

Plants with Separation Anxieties? Plants with an Eastern Asian - Eastern North American Disjunct Distribution

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A disjunction is a distribution in which closely related organisms occur in widely separated areas. In plants this may occur on several scales, the largest of which involves separation by continent. In 1716 a French Jesuit, Father Joseph Francis Lafitau, was the first person to observe and record the idea of intercontinental disjunctions in plants. He made the connection when he discovered an American ginseng (*Panax.*) growing near Montreal, Canada, shortly after he had read about the native ginseng from northern China.

The idea became widely recognized in the mid 1800s after botanist Asa Gray demonstrated that the flora of eastern North America showed a closer affinity to the flora of Japan than to that of western North America. It is because of his work that you may sometimes see the eastern North American - eastern Asian disjunction referred to as the "Asa Gray Disjunction." Since then biogeographers have been searching to explain how closely related organisms could become so widely separated.

How do Disjunctions Between Continents Occur?

Because most plants put down roots, they are unable to migrate in the way that animals can. Due to this immobility, there are only three possible explanations that can account for intercontinental disjunctions, like the one between the eastern North American and eastern Asian vascular floras.

1. The ancestral population of the disjunct species pairs occurred on pieces of the earth's crust that were once joined and have since separated, after which the separated populations continued to evolve and diverge.
2. The ancestral population had a very wide distribution which was reduced to separate fragments as some populations went extinct. These isolated pockets then continued to evolve and diverge into distinct taxa.
3. A member of the ancestral population dispersed over vast distances and then evolved in isolation, in its new location, to form a new, closely-related taxon.

These are all plausible explanations, and examples in different plant groups have been found to demonstrate that all three mechanisms have occurred at one time or another throughout the history of flowering plants.

The eastern North American - eastern Asian floristic disjunction can most likely be attributed to two major events: the initial split between the Eurasian and North American continents, and the subsequent isolation between the eastern and the western floras of North America. However, there were likely multiple origins to this pattern, involving different plant groups that separated at different times, and long-distance dispersal probably played a minor role.

The Role of Continental Drift and Subsequent Geologic and Climatic Changes

It is widely accepted that angiosperms evolved from their progenitors over a period of 60 million years during the Cretaceous. Since that time, another 60 million years has passed and similarly enormous changes have taken place in the world of flowering plants.

There is much evidence to support the theory that the eastern Asian - eastern North American floral disjunction represents remnants of the continuous temperate forests of the northern hemisphere during the Tertiary period. Studies of geology, fossils and phylogenetics (the study of the ancestral relationships between taxa) have all contributed to this idea.

During the Tertiary many plants used the Bering and the North Atlantic land bridges as their means of migration between the continents before they separated. As a result, many genera became widely distributed throughout North America and Eurasia and in the mid-Tertiary the development of the temperate deciduous forests reached a peak. Then, in the late Tertiary and Quaternary, climatic changes led to wide extinctions that affected many temperate genera, often wiping them out completely from their European and western North American ranges. The result was remnant or "relict" populations that survived in the refugia of eastern Asia and eastern North America, and these are the disjunct species that we see today.

Recent research has cast new light on the subject, showing that the flora of eastern North America is more closely related to the flora of western North America than to that of eastern Asia. A similar relationship has been observed in several genera, including *Hamamelis*. Figure 1 is a phylogenetic tree showing the relationships between species within the genus *Hamamelis*. Note that all of the North American species are more closely related to one another than to the Asian species, which suggests that once the two continents became separate, the North American group continued to diversify and evolve into several new, distinct species. This overall pattern of biogeography can be summarized in a simpler general tree (figure 2), and several other genera have shown the same pattern.

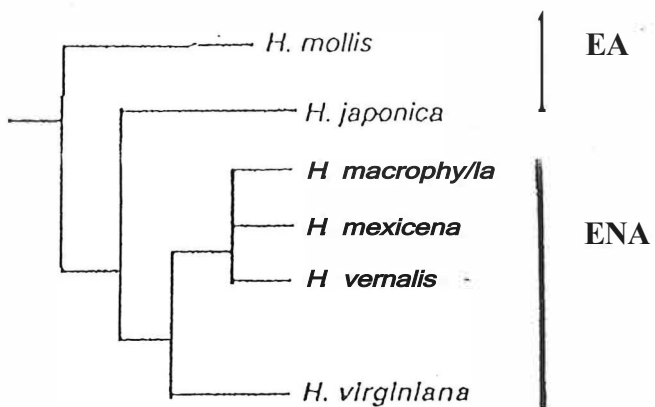


Figure 1. Phylogenetic tree representing relationships between species of *Hamamelis*



Figure 2. Summary of the relationships shown by many genera with species in eastern (ENA) & western (WNA) North America, and eastern Asia (EA)

The above evidence suggests that our current view of this well-known floristic disjunction may need to be modified, and that further phylogenetic comparisons between the two continents are needed.

Because over 10 million years have elapsed since these disjunct groups were separated, most of the taxa involved are at the genus level, with closely related species on the two continents. For example, the ancestors of the two *Liriodendron* species separated some 10 to 16 million years ago, after which the relict populations on the two continents became separate species. In only a few cases can a single species still be found on both continents.

The Importance of Phylogenetics

When seeking to explain an observed disjunction, it is extremely important to confirm that what appear to be closely related taxa, based on observable characteristics, are in fact descendants of a single common ancestor. In other words, that they are truly closely related to one another. The phylogenetic relationships within disjunct groups have been neglected in the past due to the enormity of the geographical ranges involved, but it is currently the focus of much scientific research.

Species that appear to be related because they share common phenotypic (physical) characteristics can be misleading! Two species might look alike because they evolved from a recent common ancestor and have retained most of the same features, just as siblings look alike because they have the same parents. But there may be another, less obvious explanation. Plant species may look alike because similar physical characters evolved independently in separate lineages, due to the fact that they lived in similar environments and were under similar selective pressures. This is called convergent evolution. When determining how closely two species are related, we are concerned only with heritable traits, those that are shared genetically through a common ancestry.

Phylogenetic studies, using DNA markers, proteins and morphological comparisons, combined with fossil evidence and knowledge of the Earth's geological history, enable biogeographers to piece together the complex story behind intercontinental disjunctions.

At VanDusen we have over 35 of the 65 genera that are part of this interesting biogeographical pattern. Today we will see examples of genera with representative species from both eastern Asia and eastern North America. At the end of the handout is a list of additional genera present at VanDusen, for which we have representative species from only one of the two continents. It would be interesting to add a new collection to VanDusen: an eastern Asian - eastern North American floral disjunct collection. Perhaps we should consider it a future goal to acquire the disjunct sister species for each of these taxa.

CAMPSIS - Bignoniaceae

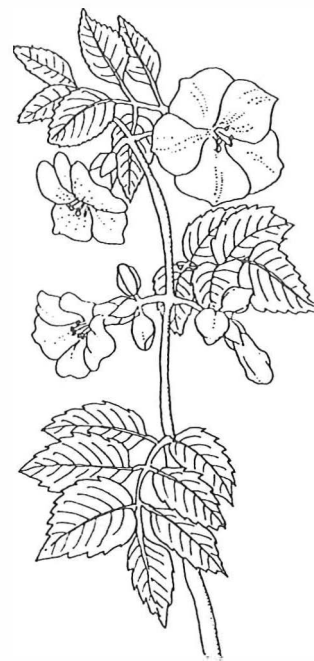
A genus of only two species. One in E. USA, the other in E. Asia.

C. radicans TRUMPET CREEPER Pennsylvania to Florida, west to Illinois & Texas

This shrubby vine climbs up to 10 meters or more. In late summer it produces tubular to trumpet-shaped red-orange flowers, which attract ruby-throated hummingbirds that love to feed on the sweet nectar. Hummingbirds are the primary pollinators of this plant. Bed 107C

C. grandiflora CHINESE TRUMPET CREEPER China

The pinnately compound leaves of this species are up to three times larger than those of the eastern American species, *C. radicans*. This climber is excellent for training over garden walls or tree stumps and prefers an open sunny spot. Bed 121 C



Campsis radicans

GLEDITSIA - Fabaceae

There are 14 species, mostly Asian, with two in E. North America.

G. triacanthos* f. *inermis THORNLESS HONEY LOCUST Ontario; C. & E. USA

The specific epithet means "three-thorned" and refers to the dangerously long, branched thorns that cover the trunk to protect the tree from both herbivores and gardeners alike! However, this is the unarmed form, so it is safe to get up close. In spring one can appreciate the newly formed, delicate, fern-like leaves, which along with the tree's elegant form and whimsical, twisted seed pods, make it a lovely addition to any garden. Bed 70

G. melanacantha HONEY LOCUST China, Japan & Korea

This tree is sometimes referred to by its synonym *G. japonica* var. *japonica* and is rarely discussed in literature on the genus. Bed 124



Gleditsia triacanthos f. *inermis*

HAMAMELIS - Hamamelidaceae

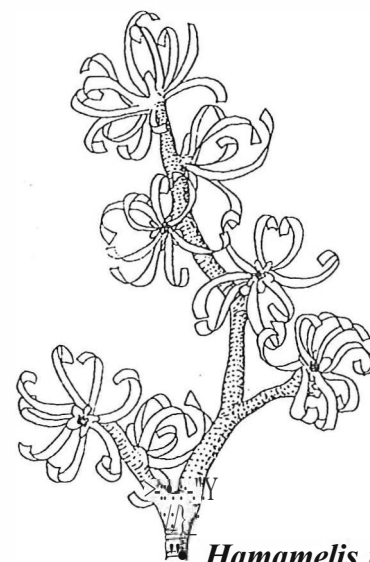
Five to six species, with two in E. Asia and the rest in E. North America.

H. virginiana VIRGINIAN WITCHHAZEL Nova Scotia to Carolinas & Tennessee

A large shrub with sweet-smelling yellow flowers produced in winter. This is the commercial source of medicinal witchhazel, an astringent, tonic and sedative, used to treat bruises, inflammation, diarrhoea, dysentery and hemorrhages. Bed 27A

H. mollis CHINESE WITCHHAZEL China (Hubei & Jiangxi)

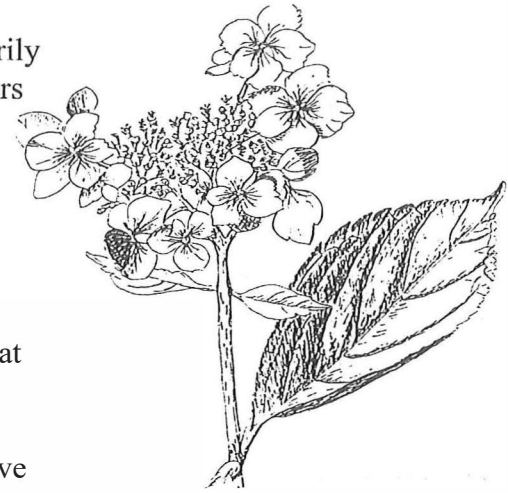
The most popular of the witchhazels. In winter the bare branches are covered with clusters of large, fragrant, golden-colored flowers. In summer the large, rounded, softly hairy leaves add delightful texture to any garden. Bed 46D



Hamamelis mollis

HYDRANGEA section **HYDRANGEA** - **Hydrangeaceae**

The genus has been divided into two sections, distinguished primarily by habit. Section *Cornidia* contains 12 species of evergreen climbers and section *Hydrangea* includes the remaining 11 species in the genus, all deciduous shrubs. Only section *Hydrangea* exhibits an eastern North American - eastern Asian disjunction. Two species occur in eastern USA with the remaining nine in eastern Asia.



Hydrangea macrophylla
var. *normalis*

H. arborescens* ssp. *discolor HILLS-OF-SNOW S.E. USA

Hardier than most hydrangeas, this is quite variable in form. The flat inflorescence of *H. arborescens* is composed primarily of small, white, fertile flowers, with a few large, sterile flowers. Subspecies *discolor* is unique in that it has mostly sterile flowers. Its leaves have tiny warts and downy hairs on their undersides. Bed 48A

H. macrophylla* var. *normalis HORTENSIA S. Japan

This 'f.c.,r,elj' has a very limited distribution, found only in a few parts of central Honshu. In summer it produces a "lacecap" inflorescence and it is the parent of the popular "mophead" hydrangeas. Bed 48B

H. heteromalla N. & W. China & Himalayas

This widely distributed eastern Asian species can grow up to 7 meters in height. It likes plenty of space, as in the mixed forests where it naturally occurs. If planted in a crowded spot it will tend toward legginess. Bed 48B



Hydrangea heteromalla

LIRIODENDRON - **Magnoliaceae**

A genus of two species, with one in E. USA and the other in E. Asia.

L. tulipifera TULIP TREE Massachusetts to Florida & Mississippi

A broad, columnar, deciduous tree with distinctive, four-lobed, saddle-shaped leaves. In early summer it bears tulip-shaped, greenish-yellow flowers. Bed 10

L. chinense CHINESE TULIP TREE China (Hubei & Jiangxi)

Until the discovery of this species in China in the early 1900s, the genus *Liriodendron* was believed to be monotypic, consisting only of the eastern American *L. tulipifera*. Bed 130B



Liriodendron tulipifera

MAGNOLIA - Magnoliaceae

There are 125 species of magnolia, with over 30 in eastern Asia and more than 10 in eastern North America.

***M grandiflora* SOUTHERN MAGNOLIA S.E. USA**

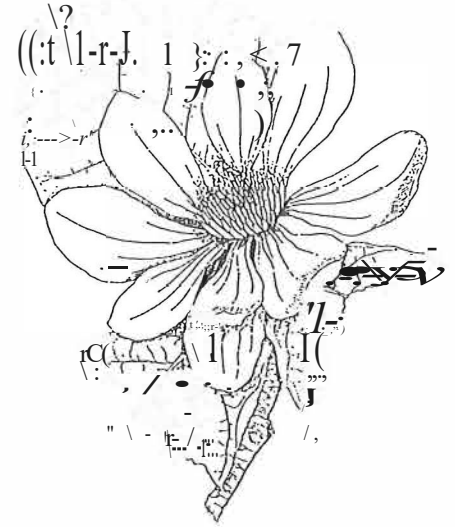
An elegant evergreen magnolia that grows along the bluffs of the Mississippi River and along the margins of ponds and river swamps. This species is variable in habit, leaf and flower attributes, and over 150 varieties have been named. The large, creamy white flowers have a light lemon fragrance. Bed 26

***M denudata* YULAN, LILY TREE C. & E. China**

Found in moist woodlands of the central Chinese provinces, this early-flowering magnolia produces lemon-scented, pure white, blooms. It has been cultivated by Buddhist monks for centuries and was a common constituent of their temple gardens. Bed 26

***M hypoleuca* JAPANESE WHITEBARKMAGNOLIA Japan**

Along with *Magnolia kobus*, this giant of magnolias has the most northerly distribution in the entire genus. In Japan it has been reported to reach over 30 meters in height. The creamy white flowers age to pinkish, and pink-flowered trees are not uncommon. Bed 26



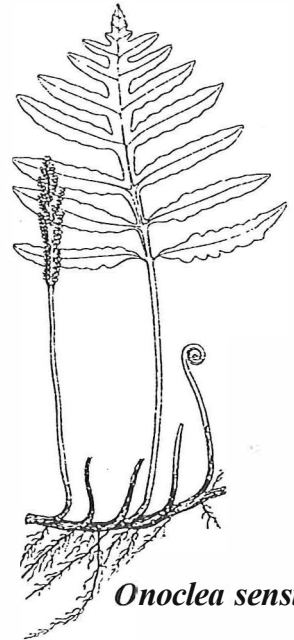
Magnolia hypoleuca

ONOCLEA - Dryopteridaceae

A monotypic genus, with only one species found in both eastern Asia and eastern North America.

***O. sensibilis* SENSITIVE FERN E. Canada & E. USA; E. Asia**

This fern has distinctly dimorphic leaves that occur along creeping rhizomes. The deeply divided, sterile leaves are delicate and deciduous, while the much-smaller fertile fronds appear to be made up of thick strings of beads and persist over winter. The species was named for the sensitivity of the sterile fronds to even the mildest of frosts. Bed 27



Onoclea sensibilis

PARTHENOCISSUS- Vitaceae

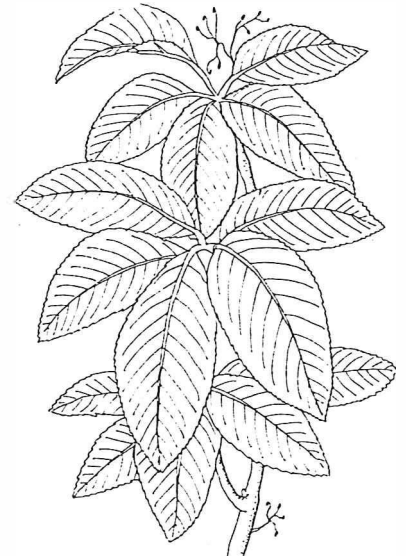
A genus of 12 species of deciduous climbers, three of which occur in eastern North America, with the rest in eastern Asia.

***P. quinquefolia* VIRGINIA CREEPER N.E. & S.C. USA; Mexico**

In autumn this vine sends up a "foliar fruit flag" of bright red leaves surrounding the fruit, a signal to birds that the fruit are ripe and ready to be eaten (and dispersed). Lathhouse

***P. henryana* SILVERVEIN CREEPER China**

A beautiful ornamental vine with dark green or bronze, silvery-veined leaves that turn a rich red color in fall. Bed 128



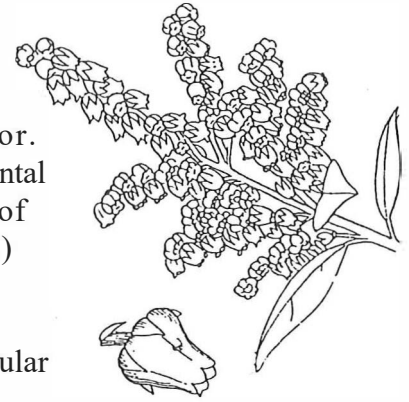
Parthenocissus henryana

PIERIS - Ericaceae

A genus of seven species with two in E. USA, and five in E. Asia.

***P. floribunda* FETTERBUSH** Virginia to Georgia

It is primarily the flowers that distinguish this *Pieris* from other species. The corolla is sharply 5-lobed with a conspicuous pouch or spur at the base of each lobe. The flowers are held in erect, horizontal panicles, and the leaves tend to be shorter and broader than those of other species. Bed 85A (soon to be moved to the ENA Collection!)



Pieris floribunda

P. formosa* var. *forrestii W. China & Myanmar

The brilliant red color of the new leaves in spring make this a popular variety among gardeners. Flowers are held in large semi-erect to drooping panicles, framed by oblong, glossy, dark green leaves. Bed 130D

SASSAFRAS - Lauraceae

Three species, with one in E. North America and two in E. Asia.

***S. albidum* WHITE SASSAFRAS** Ontario & Maine to Texas & Florida

A small tree with spicy aromatic bark. The leaves are used in Creole cooking, and the oil from the leaves is used to treat insect bites. Root beer and sassafras tea are both flavored with bark from the roots. However, despite its myriad of uses, it was recently found that *Sassafras* contains a carcinogenic compound called allylbenzene. In light of this, the FDA has now banned use of the plant in the food and beverage industry. Bed 136



Sassafras albidum

***S. tzuma* CHINESE SASSAFRAS** China (Hubei)

Displays clusters of small green flowers in spring which produce berry-like fruit in autumn. The contrast between the blue-black fruit and the red pedicel is an excellent example of a bicolor fruit display, which is believed to be more attractive to birds than a single color, and is therefore an adaptation for better seed dispersal. Bed 130A

STEWARTIA - Theaceae

A genus of 15 to 20 species, with two in E. USA and the rest in Asia.

***S. ovata* MOUNTAIN STEWARTIA** Kentucky & Virginia to Georgia

Named for its ovate, dark green leaves. In mid to late summer The cup-shaped, white flowers display a profusion of yellow or pink stamens. Bed 46D



Stewartia ovata

***S. monadelph* TALL STEWARTIA** Japan & Korea

A columnar to conical tree with peeling gray or rust-colored bark. The cup-shaped, white flowers can be distinguished from those of other species by the bicolored stamens, with cream-colored filaments and violet anthers. Bed 46D

Additional Genera at VanDusen with an Eastern Asian - Eastern North American Disjunction

<i>Ampelopsis</i>	Vitaceae	<i>Lindera</i>	Lauraceae
<i>Aralia</i> sect. <i>Dimorphanthus</i>	Araliaceae	<i>Lyonia</i>	Ericaceae
<i>Astilbe</i>	Saxifragaceae	<i>Mitchella</i>	Rubiaceae
<i>Carya</i>	Juglandaceae	<i>Nyssa</i>	Comaceae
<i>Catalpa</i>	Bignoniaceae	<i>Osmanthus</i>	Oleaceae
<i>Clad'astis</i>	Fabaceae	<i>Pachysandra</i>	Buxaceae
<i>Camus</i> subgenus <i>Mesomora</i>	Comaceae	<i>Podophyllum</i>	Berberidaceae
<i>Cotinus</i>	Anacardiaceae	<i>Saururus</i>	Saururaceae
<i>Decumaria</i>	Hydrangeaceae	<i>Schisandra</i>	Schisandraceae
<i>Gymnocladus</i>	Fabaceae	<i>Shortia</i>	Diapensiaceae
<i>Halesia</i>	Styracaceae	<i>Stylophorum</i>	Papaveraceae
<i>Illicium</i>	Illiciaceae	<i>Trachelospermum</i>	Apocynaceae
<i>/tea</i>	Grossulariaceae	<i>Triosteum</i>	Caprifoliaceae
<i>Jeffersonia</i>	Berberidaceae	<i>Wisteria</i>	Fabaceae
<i>Lespedeza</i>	Fabaceae	<i>Woodsia</i>	Dryopteridaceae

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Special thanks to Dr. Bruce Bohm, professor of botany at UBC and expert phytogeographer. Recently retired, he is busy writing a book on phytogeography. Currently he is working on a chapter on disjunct species, and he kindly agreed to share his references with us.