woodcut by A. Tardieu. © CC BY 4.0/ Wellcome Collection

On the left is his son and follower Alphonse Decandolle, a botanist and biogeographer. 1866. Public Domain

Augustin Pyramus de Candolle, known as de Candolle Sr., was one of the greatest botanists and the author of one of the first natural systems of plant classification. On behalf of the French government, he made numerous tours throughout France and Italy over six summer seasons, studying the local wild and cultivated flora. One of the outcomes of his work was an essay on botanical geography. Studying the geography of plants became the chief scientific interest of his son Alphonse de Candolle, who put forth one of the first concepts about the origin of cultivated plants. In 1835, he published *Introduction à l'étude de la botanique* ('Introduction to the Study of Botany'), in which he paid much attention to biogeography. This book was translated into Russian and used for teaching at Russian universities over a long period. But the most fundamental work by de Candolle Jr. was his treatise *Géographie botanique raisonnée* ('Reasoned Botanical Geography') (1855), where he wrote about the laws and principles underlying the spread and distribution of plants in nature. Subsequently, he built upon these conclusions in his treatises on physiological groups of plants



Lilium Superbum *Lil. Superbum*



These lithographs from de Candolle Sr.'s monograph *Les liliacées* ('The Lilies', 1802–1808) depict the African *Ornithogalum longibracteatum*, whose stems can reach almost a meter in length, and lily royal (*Lilium superbum*) of North America. Drawing by P.-J. Redouté. Public Domain

Bottom left: One of the many drawings of indigenous flora of Mexico from the book *Calques des dessins de la Flore du Mexique...* by A. de Candolle, J. M. Moziño, and M. Sessé (1874). Biodiversity Heritage Library. Public Domain



Ornithogalum Longibracteatum. *Ornithogalum à longues bractées*



Doctor of philosophy, botanist and horticultural scientist, corresponding member of the St. Petersburg Academy of Sciences Eduard August von Regel. 2016. Engraving by E. Behrens based on a photograph by S. Felbinger. Public Domain

Eduard August von Regel carried out and published numerous studies on the flora of East Siberia, Central Asia, Sakhalin, and the Ussuri region. He not only discovered and described more than a thousand new plant species but also acclimatized and brought many of them into cultivation, and the ornamental plants he discovered still remain extremely valuable objects for introduction and breeding. In 1855, Regel moved from Germany to Russia as director of the St. Petersburg Imperial Botanical Garden, which became the best one in Europe under his direction. In 1862, he founded in the vicinity of the capital city Russia's first pomological ('fruit-oriented') nursery, where fruit crops were tested for winter hardiness, acclimatization, and reproduction of local and foreign varieties, including the frost-resistant Siberian apple tree (*sibirka*). Seedlings, bulbs, and seeds from the nursery were delivered to many botanical gardens both in Russia and in Europe. Long before the German forester Heinrich Mayr (1909), Regel expounded the fundamental principles of the method of climatic analogues, widely known in introduction, the key idea of which is that plants can be transported and successfully acclimatized only in areas where an integral set of climatic conditions is identical to those in the plants' homeland

A great contribution to the development of introduction came from the works of the great evolutionist Charles Darwin. He believed that plants have hereditary habits, which manifest themselves in their attitude to climate, to the time of flowering and fruiting, to the timing and duration of the dormant period. According to Darwin, adaptation to climate is a result of natural selection, but its amplitude is not infinite. Therefore, acclimatization can be achieved through the mass selection of plants that are slightly more adapted to the new climate than the rest. A priori, he believed, at least 20 generations were needed to complete the selection of these forms.

Darwin was the first to notice that not only the vegetation season shifts as a result of the transfer, but the plant's life

Chromolithography from Regel's book *Russian Pomology. Description of Characteristics and Breeding Methods for Fruit Plants Varieties Growing in the Northern, Central, and South-Eastern Provinces of Russia* (1868). Public Domain



form itself also changes. For example, castor bean in Africa is a perennial plant with a woody stem, but in Europe and in the Altai Mountains, it is an annual herbaceous plant. Many deciduous plants in European climates become evergreen ones in the tropics.

An outstanding Russian botanist and horticultural scientist of the 19th century Eduard August von Regel believed that plants could change their morphology yet not their habits, such as resistance to cold and other unfavorable factors: "No art can cross the limits set by nature." Regel's main views boiled down to the following points: only those plants can be acclimatized that originate from a similar climate; a plant can be successfully introduced only in a country where the conditions are identical to the original growing conditions; no means can change the properties of plants and force them to tolerate cold temperatures unacceptable for them. Therefore, he believed that a plant had only one possibility to adapt to unfavorable conditions (e.g., frosts), i.e., to change the time of the growing season or the rhythm of development to fit into the new climatic conditions.

It should be noted that all researchers of that time, as well as those working in the first half of the 20th century, considered such concepts as introduction, acclimatization, naturalization, and "enslavement" (a term proposed by Andrey N. Beketov, the founder of plant geography in Russia) to be essentially the same thing. However, almost all the researchers were looking for their own way of selecting candidates for introduction.

Malthus was wrong

The fundamentality of introduction as a science lies in the study of adaptive processes occurring in plants at all levels of their organization, from biochemical processes to the rhythms of growth and development. Acclimatization can occur naturally in wildlife, e.g., during global climate changes or due to the spread of plants to new territories; in this case, it goes extremely slowly. In an introduction experiment, botanists consciously simulate this process by reducing the time frames that extend in nature over geological periods.

Regel was the first to describe the tulips *Tulipa kaufmanniana* from Uzbekistan and *Tulipa greigii* (Greig's tulip) from the Karatau Ridge, the predecessors of hundreds of modern varieties. His name was given to a rare wild species *Tulipa regelii*, which grows in the southeast of Kazakhstan. © CC BY 2.0/chernoburko



The varieties of cultivated plants developed by Luther Burbank, who managed to create about a thousand of them, comprise a lot of unusual ones: a giant sweet onion with a bulb up to one kilo, a seedless plum, a raspberry without thorns, a blue poppy... The pinnacle of his work was a spineless cactus, which was supposed to transform vast deserts into pastures. Burbank himself wrote that the most laborious, expensive, and tedious experiments he had ever undertook was on cactus. He acquired more than six hundred different varieties of cacti, which he planted and observed. In total, he spent more than sixteen years on that work... As a result, he obtained on the basis of prickly pear a tasty forage crop, which, however, was not drought-resistant

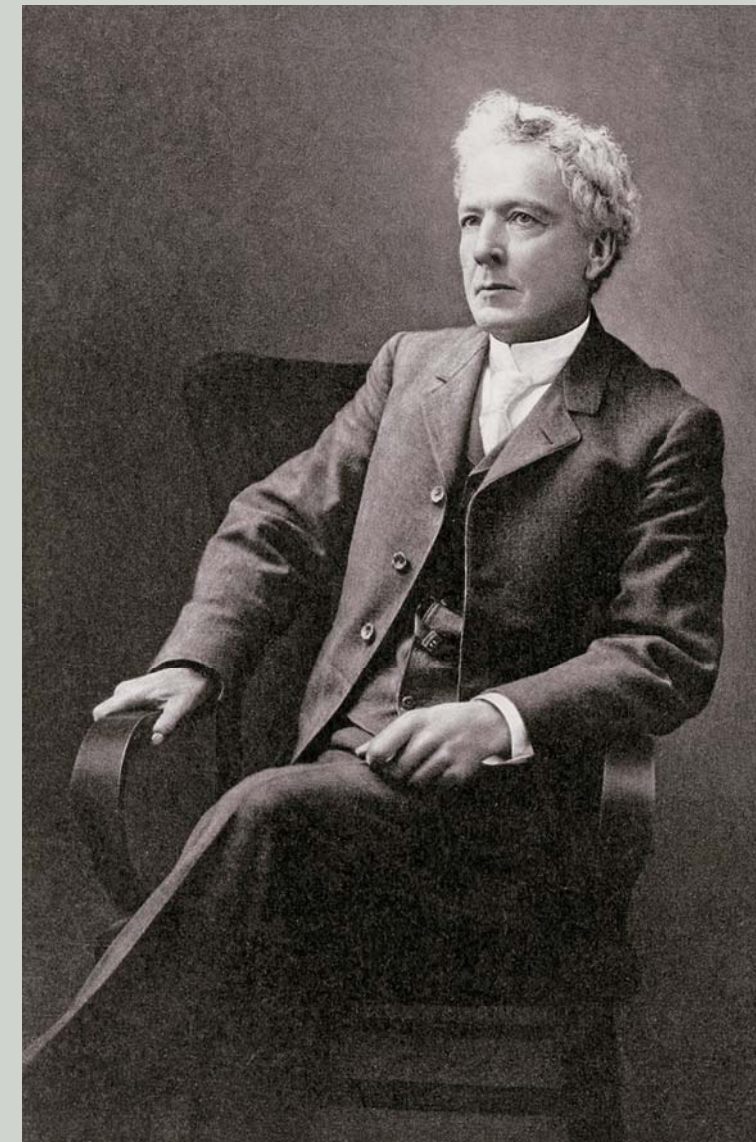
Plantation of Burbank's cactus (*Opuntia burbankii*). Smithsonian Libraries. Public Domain

On the right are the juicy fruits of Burbank's cactus, which taste like an apple or pear. Public Domain



The limitless possibilities for “reformatting” plants and breeding new varieties with the participation of the entire floristic diversity were clearly demonstrated by two outstanding botanists and horticulturists: Luther Burbank from the United States and the Russian biologist Ivan M. Michurin.

Here are Burbank's three guiding principles. The first one was to mobilize and cultivate the riches of the flora of the entire globe. The idea of the widespread use of the world's plant resources led to establishing the Bureau of Plant Industry in Washington, whose work radically changed the range of cultivated flora in the United States. The second principle was the use of seedlings from plants that traditionally reproduce vegetatively as well as the mass selection of seedlings from the seeds of cultivated plants. The third principle was widespread intraspecific hybridization, followed by the vegetative propagation of the resulting forms.



Plant breeder and horticulturist Luther Burbank, an American counterpart of the Russian Ivan Michurin. From the book *Luther Burbank's Bounties from Nature to Man* by O. Binner (1911). Public Domain

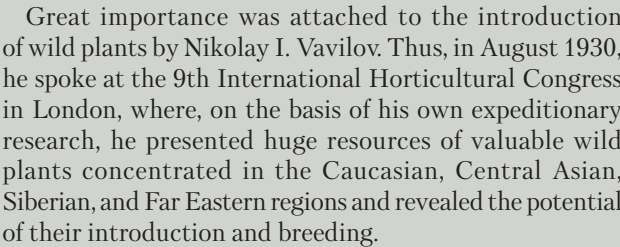
On the left is Burbank at his nursery. 1900. Library of Congress, Prints & Photographs Division

Apart from exotic plants, Luther Burbank obtained many well-known varieties of fruit, vegetable, grain, fodder, and ornamental crops that are currently in demand in horti- and agriculture. One such example is Burbank's potato, which gave rise to the Russet Burbank variety, now considered the standard for making French fries. In the United States, this variety accounts for about a half of all potato production



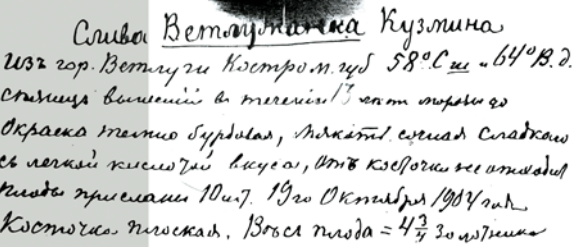
Michurin's sixty-year work became an example of human's limitless capacity in creating new varieties, even species, of plants. Michurin's endeavor enabled fruit growing to extend northward as far as 53° N. Having developed a practical groundwork for applying the results of plant crossings, he personally created 350 new varieties of most diverse fruit crops: from apple and pear trees and currants to grapes, quince trees, and actinidia.

Page from Michurin's journal with notes and sketches related to cherry hybrids. *Early 1920s. Public Domain*



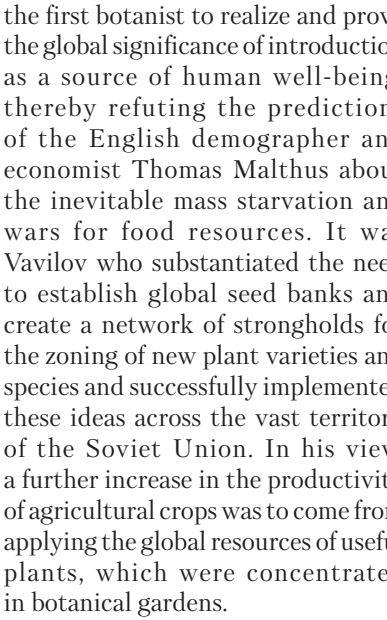
Vavilov's ideas, manifested at the congress, turned out to be prophetic. Over the following decades, as a result of selection and breeding work, new varieties were obtained and introduced into cultivation of fruit and berry plants such as *sea buckthorn*, *honeysuckle*, and high-vitamin *rosehips* – precisely those species that Vavilov called promising.

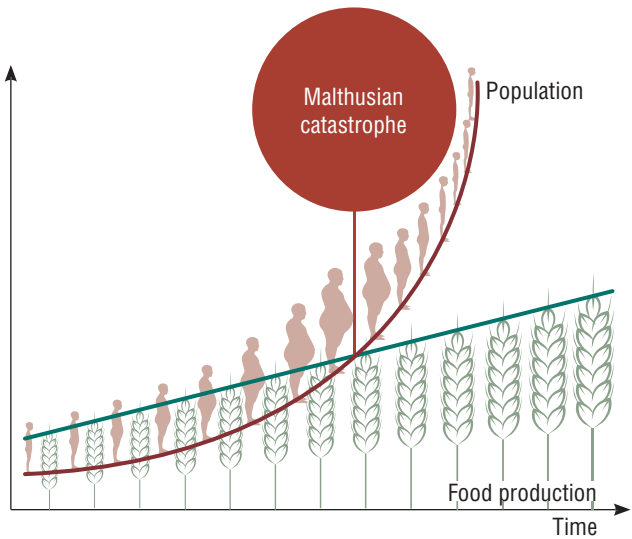
The importance of Vavilov's work for the development of introduction can hardly be overestimated. He was



Page from Michurin's journal
with a description of a resistant
plum variety. 1904

On the left is an illustration to an article about Michurin in the first edition of the Great Soviet Encyclopedia (1938). *Public Domain*





In the original formulation of Malthus' Law, population grows exponentially and food production grows linearly, and at some point food becomes insufficient, causing famines, epidemics, and wars. Subsequently, Malthus suggested that population growth constantly approaches a critical level but stays there as a result of social disasters

Thomas Robert Malthus, a priest, demographer, and economist. 1833. Drawing by J. Linnell. Public Domain

MALTHUS' CATASTROPHE SCENARIO

The English priest and scholar Thomas Robert Malthus went down in the history of economic thought as a man of one idea, namely, the Law of Population. In 1798, his book entitled *An Essay on the Principle of Population (An Essay on the Principle of Population, as It Affects the Future Improvement of Society)* was published in London in a small edition. The author argued that the population was growing “in a geometrical ratio” while the means of subsistence (by which he implied agricultural products) was increasing “in an arithmetic ratio.” In this work, Malthus essentially formulated his theory of population, which can be reduced to the following provisions: due to the biological need for reproduction, the population is constantly growing; the ability to reproduce is limited by available food resources. Malthus argued that population tended to increase faster than its subsistence. As evidence, he cited the following logical inferences: every 25 years, population can double, and if this trend continues, then “in two centuries and a quarter, the population would be to the means of subsistence as 512 to 10: in three centuries as 4096 to 13, and in two thousand years the difference would be almost incalculable.” Followers of Malthus calculated that a food crisis would erupt at the end of the 20th or beginning of the 21st century, but this did not happen due to the success of introduction and breeding of agricultural plants

Treasures of botanical gardens

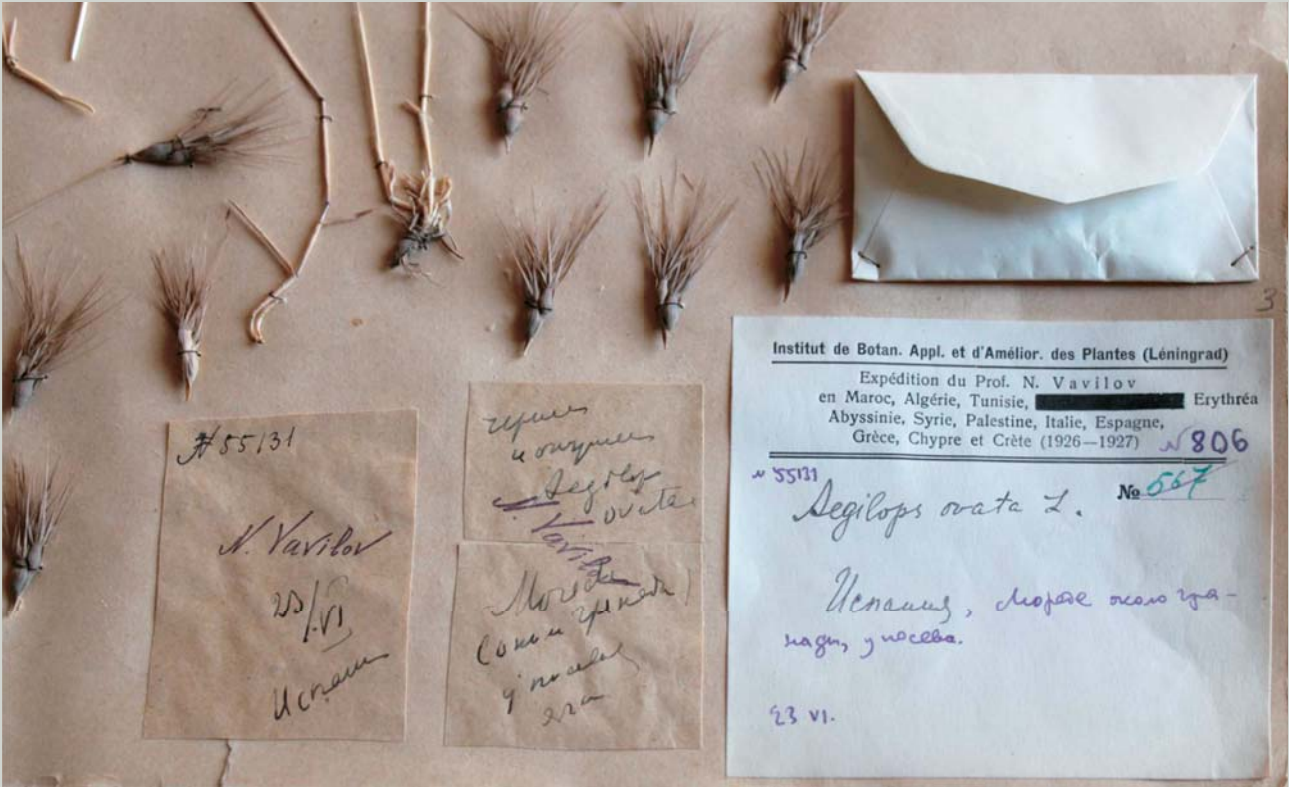
The inexhaustibility of introduction stems from the boundlessness of resources associated with the intraspecific and morphological diversity of plants in living nature; all we have to do is to unlock this gigantic potential of nature.

Herbarium and seeds of an annual herbaceous plant *Aegilops neglecta*, a closest relative of wheat, which were collected by Nikolay I. Vavilov in Spain. Some species of this genus are carriers of traits valuable for agriculture, which can be transferred to wheat cultivars through artificial hybridization. © CC BY-NC 2.0/Petr Kosina



Academician Nikolay I. Vavilov developed the doctrine of hereditary variability, the central element of which is the law of homological series. According to this law, related species have similar potential variability due to the similarity of their genotypes. Vavilov proposed a differentiated botanical geographical method of introduction, which consists in collecting and studying the global diversity of species and varieties with the subsequent selection of the best ones. He organized many expeditions to more than 50 countries, which resulted in creating a huge (over 200,000 samples) collection of plants. According to Vavilov, “previously, one would put to the fore the impact on environment, that is, land cultivation, fertilizing, soil maintenance, or, in a word, farming. But our main goal is different; it is plant production, or plant breeding. And we can achieve it differently. That is, by influencing not only the land and soil but also the plant itself, its very nature”

Nikolai I. Vavilov, a scientist, public figure, and state official. In 1940, following a false denunciation, he was arrested and sentenced to death; the death sentence was commuted to twenty years in prison. He died in prison from general exhaustion; his burial place is unknown. Photo of 1934. Library of Congress. New York World-Telegram & Sun Collection





Today, based on various sources, there are about 230,000–350,000 flowering plants on the Earth that have been described, and about 80,000 of them are grown in botanical gardens (State..., 2016). By the mid-20th century, about 12,000 plant species were used in the various sectors of world economy (Vul'f and Maleeva, 1987).

To date, the number of useful plants has grown to 31,000, which means that over the six or seven decades of introduction research, this number has increased by a factor of more than 2.5! The intensive introduction of new species testifies to the continuing global role of botanical gardens to ensure sustainable existence of humanity.

Speaking about Siberia, today 1437 species from 115 families are grown in regional botanical gardens, which amounts to 31% of the Siberian flora (Introduction..., 2017). This collection constitutes a very extensive foundation for the introduction of new plants for multiple purposes: ornamental, food, medicinal, forage, technical, etc.

An outstanding dendrologist Igor Yu. Koropachinsky, who was the head of the Central Siberian Botanical Garden for 17 years, believed that modern introduction research in the botanical gardens of Siberia should be focused primarily on the introduction of various

Imperial fritillaries (*Fritillaria imperialis*) from the lily family next to a greenhouse at the Peter-the-Great Botanical Garden. Their natural range stretches from the south of Turkey to Kashmir.

© CC BY-SA 4.0/MargaritaStartseva



Research laboratory of the Peter-the-Great Botanical Garden, the oldest botanical garden in Russia, which dates back to the Apothecary Garden, founded in St. Petersburg in 1706. Today, the garden is a department of the Komarov Botanical Institute, Russian Academy of Sciences.

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Schematic map of floristic kingdoms, adapted from (Takhtadzhyan, 1978)

Specialists of the Basnins' botanic garden successfully cultivated plants from all the floristic kingdoms and regions of the Earth.

Adapted from: (Kuzevanov, 2011)

At the beginning of the 19th century, there were only two official botanical gardens with imperial status in the Russian Empire: in Moscow and in St. Petersburg. In the east of the country, there was not a single horticultural structure that could claim this title although private horticultural enterprises had been functioning successfully there. The first "people's botanical garden," which represented the largest (more than 120 local and exotic species) collection of plants eastward of the Ural Mountains, was established in Irkutsk by Vasily N. Basnin, who descended from a long line of merchants

Alley in the Basnins' garden. 1869. Photo from F. Zenkovich's archive





Since the establishment of the Central Siberian Botanical Garden in March 1946, issues surrounding introduction and acclimatization of plants (food, forage, ornamental, etc.) have dovetailed with the main strands of its research. From the materials of the 1956 Anniversary Report of the Botanical Garden, West Siberian Branch, USSR Academy of Sciences: the photo on the left shows a plot of perennial and winter-hardy Altai onion; the photo below shows the process of weighing corn harvest from experimental plots. Museum of the SB RAS Central Siberian Botanical Garden (Novosibirsk)

ИНТРОДУКЦИЯ И АККЛИМАТИЗАЦИЯ РАСТЕНИЙ. (Проблема обща академическая)

Тема 1. Изыскание и введение в культуру новых кормовых, лекарственных, эфиромасличных и др. полезных растений.

Тема 2. Интродукция и создание новых форм декоративных растений для озеленения г. Новосибирска.

Тема 3. Биологические основы селекции и семеноводства кукурузы для условий Западной Сибири.

Тема 4. Интродукция и выведение зимостойких высококачественных сортов плодово-ягодных растений.

Тема 5. Введение в культуру в условиях Западной Сибири бахчевых и листовых культур на основе изучения их биологии.



intraspecific forms of resistant local species. The main efforts should be aimed at searching for new useful plants that have no application yet, studying them *in situ*, conducting selection, and bringing the new plants into cultivation.

In Siberia, the possibility of transforming a plant from a “thing in itself” into a “thing for us” is extremely high. In landscaping alone, one can use 766 species of woody plants, of which 227 species are originally Siberian (Koropachinsky *et al.*, 2013). The resources of forage, food, and medicinal plants are practically boundless – suffice it to remember the varieties of sea buckthorn, honeysuckle, and currants, with which Siberia has enriched the world’s cultivated flora.

Thus, one of the outstanding Russian scientists in the field of pomiculture Elizaveta I. Panteleeva devoted her entire life to producing new varieties of sea buckthorn. She is the author of 42 varieties of this amazing plant, which is new to world orcharding. To create her thornless, large- and sweet-fruited varieties, she used plants from natural populations of sea

Selection of corn seeds for treatment with microelements in a laboratory of the Botanical Garden. 1950s. Museum of the SB RAS Central Siberian Botanical Garden (Novosibirsk)

Megadenia bardunovii, an extremely rare plant. Central Siberian Botanical Garden (Novosibirsk). Photo by T. Elisafenko

Botanical gardens are “magic castles” created to preserve rare plant species that could have disappeared forever in nature. One such species is *Megadenia bardunovii*. This plant from the cabbage family was discovered in 1953 by a young botanist Leonid Bardunov, when he was working in Buryatia on the instructions of his supervisor M. G. Popov. The find turned out to be a new species, which Popov described as *Megadenia bardunovii*.

Years went by, and the discoverer became a professor and decided to revisit the place where he once found the rare plant. But ill luck befell him as the only known site was buried under a layer of gravel. For more than thirty years, the species was considered officially extinct. When botanists finally found the plant again, it received a permanent status as part of the collection of rare and endangered plants at the Central Botanical Garden, Siberian Branch, Russian Academy of Sciences, where it grows under the supervision of Dr. Sci. (Bio.) Tatyana V. Elisafenko





The Soviet botanist Fyodor N. Rusanov once developed a method of generic complexes for botanical gardens. Its essence lies in testing all or most of the representatives of the same genus, which were collected from different habitats, in one place in order to identify the general response of this taxonomic group to introduction. Rusanov believed that an integrated introduction assessment for an entire generic complex allows one to estimate the prospects of mobilizing other species, which did not participate in the introduction experiment. One such example is an amazing collection of Siberian violets that has been assembled at the SB RAS Central Siberian Botanical Garden under the supervision of Dr. Sci. (Bio.) Tatyana V. Elisafenko. The collection contains both decorative violets, which can be used in landscaping and gardening, and extremely rare ones, for which scientists have yet to develop a technology for returning them into nature

Siberian violets in the collection of the SB RAS Central Botanical Garden (Novosibirsk): *V. alexandrowiana* and *V. milanae*. Photo by T. Elisafenko



buckthorn. This is why it is so important for regional botanical gardens to have in their collections the fullest possible range of plants of the natural flora.

Introducing new useful plants into cultivation requires the efforts of many institutions and specialists in various fields: botanists, introducers, chemists, biologists, agronomists, engineers, etc. An essential drawback of modern introduction is the lack of an integrated approach when bringing plants into cultivation, which prevents them from revealing their beneficial properties.

In particular, there remain unresolved issues of creating nurseries in botanical gardens for the replication of the most fascinating species and forms of natural flora; horticultural firms show no interest in the implementation of “innovative” planting material; and farms that specialize in growing medicinal plants have almost vanished.

The global success of introduction was to overcome the food crisis on the planet. A sharp increase in the productivity of agricultural crops developed by mobilizing the world’s plant resources allowed a real “green revolution” in the mid-20th century, which helped feed humanity.

The successes of plant introductions refute the gloomy predictions of the Malthusian population theory about the inevitable mass famine, which inspires optimism about the future. Moreover, the ideas put forth by the Russian

evolutionist and breeder Vavilov enabled a sharp increase in the productivity of agricultural plants and allowed the spread of useful plants far beyond the limits of their natural range, which is why, even in the current millennium, humankind will be able to feed itself and create comfortable living conditions.

The practical value of science depends on fundamental discoveries, which establish a base for applied developments to come up with new products for the benefit of civilization. Surprisingly, introduction does not rank first among the sciences that claim to be the “benefactors” of humanity. Apparently, the science that prevented the global food crisis, which had been a fear of humankind for almost a century, is not on the list of priority scientific fields!

The innovativeness of introduction lies in bringing a new plant into cultivation and revealing its beneficial properties. Academician Vladimir A. Obruchev said once that there were no useless minerals, only unstudied ones. To paraphrase, we can argue that there are no useless plants, only unstudied ones. The search for new cultivated plants for many areas of economy continues to this day. New challenges facing humanity can largely be solved through a deeper study of the capabilities of plants. In this sense, introduction is as innovative a science in the 21st century as physics and chemistry.

The main threat to human existence on the planet is the rapid change in environmental conditions, which

Acclimatization “experiment” in nature: Bamboo Garden, covered with snow, at the Royal Botanic Gardens, Kew (London, United Kingdom). 1870s. Public domain/ Internet Archive Book Images

Transition of plants from a wild to a cultivated state is an ongoing process. In the past century, people learned the value of many new species, including Siberian ones, such as roseroot (*Rhodiola rosea*) and “maral root” (*Rhaponticum carthamoides*). Even half a century ago, few people knew about the existence of *Salsola collina*, an inconspicuous weedy annual plant with thread-like leaves covered with prickly bristles. It was seemingly destined to be a Cinderella, i. e., to always remain on the sidelines of the “beautiful life.”

However, the fate of this plant, like that of Cinderella, changed dramatically when the Irkutsk chemist A. A. Semenov, who had studied the medicinal practice of traditional healers, developed in the 1980s from the aboveground part the herbal medicine Salsocollin with a complex of flavonoid substances. Salsocollin proved to be extremely effective for the treatment of liver diseases, considering that such drugs as hepatoprotectors are very few in number. As a result of introduction, this plant, a wild one recently, has almost become a cultivar. Thus, there are still many unstudied herbs in our neighborhood, and even today the search for new medicinal herbs can lead to great discoveries



“O! THE HAPPY WILLOW TREE...”

The cultural tradition of the Indo–European peoples associates the willow tree with the origins of human civilization. Mentions of willow are found in ancient Sumerian legends and in Buryat myths, in the Scandinavian epic and in the beliefs of the ancient Slavs. The Russian language has many folk names for species of the genus *Salix*: vetla, rakita, tal’nik, verba... In Russia, since ancient times, flowering willow branches have served as a symbol of spring and the beginning of a new life.

All in all, there are more than three hundred species of willows on our planet because this tree is amazingly enduring and capable of adapting to a wide range of climates. Over the past decades, many decorative varieties have been obtained, which are now used in landscape design. And yet the role of willows in landscaping is still largely downplayed.

In Russia, in the mid-20th century, remarkable plant breeders V.I. Shaburov and I.V. Belyaeva from Yekaterinburg built a unique collection of willows, both species and hybrids, including frost-resistant ones. Seedlings of 120 species and hybrids were donated to the Kuzbass Botanical Garden, Federal Research Center for Coal and Coal Chemistry, Siberian Branch, Russian Academy of Sciences, where the Willow Garden exhibition was created in 2010. Today, the Willow Garden in Kuzbass is the largest one in Asian Russia in terms of the number of species and varieties

Willow Garden at the Kuzbass Botanical Garden (SB RAS Federal Research Center for Coal and Coal Chemistry), the youngest botanical garden in Russia, which was founded in 1991. One of the main directions of its work is the introduction of new plant species and forms.

Photo by the author

biological evolution cannot keep up with. In 1992, the Convention on Biological Diversity was adopted in Rio de Janeiro; i.e., the world community came to an understanding that biological diversity guarantees the preservation of the biosphere buffering and the stability of human environment.

This convention lays out the strategy for protecting plants *ex situ*, i.e., in botanical gardens, as one of its key concepts. In this sense, one should remember that today, botanical gardens aim not only to preserve rare and endangered plants in their collections but also to study their biology and developmental features as well as set up seed production in order to subsequently reintroduce the plants into natural conditions, where they are on the verge of disappearance.

Dynamic urbanization has led to increased environmental risks for people and to extensive economic damage to the environment. It is obvious that cities now represent a qualitatively new sanitary and environmental situation whose defining feature is the high concentration of anthropogenic factors, which adversely affect, inter alia, the condition of green spaces. While performing crucial protective, environmental, recreational, and sanitary hygienic functions, green spaces not only shape the outlook of cities but also serve as an indicator of environmental well-being in urban areas – hence the increasing role of botanical gardens in studying the mechanisms of sustainability of the “green urban dwellers.”

The continued existence of man on the Earth will hardly be possible without expanding the activities of botanical gardens. The challenges faced by humanity demand to increase the productivity of agri- and horticultural crops, search for new natural medicinal plants, and maintain the resistance of green spaces to anthropo- and technogenic pollutants... And all these issues can be addressed with the help of a modest yet necessary science, i.e., plant introduction.

Bergenia crassifolia is a well-known medicinal plant in the folk medicine of Siberia and Tibet. This plant is also highly decorative, hence its popularity in rockeries and rocky hills. Specialists of the Kuzbass Botanical Garden have obtained a unique decorative variety of bergenia – Beauties of Kuzbass – with brightly colored flowers, a very large inflorescence, a long flowering period, and the ability to rebloom in the autumn.

Photo by the author

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