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AUTUMN COLOR

ALL indications point to a splendid display of autumn color this fall. There has been plenty of sunshine during September and rainfall has not been excessive. The few days prior to the hurricane of September 14 were about the last during which there was an appreciable amount of rain in Boston. The nights during the first week of October have been very cool, with light frosts in low spots in the Boston suburbs. All these indications thus point to the combination of conditions that should produce a fine display of color during the next few weeks. In order that Arnoldia subscribers will be better able to interpret what they may see during this period, the following notes on autumn color are presented, these data being in part publication of an earlier number of the Bulletin of Popular Information (Series 4, Vol. IV, November, 1936).

The eastern United States is fortunately located in one of the few regions of the world where brilliant autumn coloration of foliage prevails. There is only one small region in the southern hemisphere, and that in South America. In the northern hemisphere, there is a large region in eastern Asia, including central and northern Japan, and a small region in the southwestern part of Europe. In North America, the region characterized by brilliant autumn foliage extends from the Gulf of St. Lawrence to Florida and westward to the Great Plains, areas which are blessed with extensive deciduous forests and considerable rainfall. Here the general climatic conditions are often just what is needed to produce that lovely phenomenon of nature—the autumn coloration of deciduous foliage.

In North America the most brilliant displays of autumn color are of course in southeastern Canada, the northeastern United States and in certain other areas at higher altitudes. The further south one goes, the less brilliant is the display of autumn color, particularly in areas along the seacoast. In the higher altitudes of the South, such as the Blue Ridge Mountains, the color is usually just as brilliant as in the northeastern United States.

It should be pointed out that it is chiefly in areas of predominantly deciduous forests that autumn color displays are best, and such forested areas occur only in two general regions in the world. Plants growing in deciduous forests in tropical regions usually drop their leaves towards the end of the dry season. Since these leaves usually dry up before they fall (because of lack of water), they do not develop brilliant colors but usually turn brown and then fall off. In the case of plants growing in deciduous forests in temperate regions—especially in areas with ample rainfall equally distributed throughout the year—the leaves fall at the approach of cold weather, and because the plants have been well supplied with water, leaves of many trees do change color before they fall. This gorgeous phenomenon is what focuses our attention on the woods and forests at this time each year.

In some years, the autumn color is much more pronounced than in others. There are always plants, the foliage of which turns yellow in the fall, but it is the brilliant reds and gorgeous scarlets which, in combination with the yellows, make autumn color of outstanding beauty. It is chiefly the reds and scarlets which are intensified by the right climatic conditions.

Leaves are green because they contain a complex material called chlorophyll. This is essential to the growth of all plants, except the saprophytes and a few parasites, for it is through the action of chlorophyll that the plant can manufacture the food it requires from crude chemicals in the presence of light and heat. Chlorophyll is a highly complex chemical material, being continually manufactured in the leaf and at the same time being continually broken down. Ordinarily, the rate of its breakdown about equals the rate of its manufacture. In the fall, the rate of chlorophyll manufacture is gradually reduced, although the rate of its decomposition is maintained. The exact cause for this phenomenon is not fully understood, but the accumulation of waste products in the leaf may be the principal cause.

Why leaves are yellow

A certain stage is reached where there is little if any chlorophyll manufactured. Most of the chlorophyll already made eventually is destroyed. This is the reason why leaves are yellow, for the two yellow pigments usually present, carotin and xanthophyll, are continually masked by the chlorophyll. When most of the chlorophyll is destroyed, these pigments become apparent. These same coloring materials are present in large quantities in egg yolk, carrots, and in some yellow flowers.

When green plants are taken into dark places, such as a cellar, the leaves often turn yellow. Also, young shoots appearing for the first time under the dark conditions of the cellar are usually yellow. This is explained by the fact that chlorophyll is manufactured only in the presence of light. When light is absent, plants are unable to manufacture new chlorophyll and the yellow pigments become predominant as soon as all the previously manufactured chlorophyll has been destroyed.

The gradual cessation of chlorophyll manufacture and the final breakdown of all that previously made, completes the first stage in autumn coloration. This is the reason for certain plants becoming yellow. There are some plants, like some magnolias for instance, the leaves of which do not turn yellow, but change from green directly to brown. For some reason, the breakdown of the chlorophyll does not start soon enough or is not complete enough to result in the appearance of the yellow pigments. The yellow color does appear in the foliage of many other plants regardless of the weather conditions. There is an interesting high degree of individuality in certain species. Red maple, for instance, usually turns a good red in the fall, but certain individuals may color yellow. The same can be said of sugar maples and several other plants. This is a most interesting physiological problem worthy of considerable investigation.

Why leaves are red

The gorgeous beauty of most autumn color combinations results from the brilliant reds and scarlets, together with the yellows. The sassafras, some of the maples, oaks, sumacs, sourwood, tupelo, and other plants are particularly outstanding for their brilliant red autumn color. These plants are most interesting in that the brilliance of their color apparently varies from year to year. The red in their leaves is caused by a third pigment called anthocyanin, which results in some way from the accumulation of sugars and tannins in the leaf. In some of the maples valued for their sugar production, it is probably the sugars which cause this red color. The oaks, however, being rich in tannins probably owe their high autumn coloration to the presence of these.

There are two factors necessary in the production of red autumn color. The first is light. There must be warm, bright, sunny days in the fall, during which time the leaves naturally manufacture a great deal of sugar. Secondly, such days must be followed by cool nights, during which the temperature is below 45° F. Plant physiologists have shown definitely that, under such conditions, there is little or no translocation of sugars and other materials from the leaf to other parts of the plant. In other words, when cool nights occur, following warm, bright, sunny days, sugars and other materials are "trapped" in the leaves. The accumulation of these products results in the manufacture of the red anthocyanin.

The combination of these factors is well understood when one observes a certain tree that may be red only on that side exposed to the sun. Other leaves not directly in the sun's rays may be green or yellow. Leaves exposed to the sun have been able to manufacture more sugars, which when accumulated and "trapped" in the leaves by cold night temperatures may result in the red color. It is interesting to note that trees and shrubs growing in swamps and other low places are often among the first to color in the fall, simply because it is in such places that cold air first settles on still nights.

With these points in mind, it can be easily seen why there is so much divergence of opinion about autumn color. When plants are located so that they re-

ceive full sunlight, especially in the late afternoons during the early fall, they should be expected to show pronounced color if the weather conditions have been favorable. On the other hand, if a plant grows in the shade where it receives no direct sunlight, it cannot be expected to have marked autumn color.

One species in the Arboretum annually demonstrates this point. There is a splendid plant of *Fothergilla monticola* in the shrub collection of the Arboretum. This plant is exposed to full sunlight, while the shrub collection is in the lowest spot in the Arboretum, so one would normally expect plants there to color if any did. In years when the climatic conditions have favored autumn color formation, this particular plant of *Fothergilla monticola* is gorgeously colored red and yellow **—on the western side.** On the eastern side, where the foliage is shaded from the late afternoon sun, the foliage is merely colored yellowish and does not show the brilliant contrasts of red and yellow. Fortunately all plants do not show such great variation in autumn color when one side is compared with another, but it is a fact, that the western side usually has the deepest colored foliage when there has been plenty of sunshine. This point should be kept in mind in planting, locations and plants being selected that would show to best advantage during the period of autumn color.

Dull autumn coloration

A warm, cloudy fall, sometimes with much rain, will restrict the formation of bright colors in the foliage. With insufficient sunlight, the sugar production is greatly reduced, and with warm nights, what little sugar has been manufactured in the leaves can be readily transported to the trunk and roots where it has no effect on the color of the foliage.

The leaves of many evergreens change color in autumn. Some of the junipers and arborvitaes are listed in the following groups. Some pines may turn yellow, but usually such color lasts only for a short time, the leaves quickly turning brown. This is particularly true of those evergreen leaves which are normally shed each year, and although the autumn color may not be conspicuous in many evergreen plants, nevertheless it is evident on close examination.

All leaves eventually turn brown. This is not an autumn color, but is merely the result of the death, and in some cases the decay of the plant tissue. Sometimes, the leaves turn brown while they still remain on the tree, as in the American beech and in some of the oaks. In other cases, like the sugar maple and the spicebush, the leaves drop from the plants while they are still brightly colored and turn brown afterwards.

Autumn color is then a physiological phenomenon which is very complex. There are plants the leaves of which will always turn yellow regardless of current climatic conditions, but many of the plants with red fall foliage will be striking in appearance only when warm, sunshiny days prevail, followed by nights with temperatures below 45° F. The sugar formation in the leaf, the amount of sunshine

received by the plants, and the temperature of the air are three variable factors which to a large degree control autumn coloration.

Woody Plants with Autumn Color

The following plants are listed according to their most conspicuous autumn color. As has been explained above, these may change from year to year, depending on climatic conditions. For instance, some years *Cladrastis lutea* will be yellow, other years the same trees will be purplish. The degree of color may also depend on soil conditions, it being a well-known fact that pin oaks, for instance, which have received heavy applications of nitrogenous fertilizers, will have a much deeper red color than those grown on poor soils without such fertilizers. With these qualifications in mind, the following lists are offered. Plants with an asterisk (*) usually show conspicuous autumn color.

Autumn Color - Red

*__Acer__ Ginnala
japonicum
mandshuricum
palmatum
platanoides Schwedleri
* rubrum – red and yellow
* Schlesingeri – very early red
* saccharum – red and yellow
triflorum
__Aronia__ arbutifolia
melanocarpa
prunifolia
*__Berberis,__ many species
__Carpinus__ caroliniana
*__Cornus__ alba
* florida
kousa
mas
stolonifera
*__Cotinus__ americanus
* Coggygria
__Cotoneaster__ divaricata
*__Crataegus__ Phaenopyrum
*__Enkianthus__ campanulatus
* perulatus
*__Euonymus__ alata
atropurpurea
europaea
obovata
* sachalinensis
sanguinea
*__Fothergilla__ species – red and yellow
__Franklinia__ alatamaha – red and yellow
*__Liquidambar__ Styraciflua – red and yellow
__Malus__ Dawsoniana – red and yellow
__Nemopanthus__ mucronatus
*__Nyssa__ sylvatica
*__Oxydendrum__ arboreum
*__Parthenocissus__ quinquefolia
* tricuspidata
__Photinia__ villosa
__Prunus__ mandshurica
Maximowiczii
nipponica
* Sargentii
*__Pyrus__ communis
* pyrifolia
* ussuriensis
*__Quercus__ borealis maxima
* coccinea
* palustris
* velutina
__Rhododendron__ calendulaceum
Schlippenbachii

*Rhododendron Vaseyi
*Rhus aromatica
* copallina – shining red
* glabra
* radicans – red and yellow
* typhina
verniciflua
Ribes aureum
hirtellum
odoratum
*Rosa rugosa – red and yellow
setigera
* virginiana – red and yellow
*Sassafras albidum – red, yellow to orange
*Spiraea prunifolia – glossy red
Syringa oblata dilatata
*Vaccinium species
*Viburnum dentatum
* Lantana – deep red
* prunifolium
* tomentosum – velvety, dull red

Autumn Color - Reddish to reddish purple

Cornus Amomum
* racemosa
Forsythia viridissima
*Fraxinus americana
*Gaultheria procumbens
*Gaylusaccia brachycera
Ilex decidua
*Juniperus horizontalis plumosa
virginiana
*Leucothoe Catesbaei
Ligustrum obtusifolium Regelianum
*Mahonia Aquifolium
* repens
Malus baccata
purpurea Eleyi
* sublobata
Myrica pensylvanica – bronze
*Pachistima Canbyi
Physocarpus monogynus
Prunus allegheniensis Daviesi
armeniaca "Mikado"
canescens
cyclamina
serrulata spontanea
*Quercus alba
Rhododendron obtusum Kaempferi
roseum
Rubus hispidus
Symphoricarpos Chenaultii
*Thuja occidentalis ericoides – purple
plicata – bronze
*Viburnum acerifolium
Carlesii
* dilatatum
* Lentago
molle
Rafinesquianum affine
Vitis Coignetiae

Autumn Color - Yellow

*Acer pensylvanicum
* platanoides
rufinerve
saccharinum
Actinidia arguta
*Amelanchier species – yellow to red
*Assimina triloba
*Betula species
*Celastrus species
Cercidiphyllum japonicum
*Cercis canadensis
*Cladrastis lutea – yellow to purplish
*Clethra acuminata
* alnifolia
Diospyros virginiana
Dirca palustris

*Ginkgo biloba
*Hamamelis mollis
* vernalis
* virginiana
Hypericum species
Kalopanax pictus
Kerria japonica
*Larix decidua
* laricina
*Lindera Benzoin
*Liriodendron Tulipifera
Maclura pomifera
Malus Halliana spontanea – yellow and purple
Ostrya virginiana
Parrotia persica – yellow to orange
*Phellodendron amurense
Physocarpus opulifolius
Populus alba
grandidentata
nigra italica
tremuloides
Poncirus trifoliata
Prinsepia sinensis
*Pseudolarix Kaempferi
*Sorbus americana
* aucuparia
Ulmus americana
Zelkova serrata

Autumn Color - Yellowish to Bronze

Aesculus parviflora – yellow brown
*Carya species – yellow to brown
*Castanea dentata – yellow to brown
mollisima – yellow to brown
Dirca palustris
*Fagus grandifolia
* sylvatica
Gymnocladus dioica
*Magnolia stellata – yellow brown
Malus ioensis plena – yellow brown
*Quercus imbricaria

No autumn color

Ailanthus altissima
Akebia quinata
Baccharis halimifolia
Clematis, many species
Daphne Mezereum
Davidia involucrata
Elaeagnus angustifolia
Euonymus Bungeana semipersistens
Hibiscus syriacus
Ligustrum vulgare
Lonicera fragrantissima
syringantha
thibetica
Lycium halimifolium
Polygonum Auberti
Potentilla species
Prunus Persica
Robinia Pseudoacacia
Salix blanda
pentandra
Sophora japonica
Vitex Negundo

Note:—Since this number of Arnoldia deals with foliage colors for a short period in the fall only, attention should be called to other recent issues which treat of foliage colors at other times throughout the year.

Winter Foliage Color of Narrow-leaved Evergreens. Arnoldia, Volume 3, No. 3, May, 1943.

Broad-leaved Evergreens with Green Foliage Throughout the Winter. Arnoldia, Volume 3, No. 4, May, 1943.

Foliage Colors of Woody Plants April to September. Arnoldia, Volume 2, Nos. 11 to 12, December, 1942.

Autumn blooming shrubs

The display of color in the fall not only consists of colored foliage and bright colored fruits, but also includes the flowers of a few late blooming shrubs and vines. The sweet autumn clematis (*Clematis paniculata*) and the fleecevine (*Polygonum Auberti*) are two vines whose white flowers have considerable merit in the fall.

Elsholtzia Stauntoni is a fall flowering shrub from China which grows about four feet tall and has many spikes of small lilac colored flowers. It was first introduced into this country in 1905, and although it has not found its way into many gardens, it is listed by several nurseries.

Franklinia alatamaha in the Arnold Arboretum begins to bloom about the first of September and continues until frost kills flower buds and leaves. The plants this year do not have many of their pure white, waxy flowers, due in large measure to the serious set-back the plants received in the prolonged drought this summer. Usually at this time they are covered with flowers. Though this native American plant is usually grown in the south as a tree, it is grown in the Arnold Arboretum as a shrub, with many branches from the base of the plant. When grown in this manner, winter killing is not nearly as severe as it is when the plant is grown as a tree, and, also, soil can be mounded around the base of the plant to aid in winter protection.

There are several members of the *Lespedeza* clan which are in bloom now. One of the most conspicuous this year is *Lespedeza japonica*, almost impossible to find in nursery catalogues, but a handsome, free-flowering shrub nevertheless, with its pure white flowers borne on conspicuous terminal spikes. Our plant is about four feet tall. *Lespedeza Thunbergii* is also in full bloom, with pink flowers. It is only about three feet tall, and the flowers are not as conspicuous as those of *L. japonica*. The native witch-hazel (*Hamamelis virginiana*) is starting to bloom now, usually an indication that most shrubs have ceased flowering for the year. However, the unseasonably warm weather (it was 86° the other day) not only brought it into bloom ahead of schedule, but the flowers of many spring blooming shrubs (*Spiraeas*, *Chaenomeles*, etc.) are starting to appear here and there in the plantings also. The "advantages" of New England weather this year have been forcibly emphasized by a late spring freeze, a long summer drought, an earthquake, a hurricane, and now a real Indian summer; to say nothing of a mosquito menace in mid October!

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