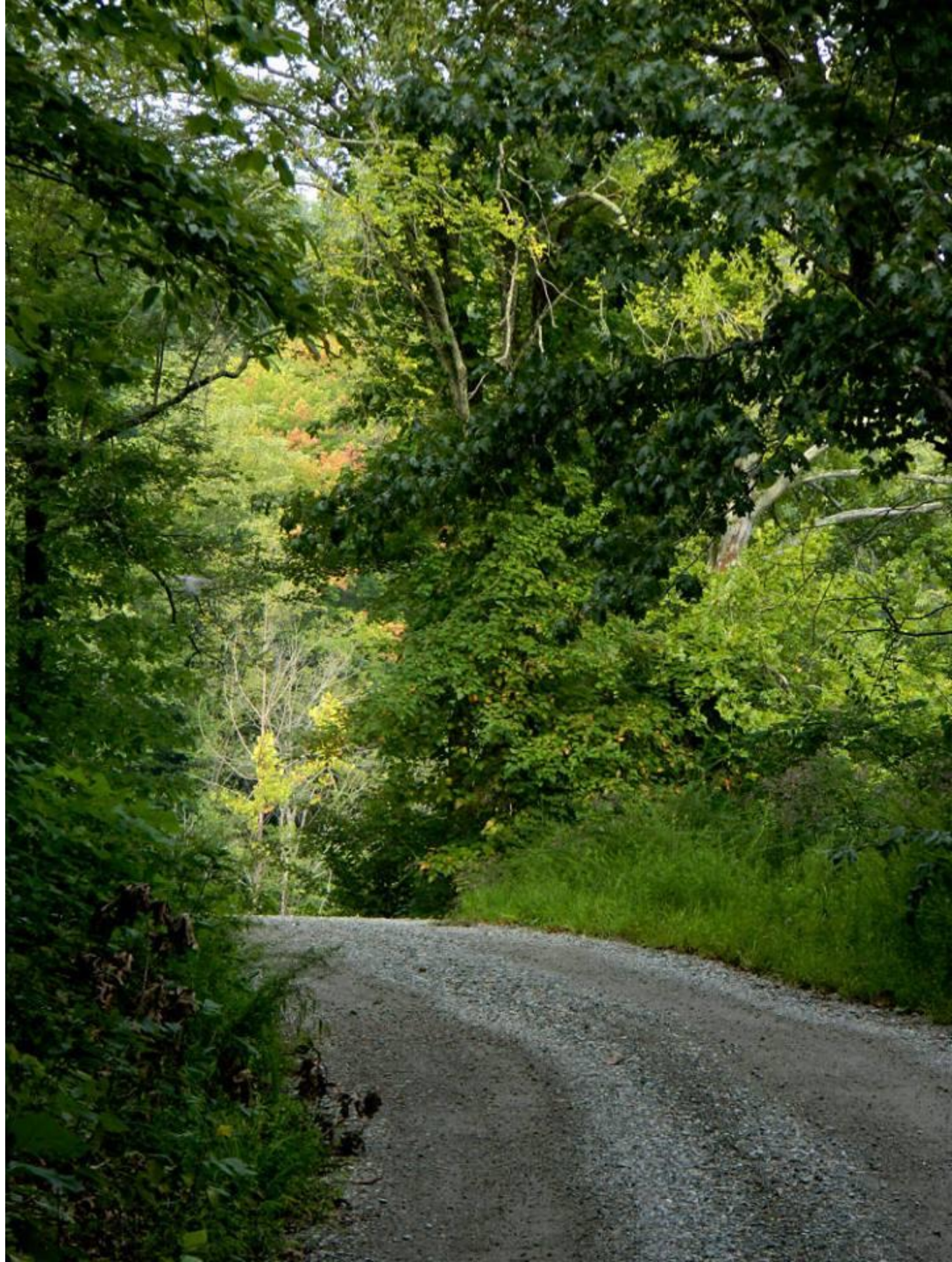


The Botany of Fall Color

**W. John Hayden
University of Richmond
& Botany Chair, VNPS**

**Powhatan WMA,
road along Lower Lake**





***Sassafras albidum* – sassafras**
Dutch Gap, Chesterfield Co., VA

***Sassafras albidum* – sassafras**
Powhatan Co., VA



***Acer saccharum* – sugar maple**
University of Richmond

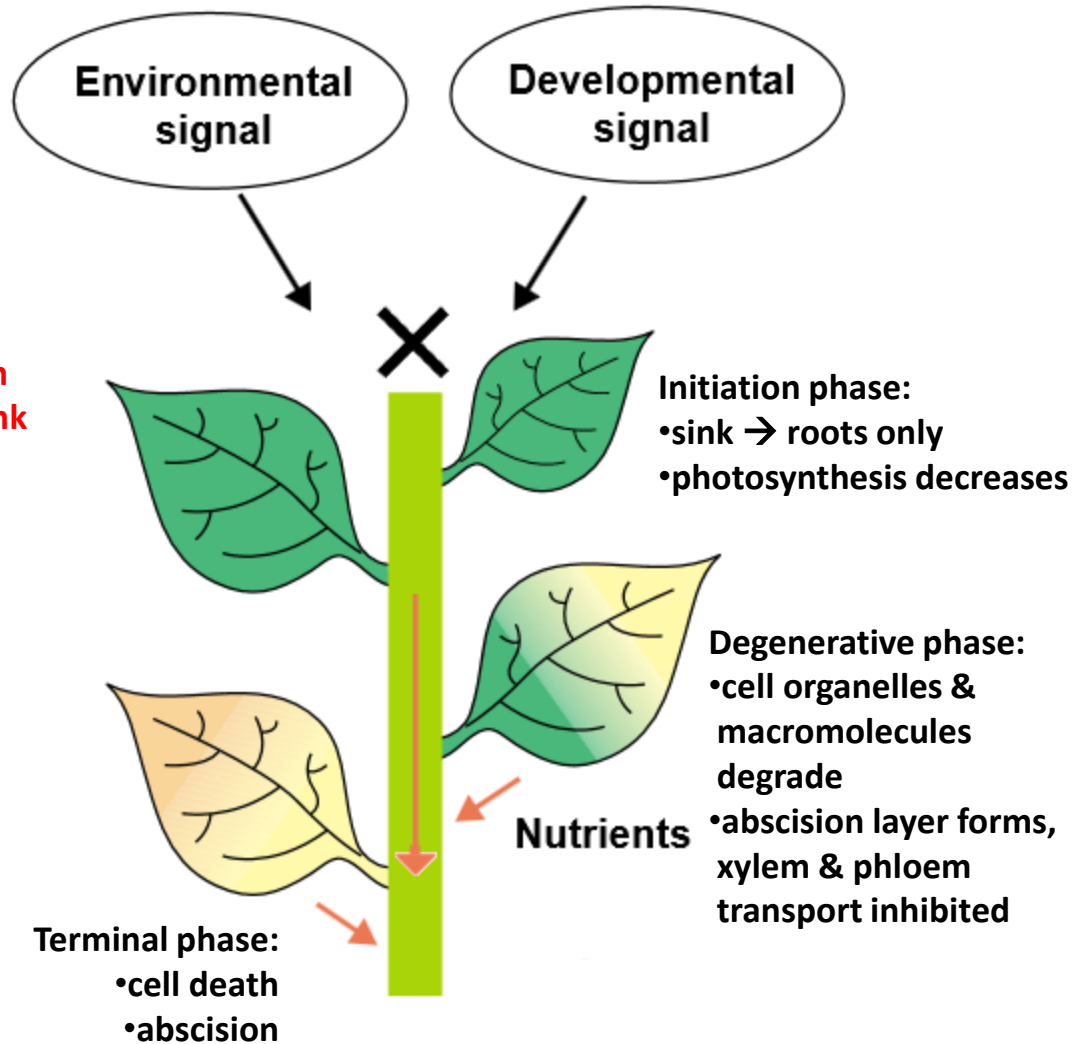
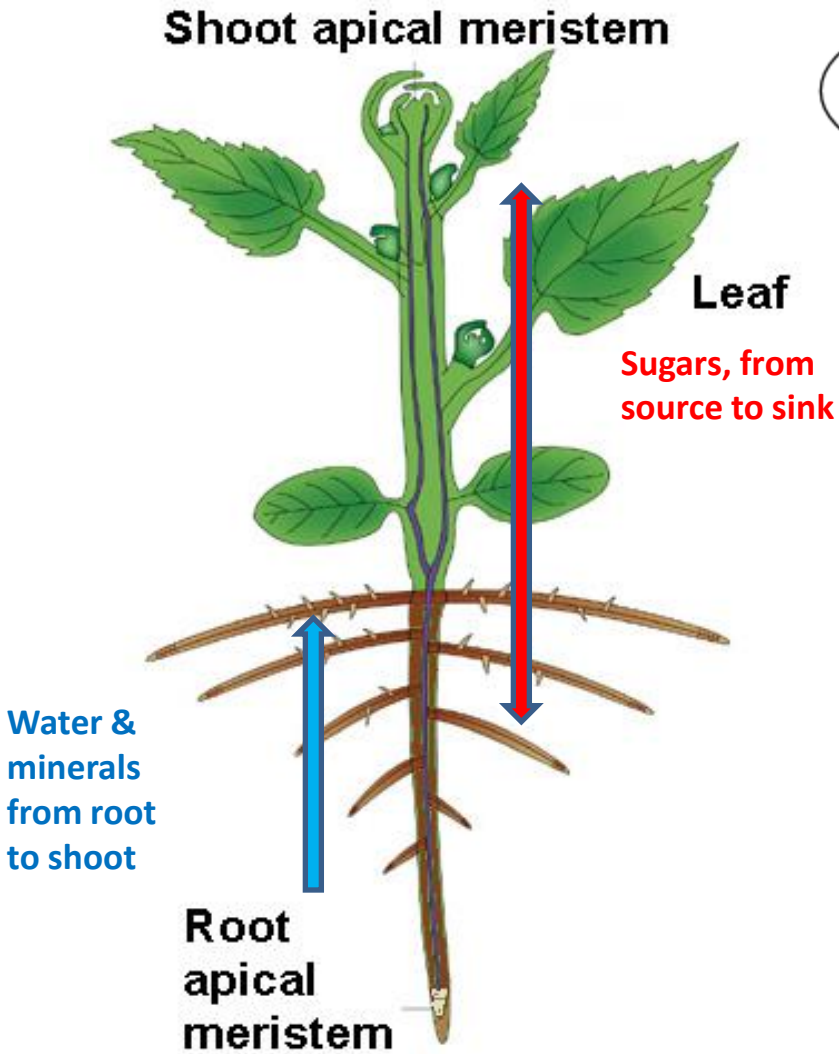




***Acer rubrum* – red maple**
University of Richmond

Basic physiology during active growth:

Physiology of senescence (overview):



Modified from diagram in:
Yoshida. 2003. Molecular Regulation of Leaf Senescence.
Current Opinion in Plant Biology. 6: 69-84

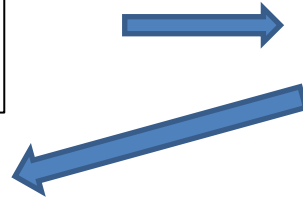
Physiology of senescence (late summer & fall)

•Environmental signals:

- photoperiod – less daylight
- temperature decrease

•Internal signals (hormones):

- auxin decreases
- ethylene increases
- abscissic acid increases



- active meristems → dormant buds
- new chlorophyll synthesis
 - slows,
 - eventually stops completely
- existing chlorophyll degrades
 - green color is lost
 - carotenoid pigments unmasked
- macromolecules degrade
 - AA's simple sugars, etc., transported to roots for winter storage
- leaf abscission begins, impairs:
 - xylem – water transport to leaf
 - phloem – sugar transport from leaf
 - induces anthocyanin pigments

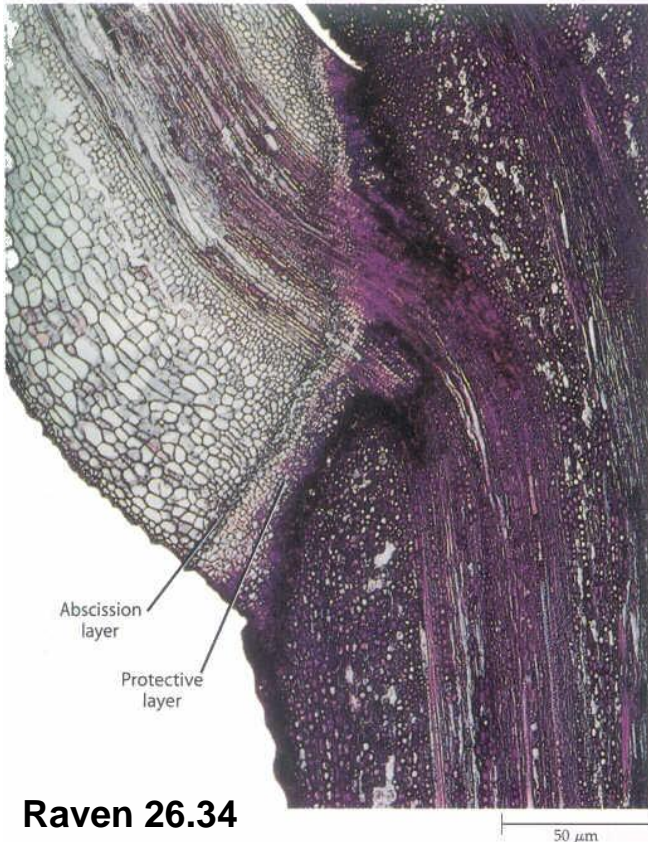


Aesculus parviflora
bottlebrush buckeye

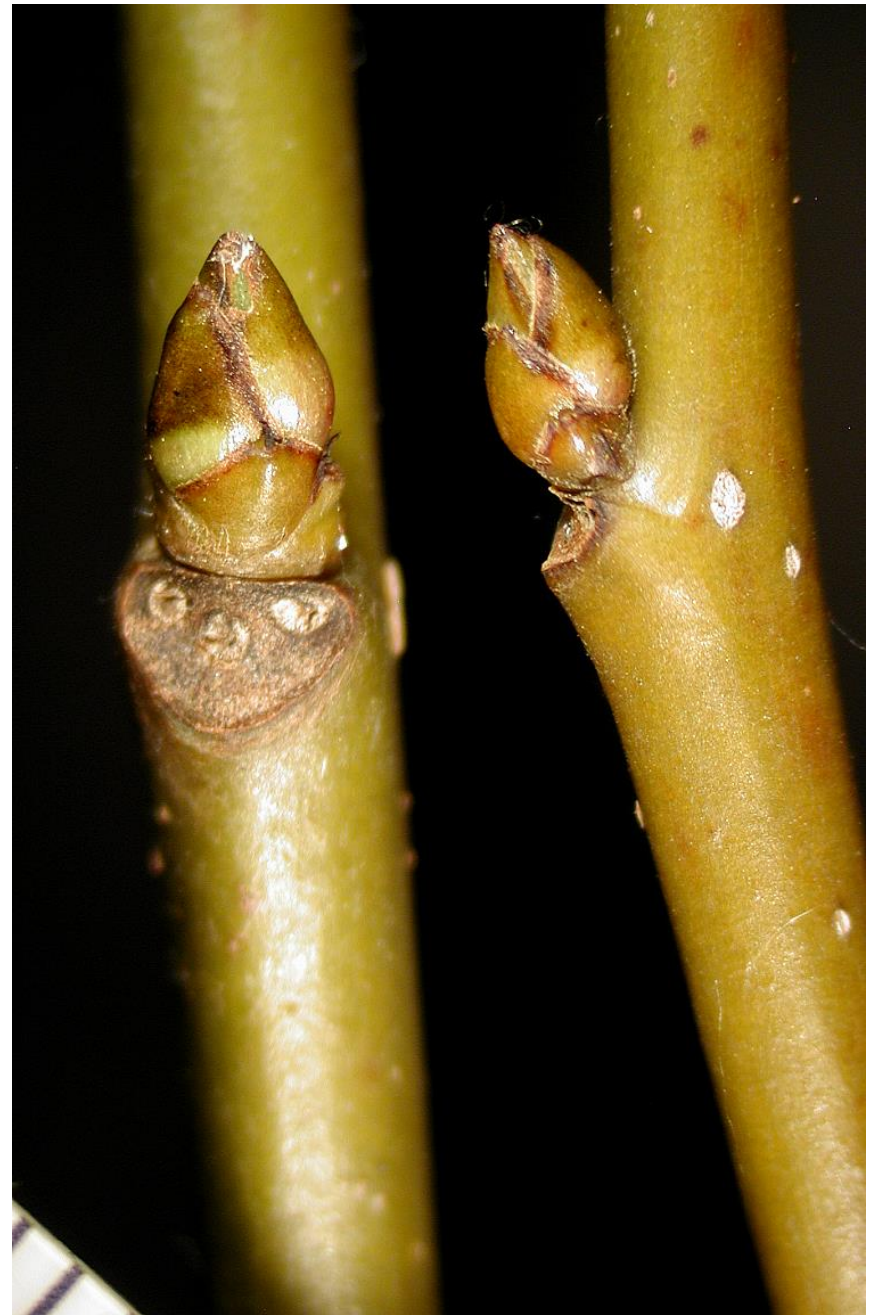
Lewis Ginter Botanical Garden

Leaf Abscission

- abscission or separation layer
 - small, weak cells
 - under hormone induction middle lamella dissolves
- protective layer of cork cells
 - impermeable
 - becomes leaf scar



Raven 26.34



Liquidambar styraciflua – sweet gum

The pigments . . .

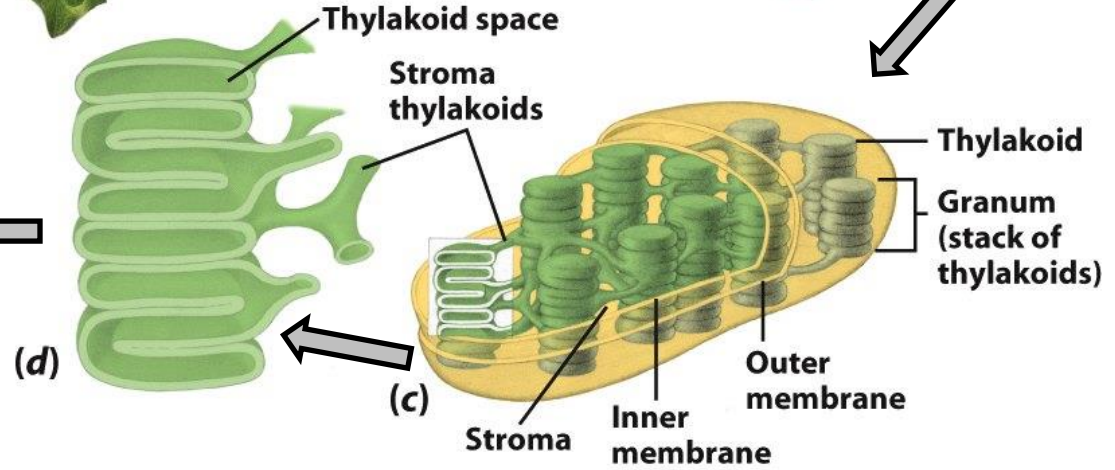
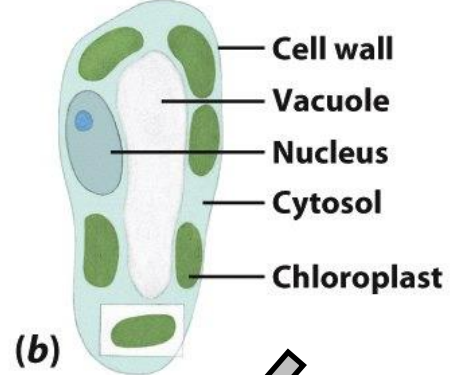
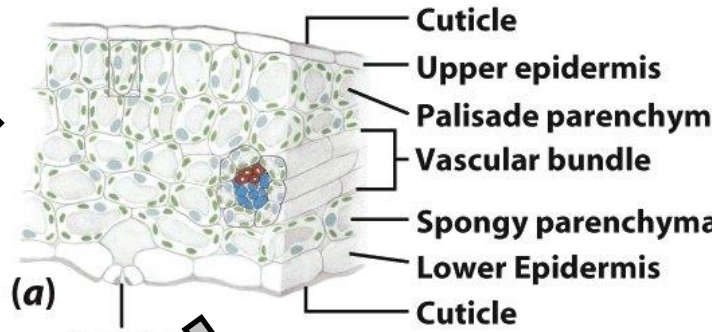


Acer x freemanii– Freeman maple
(*Acer rubrum* x *Acer saccharinum*)
University of Richmond

Chlorophyll & Carotenoid Pigments

- lipid-soluble molecules
- components of chloroplast thylakoid membranes

Whole plant (dandelion)



Photosynthetic pigments:

- Chlorophyll a
- Chlorophyll b
- Carotenes
- Xanthophylls

Figure 7-7
 Biology of Plants, Seventh Edition
 © 2005 W. H. Freeman and Company

Chromatographic separation of photosynthetic pigments

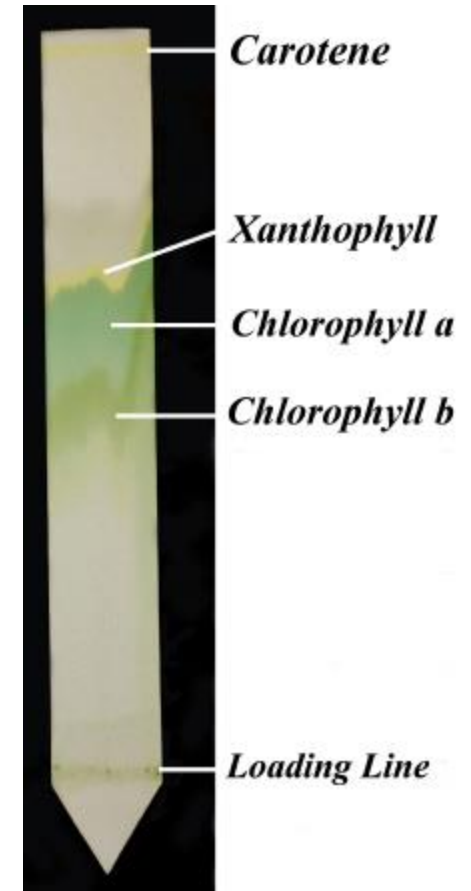
Acetone or ethanol extract
of green leaf pigments

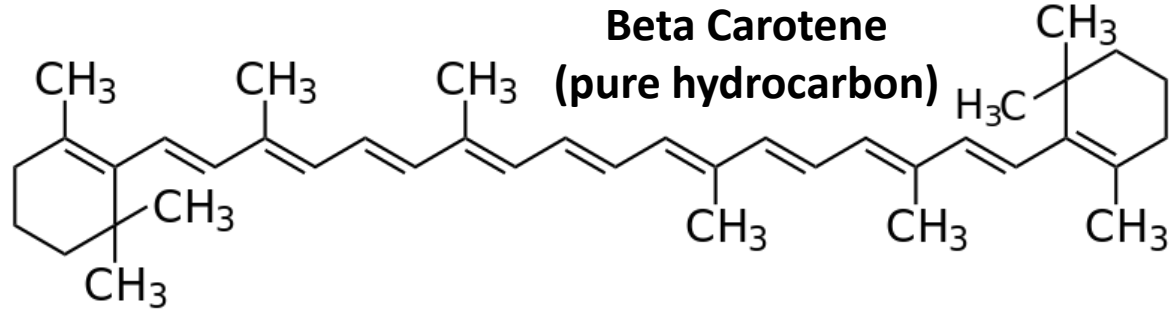


“Spotting” pigment extract
on chromatography paper

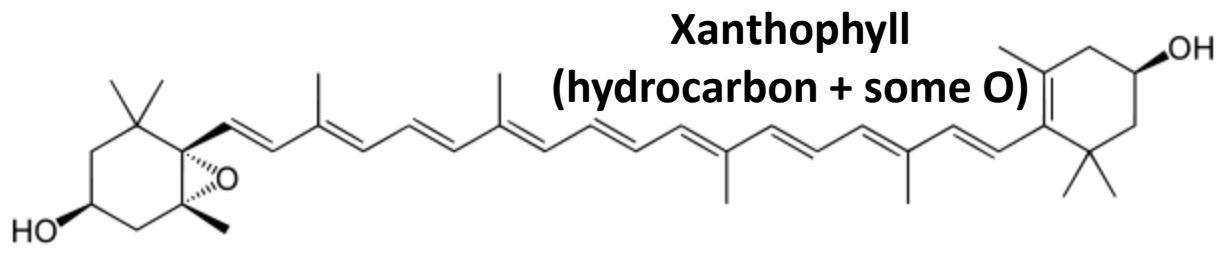


Chromatographic separation
of pigments





Carotenoid Pigments



Sassafras albidum
sassafras
University of
Richmond



**Taxa with carotenoids dominant
in fall color (brilliant yellows):**

***Acer* – maple**

***Alnus* - alder**

***Betula* - birch**

***Carya* – hickory**

***Fraxinus* – ash**

***Liriodendron* – tulip/yellow poplar**

***Platanus* - sycamore**

***Populus* – aspen/poplar**

***Prunus* – cherry**

***Sassafras* – sassafras**

(List from Wikipedia)

***Aesculus flava* – yellow buckeye**

University of Richmond



Aesculus parviflora
bottlebrush buckeye
Lewis Ginter Botanical Garden



© W J Hayden



***Carya* sp. – hickory**
University of Richmond



Cercis canadensis – redbud
University of Richmond



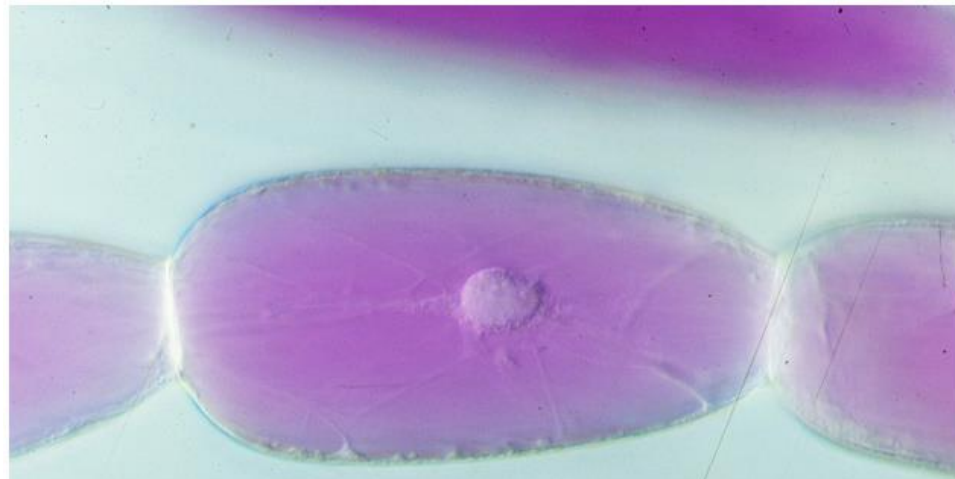
***Liriodendron tulipifera* – tulip poplar**
University of Richmond



***Morus alba* – mulberry**
Piedmont Virginia Community College

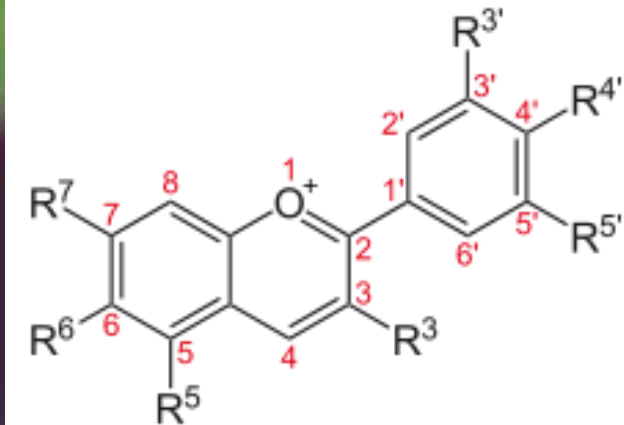
Anthocyanin Pigments:

- water soluble pigments
 - contained in cell vacuoles
 - red to purple
 - color can be pH sensitive
- in some plants, always present
- in other plants, increases in Fall



Single cell from stamen-hair of *Tradescantia*; purple anthocyanin pigments contained in vacuole (which occupies most of the cell volume)

© Biological Photo Service



Anthocyanidin basic structure; addition of sugar molecules converts it to anthocyanin (image ex Wikipedia)

Tradescantia pallida
Chesterfield Co.



Some plants produce large amounts of anthocyanins in young foliage

- **new growth, young leaves:**
 - **delicate, tender**
 - **fibers and sclereids immature**
- **protective functions of anthocyanins in young plant tissue:**
 - **“sun block” effect**
 - **color effect on herbivores, red leaves:**
 - **not recognized as food?**
 - **foil green insect camouflage from predators**

***Photinia x fraseri* – red-tip
University of Richmond**



**Taxa with anthocyanins dominant
In fall color (reds & purples):**

***Acer* – maple**

***Cornus* – dogwood**

***Diospyros* - persimmon**

***Liquidambar* – sweet gum**

***Nyssa* – tupelo, sour gum**

***Quercus* – oak**

***Oxydendrum* – sourwood**

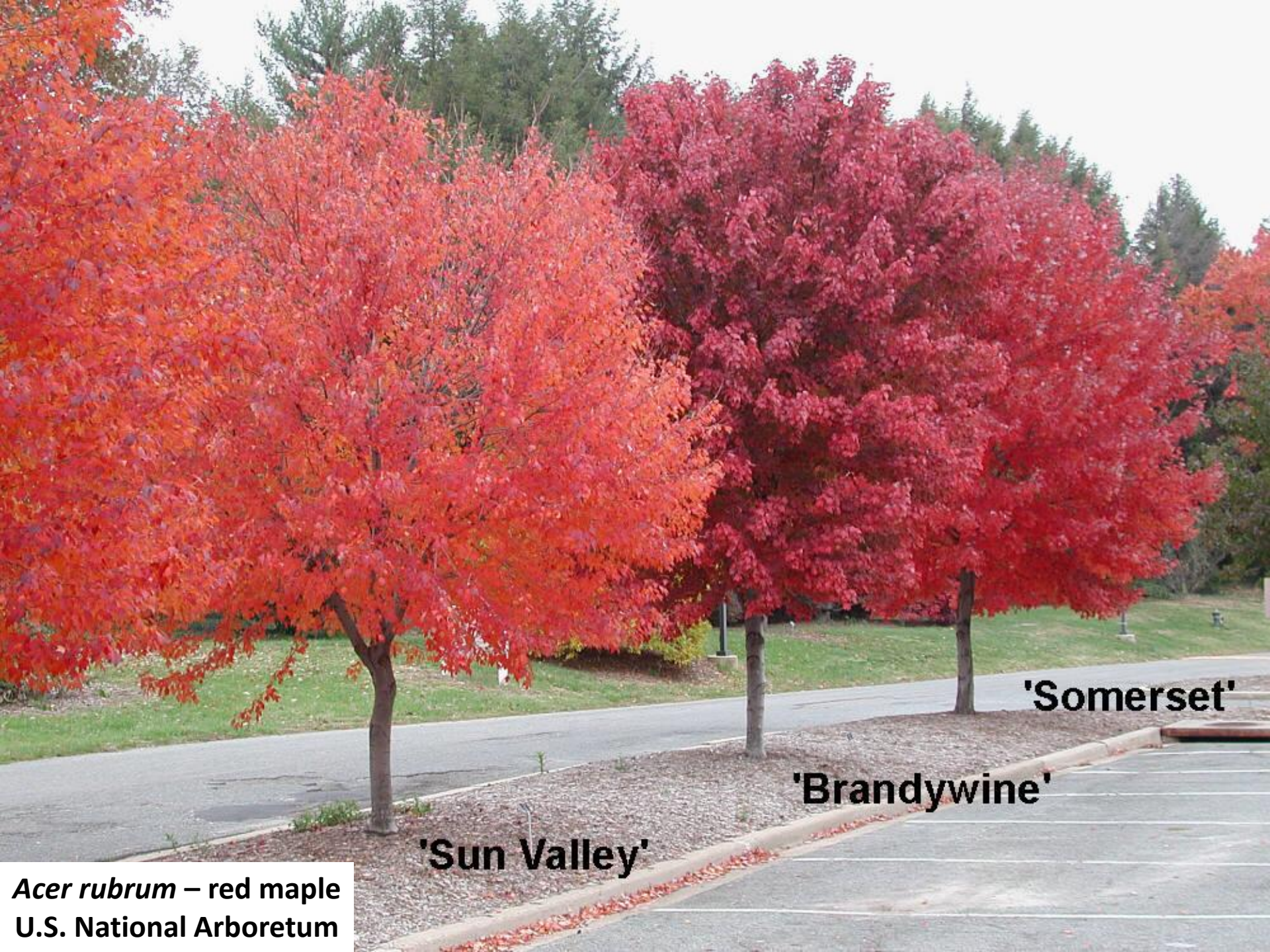
***Prunus* – cherry**

(List from Wikipedia)

***Oxydendrum arboreum* – sourwood
University of Richmond**

***Acer rubrum* – red maple**
Powhatan Co., VA





'Somerset'

'Brandywine'

'Sun Valley'

***Acer rubrum* – red maple
U.S. National Arboretum**



***Cornus florida* – flowering dogwood
University of Richmond**

***Hydrangea quercifolia* 'Sike's Dwarf'**
Lewis Ginter Botanical Garden





***Nyssa sylvatica* – black gum**
U. S. National Arboretum

Quercus alba – white oak
University of Richmond





Rhus aromatica – fragrant sumac
Sweet Briar College

***Oxydendrum arboreum* – sourwood**
Lewis Ginter Botanical Garden





Diospyros virginiana
persimmon
Powhatan Co., VA



**Combinations of
Carotenoids &
Anthocyanins**

***Acer saccharum* – sugar maple
University of Richmond**

Acer rubrum – red maple
Powhatan Co., VA





***Acer rubrum* – red maple**
East Tennessee State University

Prunus serrulata 'Kwanzan'
University of Richmond





***Cornus florida* – flowering dogwood**
University of Richmond



Toxicodendron radicans – poison ivy
University of Richmond

**Dominance of anthocyanins vs
carotenoids may depend on
environmental conditions**



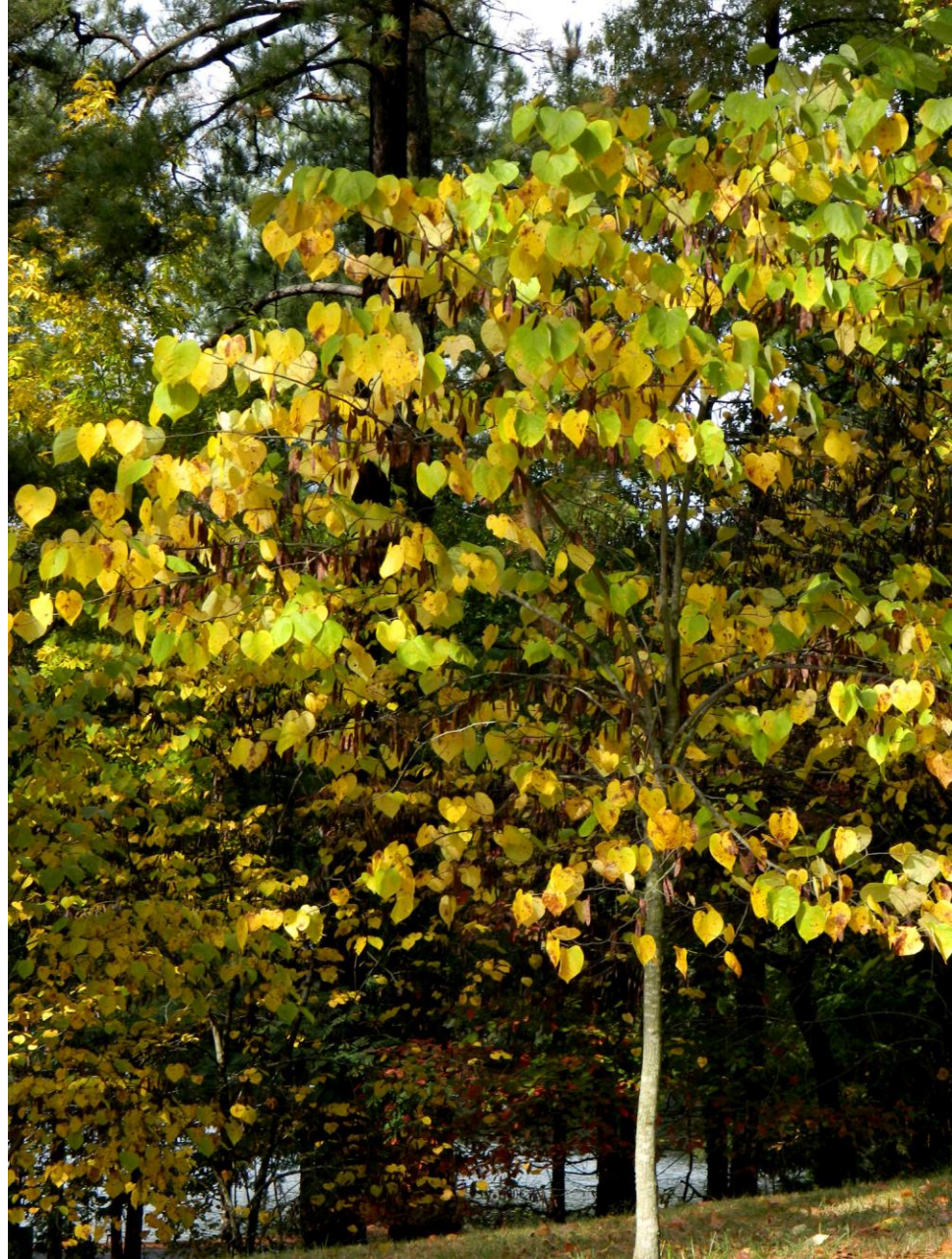
***Sassafras albidum* – sassafras
Johnson City, TN**

***Sassafras albidum* – sassafras
University of Richmond**

© W J Hayden



***Cercis canadensis* 'Forest Pansy' – redbud (spring)**
Van Dusen Bot. Gard., Vancouver, BC



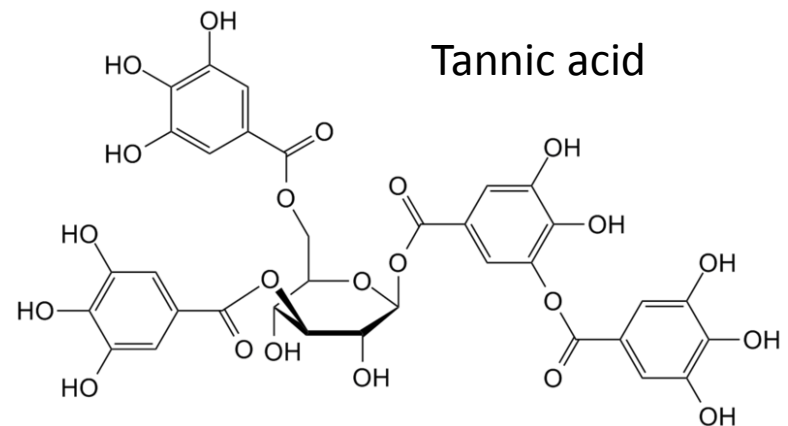
***Cercis canadensis* – redbud (fall)**
University of Richmond



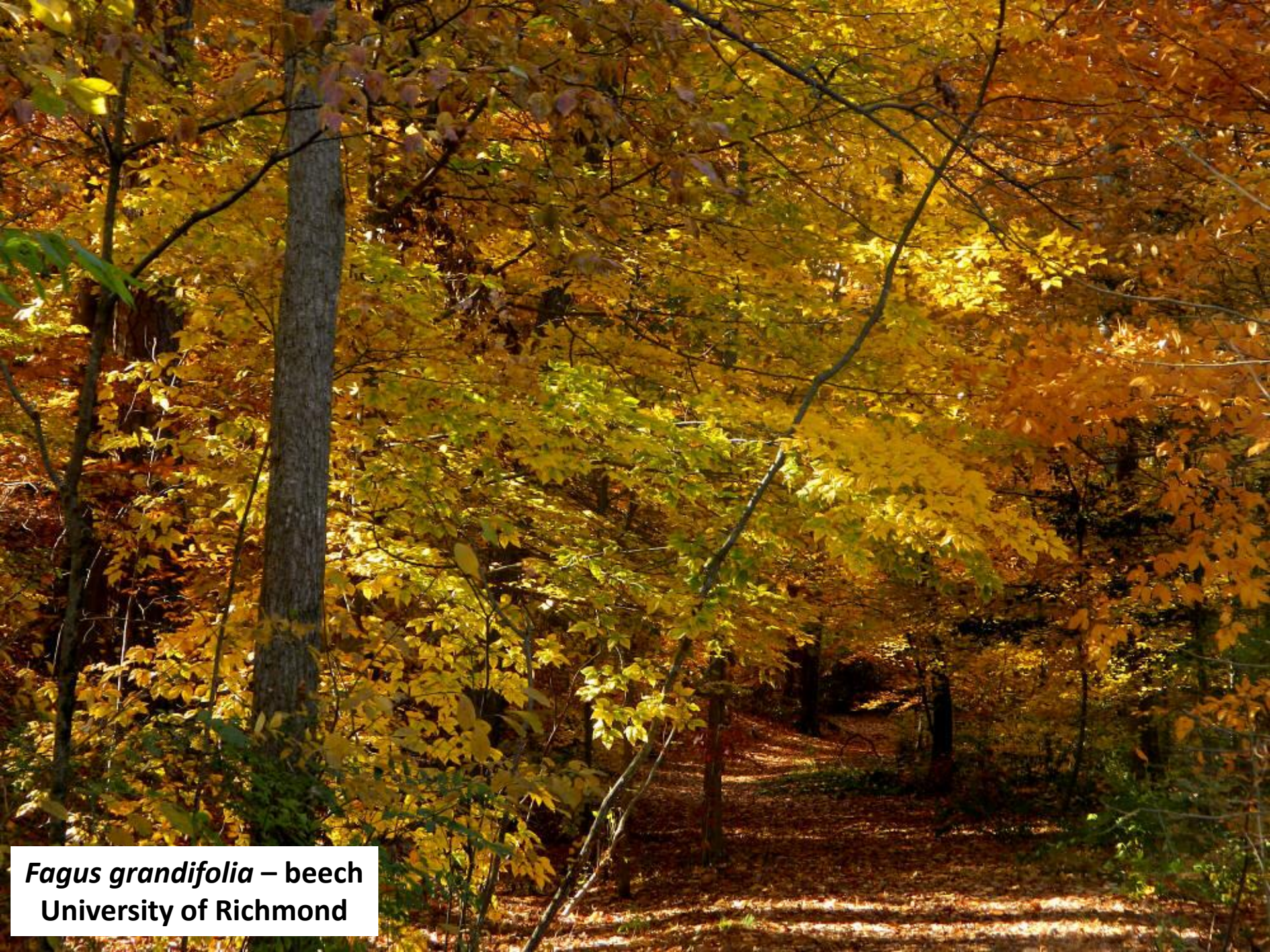
Brown Colors

- from deposits of tannins in leaves
- like anthocyanins, also deposited in cell vacuoles

(Wikipedia states that brown colors in leaves come from the cell walls, but this is just plain incorrect!!!)



***Fagus grandifolia* – beech
Powhatan Co., VA**



Fagus grandifolia – beech
University of Richmond



***Magnolia virginiana*– swamp bay
University of Richmond**



© W J Hayden

***Taxodium distichum* – bald cypress**
U. S. National Arboretum



© W J Hayden



White fall “color”

- absence of pigments
- rare

Euponymus americanus
strawberry bush
University of Richmond



*Eupnymus
americanus*

strawberry
bush

University
of Richmond



Fall color in shrubs

***Hydrangea quercifolia* 'Sike's Dwarf'**
Lewis Ginter Botanical Garden

Itea virginica 'Harry's Garnet'
U. S. National Arboretum





Rhus aromatica – fragrant sumac
Lewis Ginter Botanical Garden

Rhus copallinum – winged sumac
Powhatan Co., VA



Rhus glabra – smooth sumac
U. S. National Arboretum





Viburnum acerifolium
maple-leaf viburnum
University of Richmond

Viburnum prunifolium – black haw
Point of Rocks Park, Chesterfield Co., VA





Fall color in herbs

Apocynum cannabinum
dogbane
Palmyra, VA



***Amsonia hubrechtii* – bluestar**
Lewis Ginter Botanical Garden

Very few monocots have notable fall color

. . . but some grasses do:



© W J Hayden

Miscanthus floridulus



© W J Hayden

Molina coerulea ssp.
arundinacea 'Sky Racer'

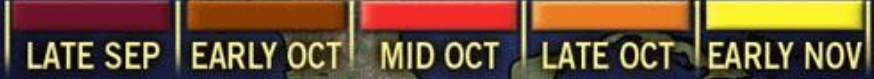
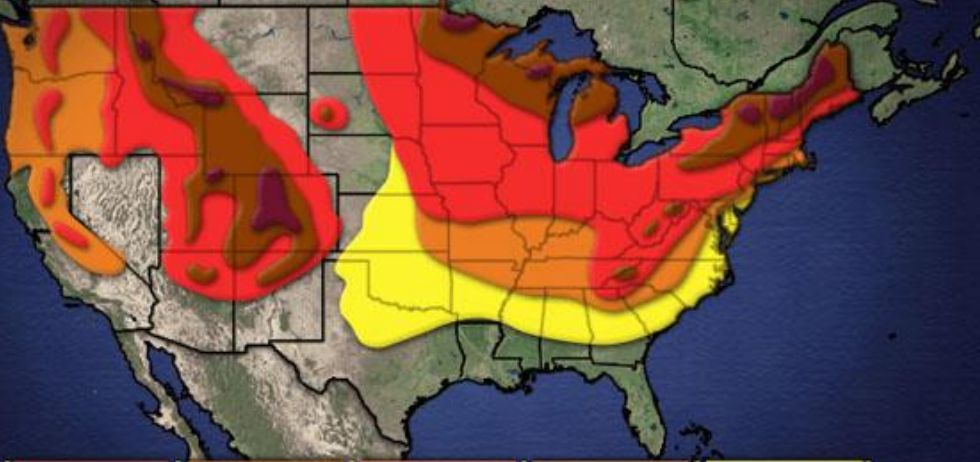


Panicum virgatum
'North Wind'

All photos: U. S. National Arboretum

17:03Z 5-OCT-08

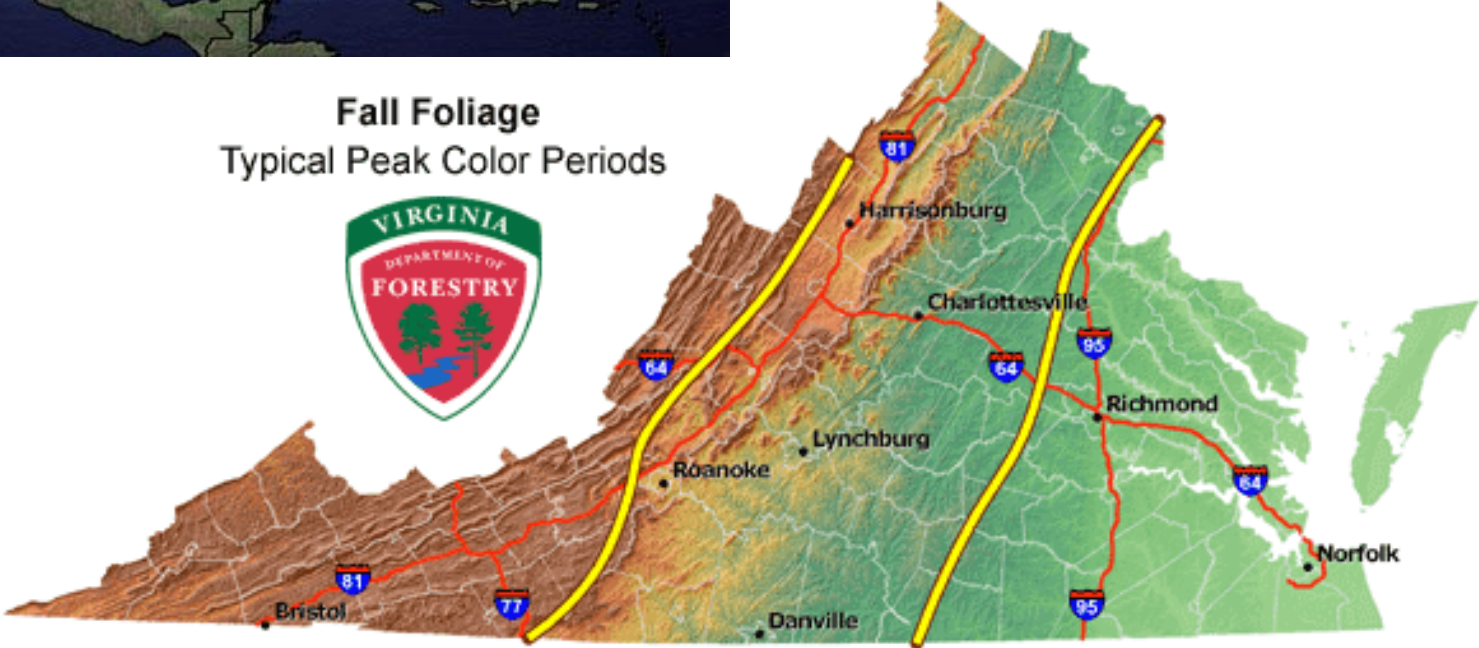
Average Time of Peak Foliage Color



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Calendar Season of Fall Color

Fall Foliage Typical Peak Color Periods



Oct 13-Nov 3

Oct 27-Nov 10

Nov 1-Nov 15

Fall color: a global perspective

•some degree of fall color occurs wherever deciduous trees are found

“best” areas:

- Eastern US & southern Canada
- Western Europe north of Alps (incl. Scandinavia)
- Caucasus region (near Black Sea)
- Russia
- Eastern Asia (NE China, Korea, Japan)
- South island of New Zealand



Fall color:

Eastern N America vs Western Europe

800 tree species

51 tree species

70 oaks

3 oaks

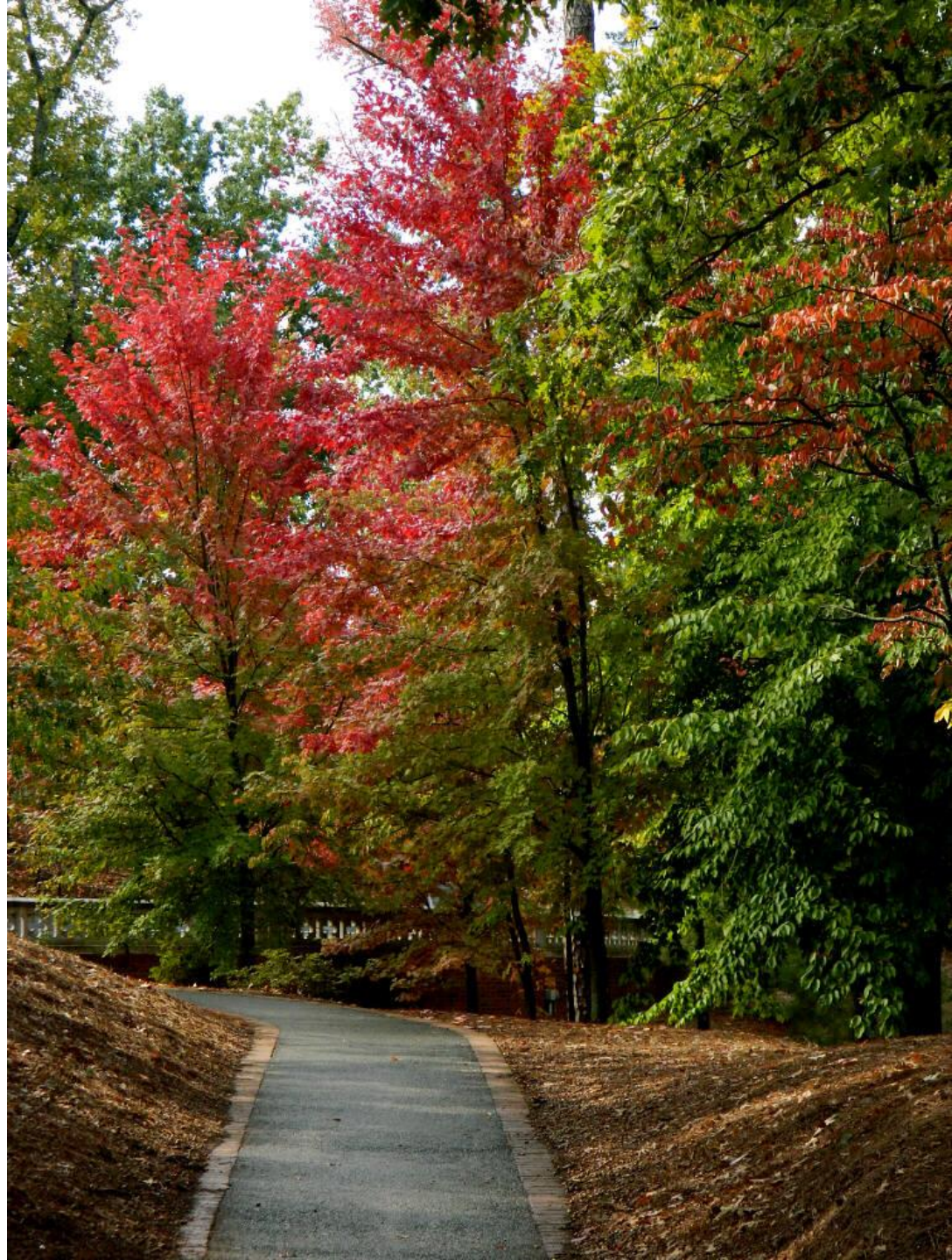
N-S mountains

E-W mountains

Glacial refugia

no glacial refugia

Acer x freemanii– Freeman maple
(*Acer rubrum* x *Acer saccharinum*)
University of Richmond



**Fall color in exotic plants
as grown in the mid-Atlantic region**

***Metasequoia glyptostroboides*
dawn redwood
U. S. National Arboretum**



Lagerstroemia 'Osage'
U. S. National Arboretum





Lagerstroemia indica – crepe myrtle
University of Richmond

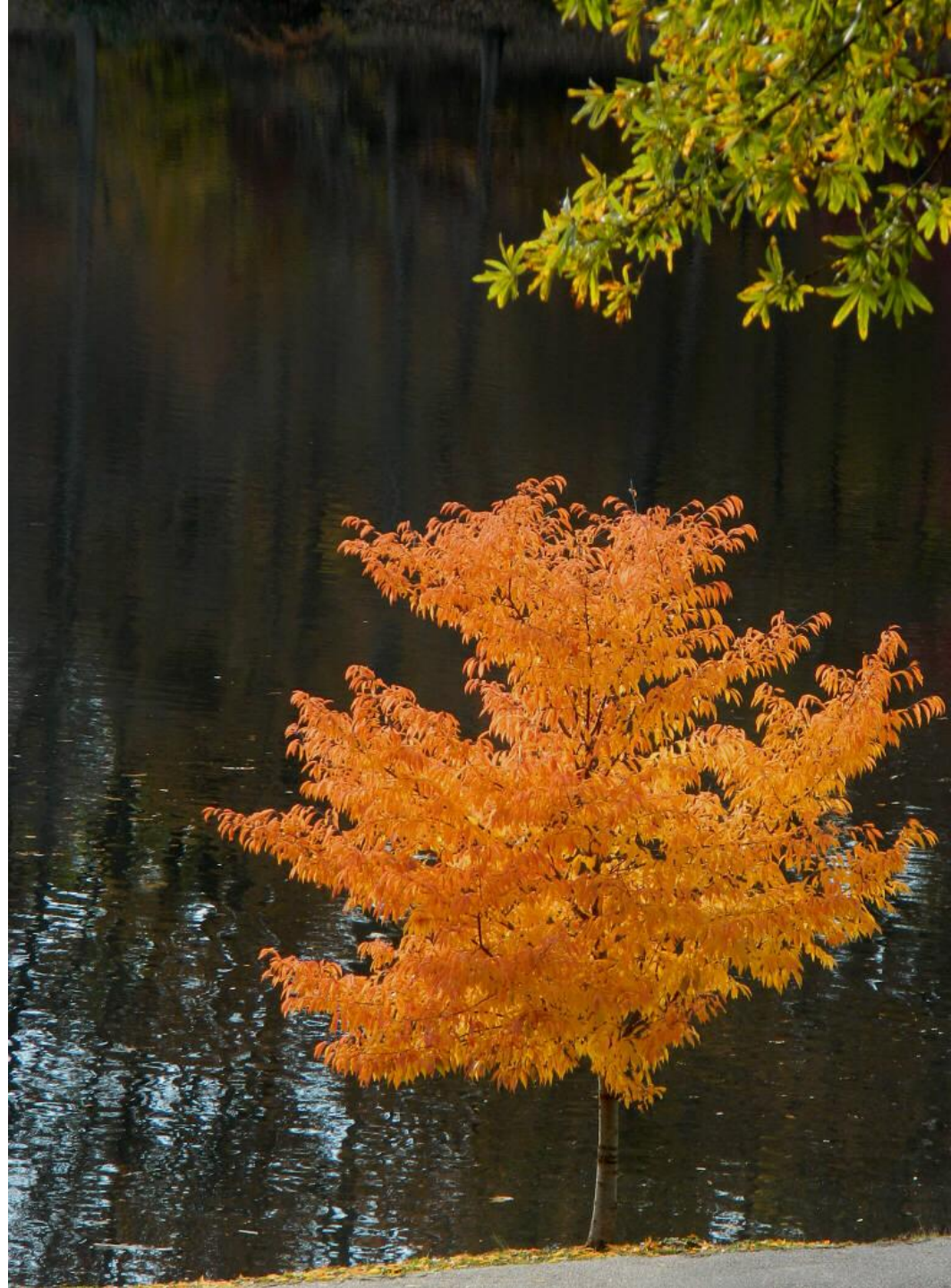


***Euonymus alatus* 'Compactus'**
Lewis Ginter Botanical Garden



Parrotia persica
Lewis Ginter Botanical Garden

***Prunus serrulata* 'Kwanzan'**
University of Richmond





***Viburnum dilatatum* – linden viburnum**
Lewis Ginter Botanical Garden



Fall color with fruits

***Viburnum prunifolium* – black haw**
Lewis Ginter Botanical Garden

Rhus copallinum – winged sumac
Norfolk Botanical Garden





Nyssa sylvatica – black gum
Chesterfield Co., VA

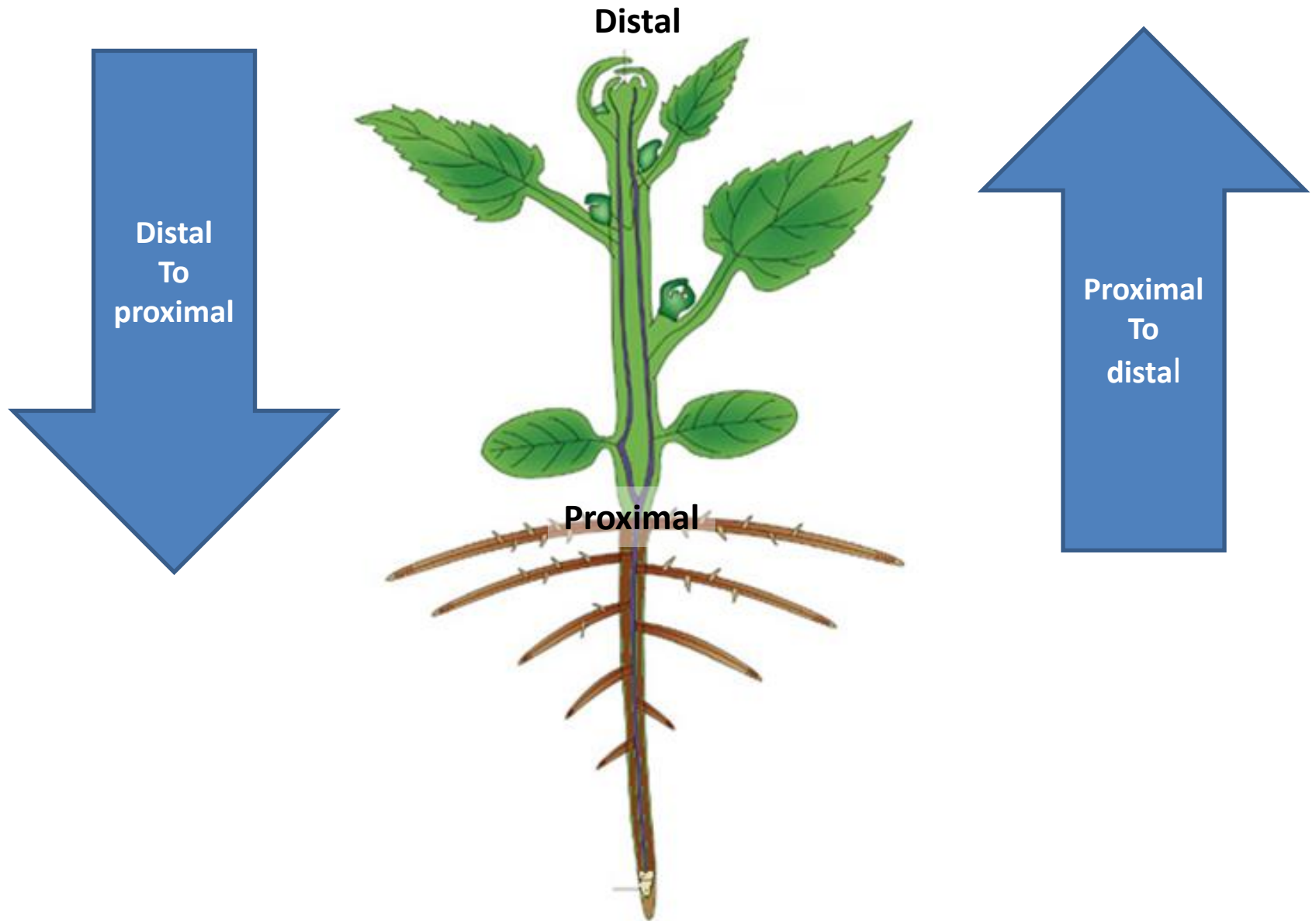


***Cornus florida* 'Xanthocarpa'**
Lewis Ginter Botanical Garden



Aronia arbutifolia 'Brilliantissima '
Red Chokeberry
U. S. National Arboretum

Direction of Fall Color Progression



Acer rubrum – red maple
Piedmont Virginia Community College
(distal first)



***Acer rubrum* – red maple**
University of Richmond
(distal first)



***Calycanthus floridus* – carolina allspice**
Powhatan Co., VA
(proximal first)



***Cornus florida* – flowering dogwood
University of Richmond
(proximal first)**



***Liquidambar styraciflua* – sweet gum**
Powhatan Co., VA
(proximal first)



Sassafras albidum – sassafras
University of Richmond
(proximal first)

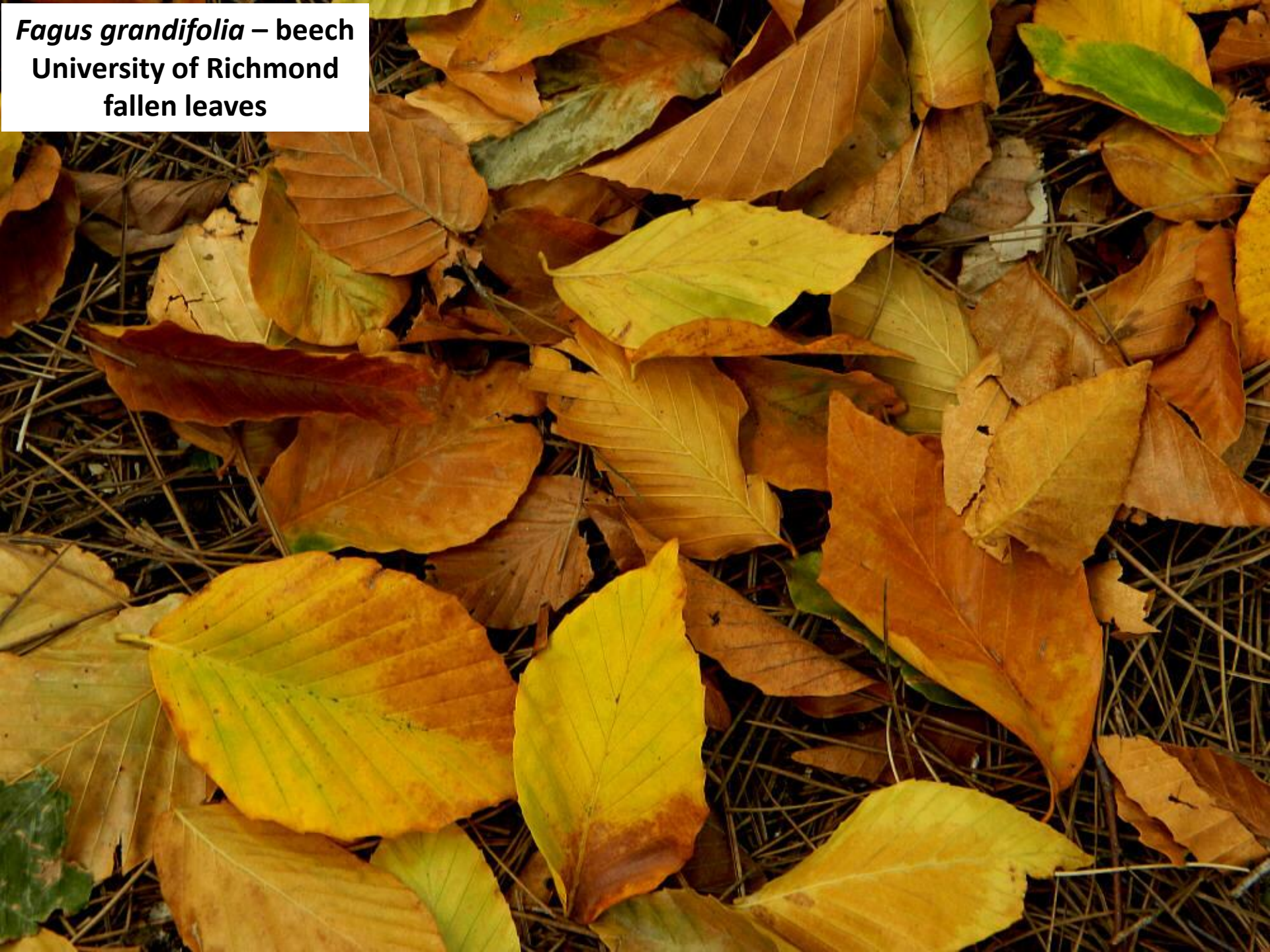




Viburnum x burkwoodii 'Mohawk'
Lewis Ginter Botanical Garden

(proximal first)

***Fagus grandifolia* – beech**
University of Richmond
fallen leaves





Hamamelis virginiana – witch hazel
U. S. National Arboretum
fallen leaves



**Marcescent
Leaves**

***Fagus grandifolia* – beech
Little River Park, Hanover Co., VA**



***Fagus grandifolia* – beech**
Powhatan Co., VA



Cornus florida – flowering dogwood
Lewis Ginter Botanical Garden
+/- uniform leaf color

Cornus florida – flowering dogwood
University of Richmond





***Diospyros virginiana* – persimmon**
Norfolk Botanical Garden



***Carpinus caroliniana* – ironwood**
University of Richmond



Fothergilla sp.
Millsaps College, Jackson MS



Viburnum acerifolium
maple-leaf viburnum
University of Richmond



**Sunfish Lake
Powhatan Wildlife Management Area**