Plant Ecology

Jeff Pippen
NC Botanical Garden, 2026

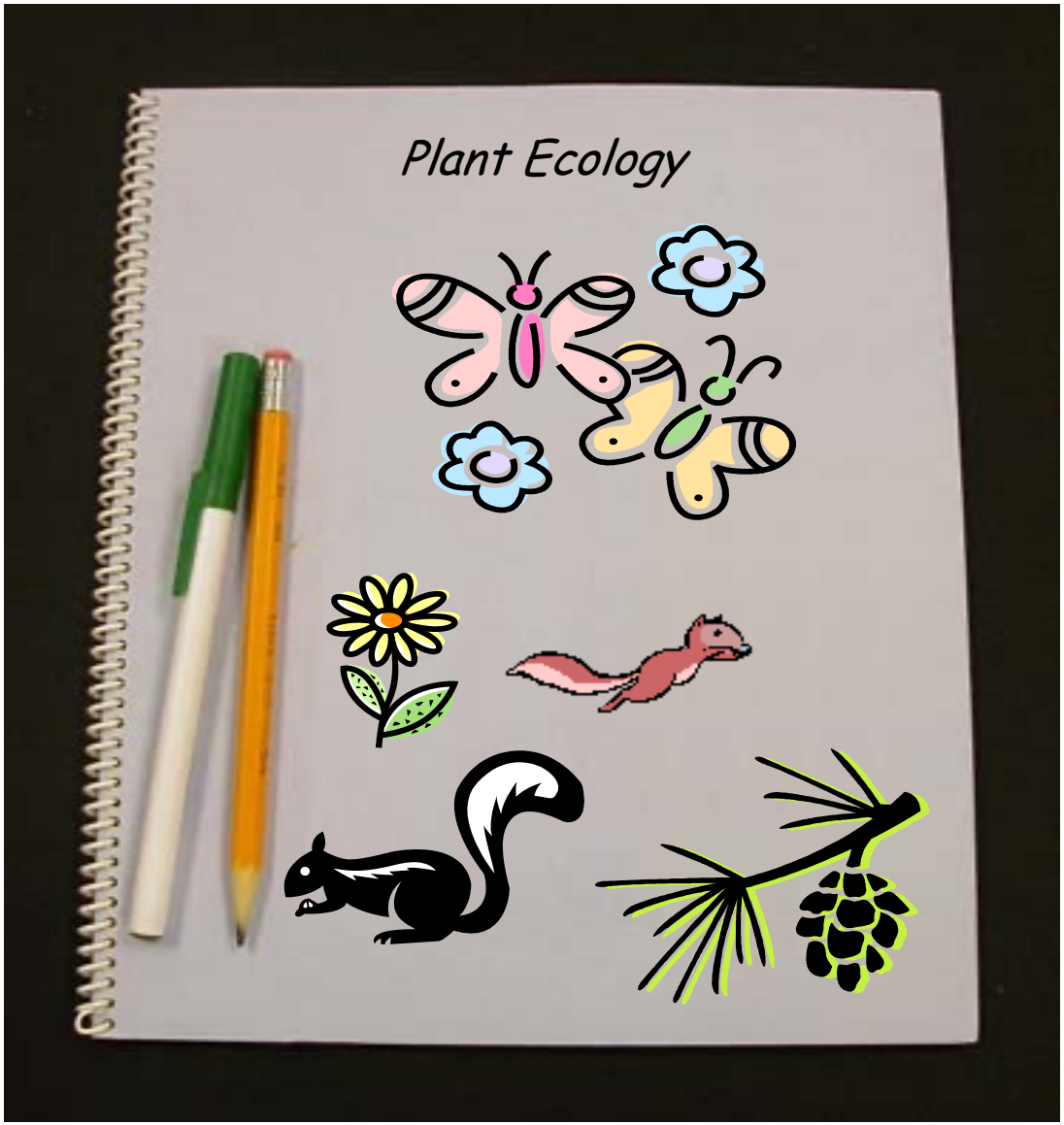
Today's agenda

- Course info and logistics
- What is Ecology?
  - History/background
  - Ecological Energy Flow
  - Plant Community Structure, Succession
  - Plant Systematics and Identification Primer
- Field trip to NCBG Natural Area trails
  - Plant ID
  - Habitat/community descriptions
- Prep for next week
- But first, let's do Introductions ☺

Plant Ecology Course Structure

- Lecture/In-classroom activities
- Field activities
  - Right here at NCBG
  - Field notebook and dress appropriately!

Field Journaling



A few pointers

- Invaluable!!
- Name/Phone Inside Cover
- Organization & legibility
- Date/Time/Location/Weather/People/Habitat
- Sketches/Photo reference
- Be descriptive!
- Handout - emailed!

General Topic Outline

Day 1

Introductions, general info, intro ecology, energy flow, community structure, succession, systematics & ID; NCBG field trip

Day 2

Adaptations and natural selection, competition and predation, co-evolution; NCBG field trip

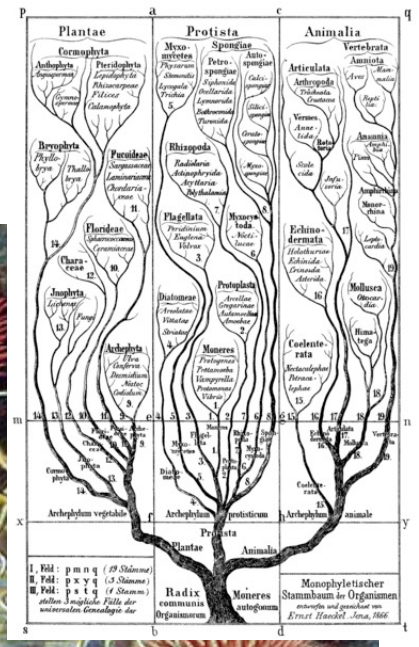
Day 3

Ecosystems, biomes, biogeography, extinction, and conservation, student plant adaptation presentations; NCBG field trip

Field Outings

"Ecology"

- Coined by German biologist Ernst Haeckel in 1870



- From the Greek *oikos* meaning house
  - An organism's surroundings or immediate environment; their "house"
  - Same root as "economy" ("mgmt of house")

"Ecology"

- Modern definition by ornithologist/ ecologist Robert Ricklefs at Univ. Missouri S. L.

- The science by which we study how organisms (animals, plants, microbes) interact in and with the natural world.

Fundamental Questions in Ecology

- Why so many species?
- Why some species but not others?
- What survival strategies work best?
- Why does this species live here and not there?

Ecology helps us understand how the natural world works.

Goal – NOT just to memorize facts but to learn how to ask and answer questions about ecological conditions and understand how communities function.

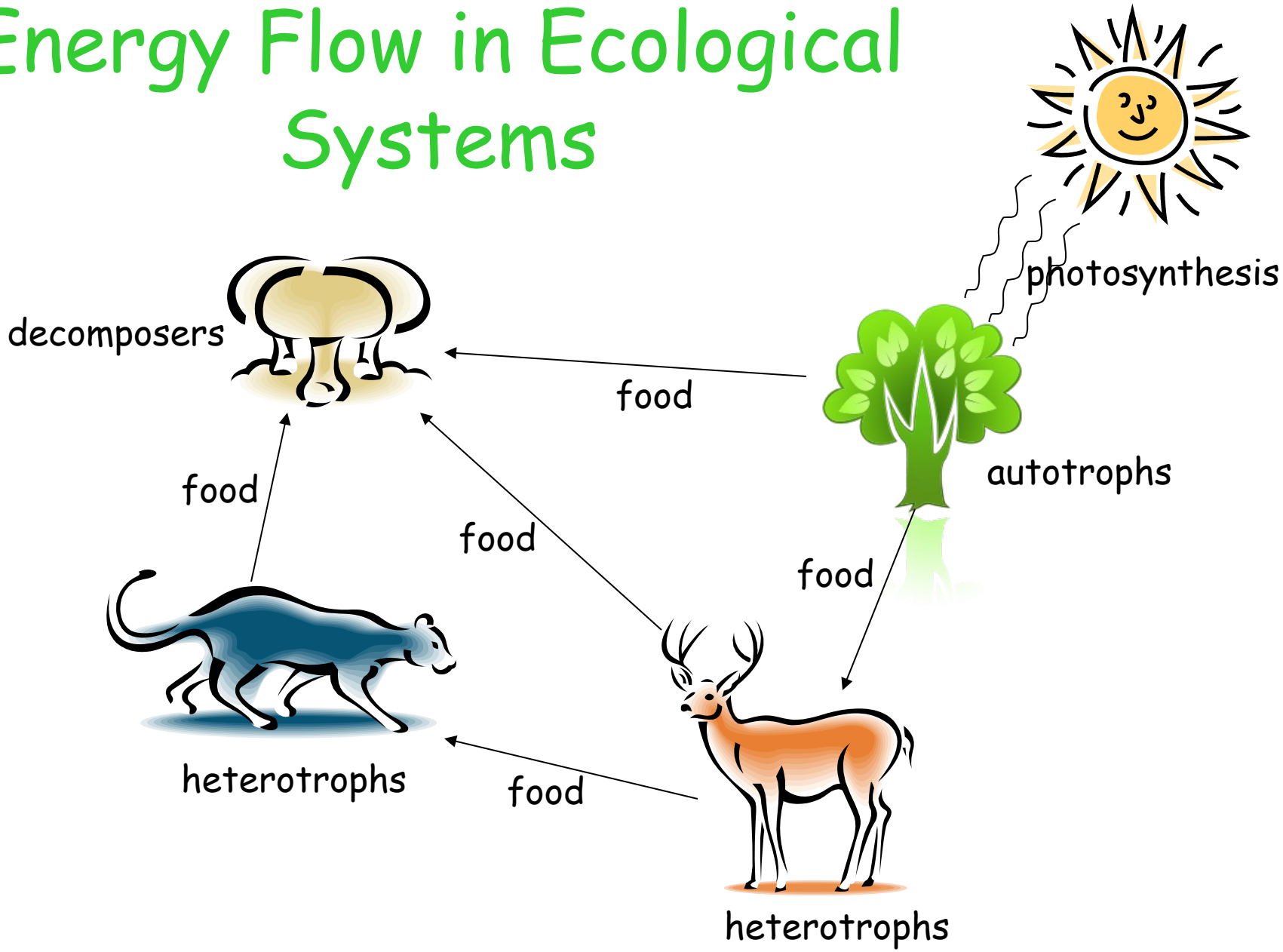
Ecological Systems

- Non-living (abiotic): things like air, soil, water, energy, organic and inorganic chemicals, etc.
- Living (biotic): individuals/populations of interacting organisms

Ecological Systems

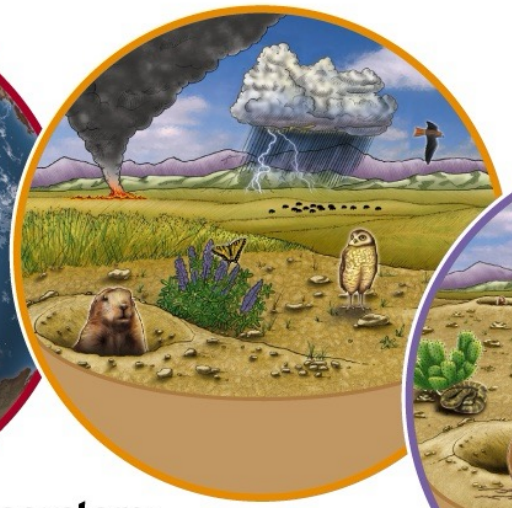
- All organisms require energy…
  - Chemical bond energy used for metabolism
  - Autotrophs: make own food
  - Heterotrophs: "eat" food
    - Consumers
    - Decomposers

Energy Flow in Ecological Systems



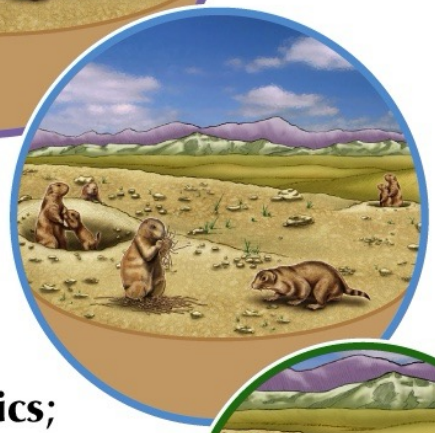
Ecological systems, large and small

Biosphere:
Global processes



Ecosystem:
Energy flux and cycling of nutrients

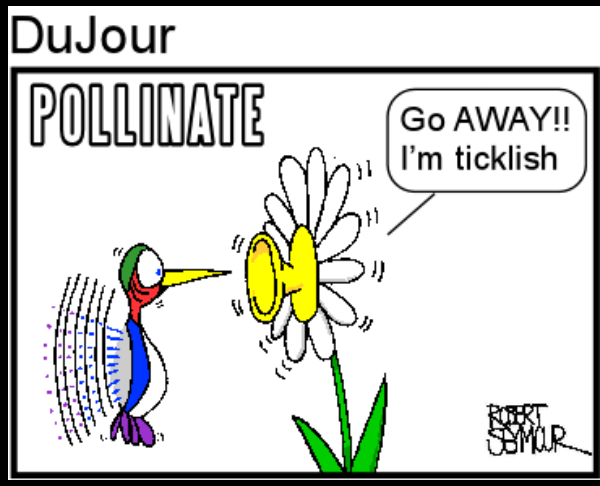
Community:
Interactions among populations



Population:
Population dynamics; the unit of evolution

Organism:
Survival and reproduction; the unit of natural selection

Communities



Community – assemblage of populations of different species potentially interacting with one another

Examples:

- Plant communities (Dry Oak-Hickory Forest; Piedmont Bottomland Forest; etc.)
  - Note that the NC Natural Heritage Program recognizes 340 distinct natural community types in North Carolina!
- Animal communities (oak-hickory forest fauna; New Hope Creek fish, frogs, crayfish, aquatic insects, etc.)
- Total community includes both plants and animals

Communities

Microcommunity Examples:

- Rotting log
- Large animal droppings

Cartoon By **T. McCracken**

Habitat – natural local environment in which an organism normally lives

1. large scale: pine forest, old field, river, etc.

2. microhabitat: immediate surroundings & other physical factors of where an organism lives within the larger habitat; e.g. rotting log; rocky shoreline; etc.

Habitats

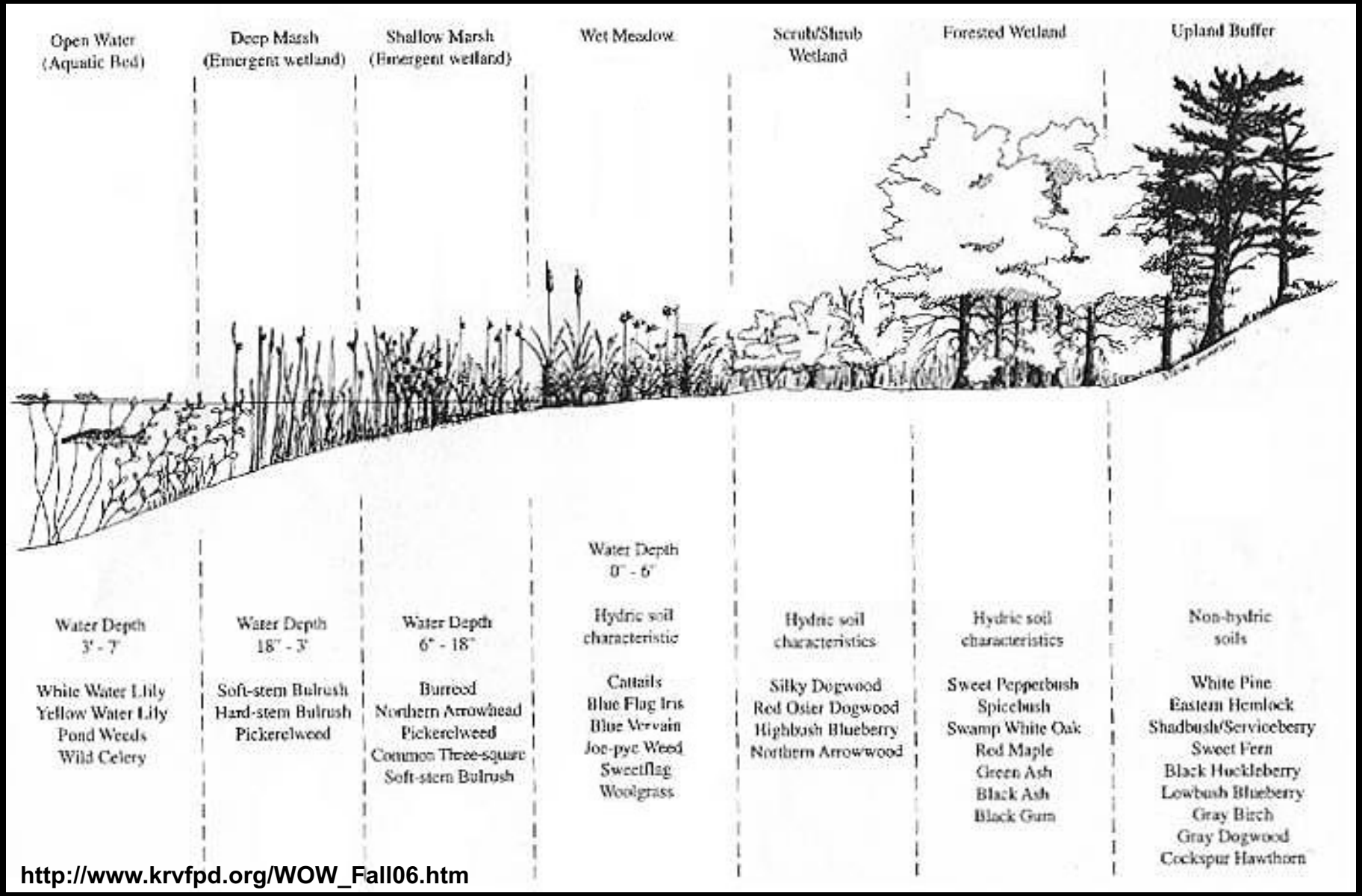
Often described by moisture availability, which is dependent upon precipitation (rain & snow) and how well the soils or substrates drain water.

1. xeric -- habitats that are relatively *dry*
   -- receive relatively little rain and/or…
   -- well drained soils that don't retain water
   -- rocky ridgetops; steep, rocky slopes

2. mesic -- habitats with *moderate* water availability
   -- most of the NC Piedmont
   -- how much rain do we get here??

3. hydric -- habitats that are very *wet*
   -- swamps; creeks, shorelines

Plants depend on moisture



http://www.krvfpd.org/WOW_Fall06.htm

Xeric Piedmont Habitats

Example: Occoneechee Natural Area

Chestnut Oak *(Quercus montana)*

Mountain Laural *(Kalmia latifolia)*

Deerberry *(Vaccinium stamineum)*

Mesic Piedmont Habitats

Example: New Hope Creek Slopes in Duke Forest

American Holly
(Ilex opaca)

American Beech
(Fagus grandifolia)

Downy Arrowwood
(Viburnum rafinesquianum)

Hydric Piedmont Habitats

Example: Jordan Lake Bottomlands

Plant Community Ecology

What makes one community different from another?
How do we describe and define specific communities?

- *Community structure*
  - Species present
  - Relative abundance
  - Spatial distribution

Why do communities have structure?

- Environmental conditions vary over space
- Different species have adapted to different environmental conditions
- Species abundances (distribution) vary over space

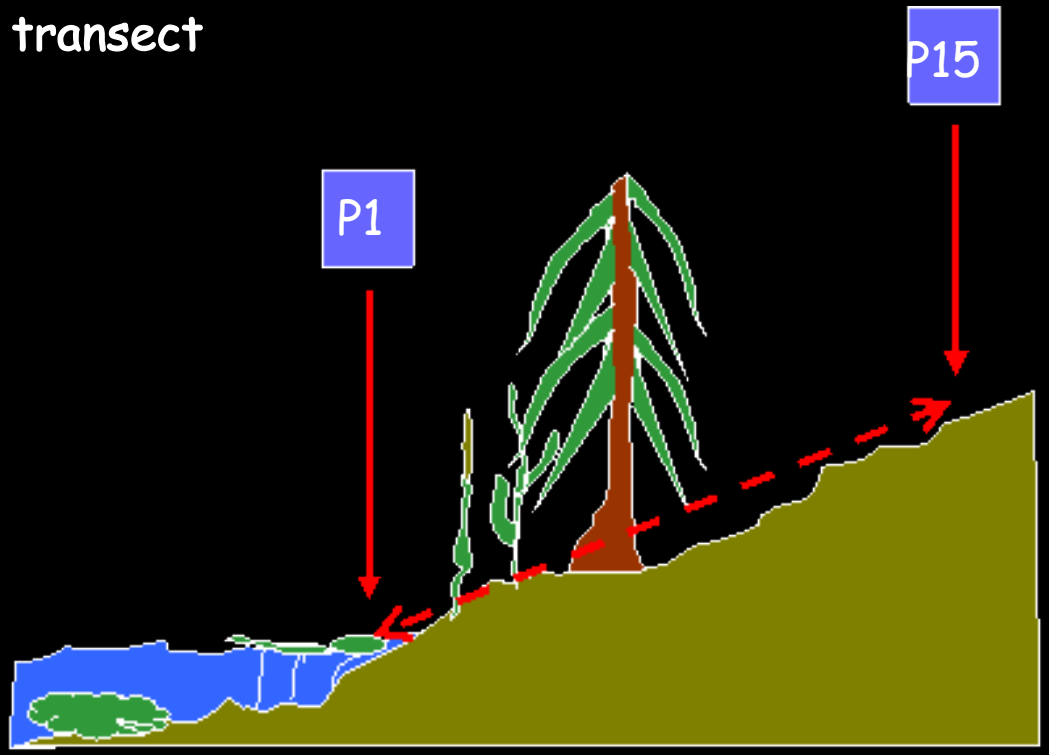
How can we identify & describe features of community structure and the factors that cause them?

Collect data on the abundance of different species at different locations, and the environmental conditions at those locations

Example

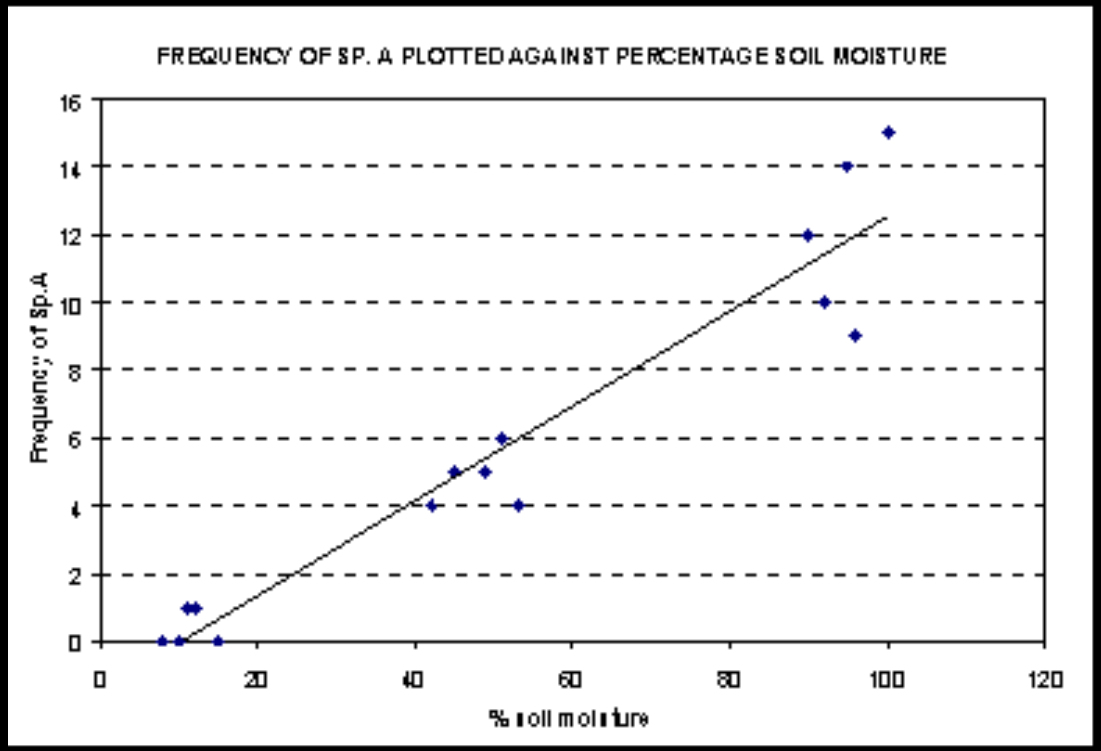
Establish 15 plots along a transect and measure:

- Frequency of 5 plant species of interest
- % soil moisture
- soil pH in 15 plots along a transect



Now what? How can we tell if a particular environmental variable might be influencing plant distribution?

Use some simple statistics to see if species distributions are correlated with environmental variables



Abundance of Species A is positively correlated with % soil moisture
R^2 = 0.96 HIGH (Max=1.00)

Correlation does NOT equal causation!

- Correlation doesn't *prove* that one variable is/isn't influencing the other

  - **Example**: Sleeping with shoes on is strongly *correlated* with waking up with a headache. However, sleeping with shoes on doesn't *cause* headaches…

    - but rather high alcohol consumption and passing out fully clothed certainly can!

  - Correlation does give statistical evidence that can be basis for further investigation…
    - Who sleeps with shoes on?
    - Why?
    - Complexities!

Communities are complex!

- **Lots of species…**
- **Lots of environmental factors**
  - Soil moisture
  - pH
  - Soil nutrients
  - Light
  - Temperature
  - Slope Aspect
  - Altitude
- **Complex interactions**
  - Density of species
  - Herbivory
  - Frequency of disturbance
  - …

Succession

Succession – change in communities over time

- follows disturbance
- can arise from natural causes or anthropogenic causes
- changes in local environment causing a change in species composition. . .

Succession

1. Primary Succession
   - occurs "from scratch"; involves building soils
   - examples: lava flow, glacier retreat

2. Secondary Succession
   - occurs after an existing community is disturbed
   - examples: fire, clearcut, hurricane

Succession

Pioneer species – the first species to move in and colonize an area after a disturbance
-- usually require high light environments

Examples from the Carolina Piedmont:

- grasses like Broomsedge and Crabgrass
- flowers like Fleabanes, Blackberries, Dog Fennel
- trees like Loblolly Pine, Sweetgum

Sweetgum sapling *(Liquidambar styraciflua)*

Succession

Succession

Succession

Succession

Sere

Sere – sequence of communities or vegetational phases through succession on any given site

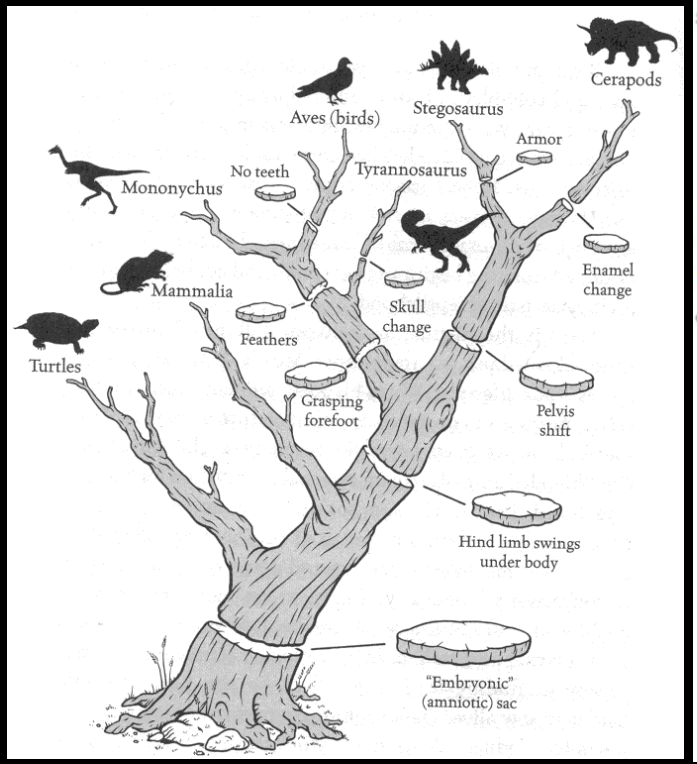
Piedmont Seres:

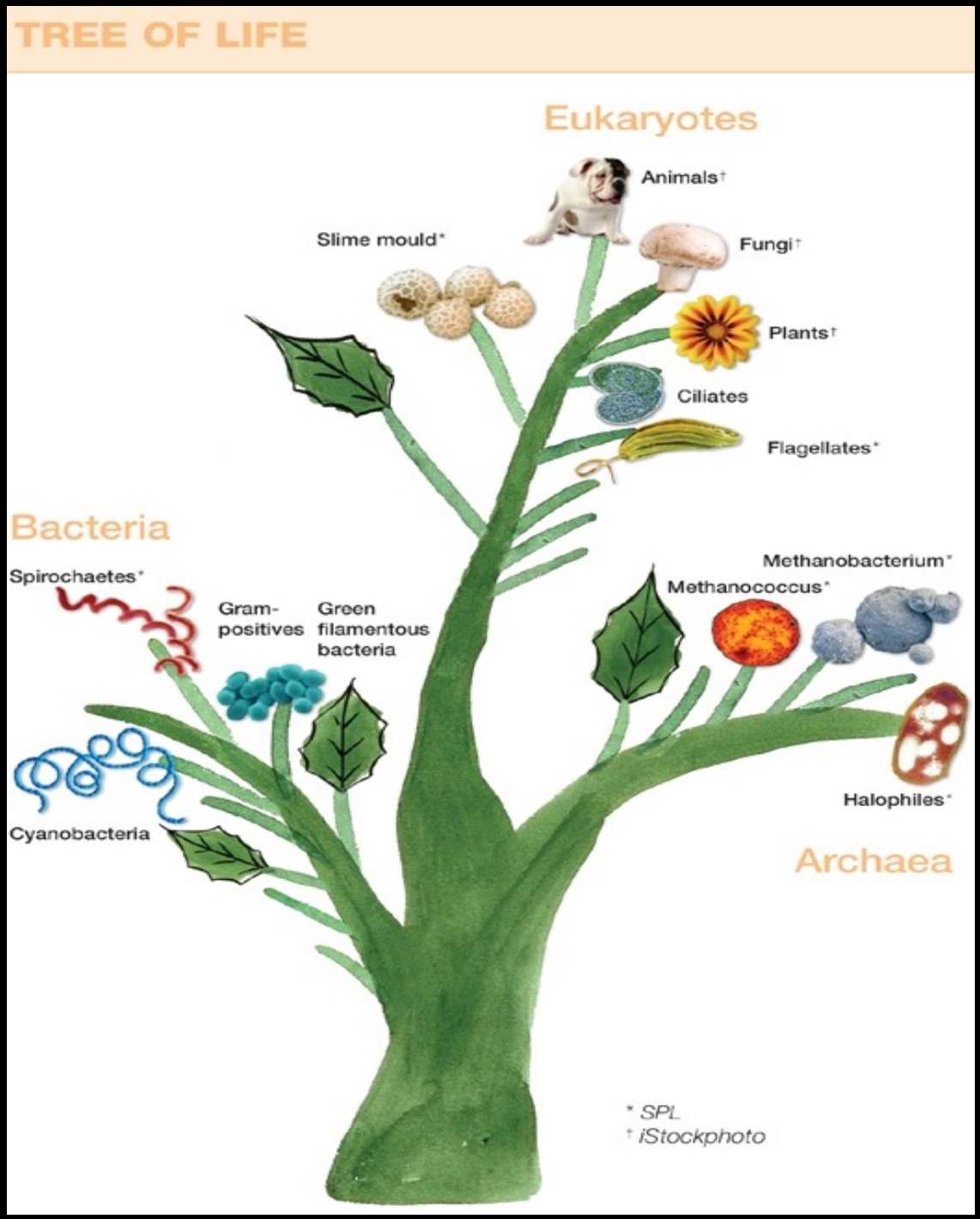
1. Xerosere – ridge tops, steep slopes, dry rocky/sandy soils

2. Mesosere – most local forests with moderately drained soils

3. Hydrosere – swamps, streams (note there are no natural lakes in the piedmont!)

Systematics & Classification





Systematics & Classification

"The fundamental aim of SYSTEMATICS is to discover all the branches of the evolutionary tree of life, to document changes that have occurred during the evolution of these branches, and to the greatest extent possible describe all species--the tips of the branches. Systematics is therefore the study of biological diversity that exists on Earth today and its evolutionary history." (Judd et al.)

Plant Systematics, A Phylogenetic Approach, Third Edition **by Walter S. Judd et al., 2008**

Systematics & Classification

"A secondary but critical aim of systematics is to convey the knowledge of the tree of life -- of the terminal branches and their relationships to one another -- in an unambiguous system of classification, which can then orient our understanding of life and the world around us. This is the phylogenetic approach to systematics. " (Judd et al.)

Plant Systematics, A Phylogenetic Approach, Third Edition **by Walter S. Judd et al., 2008**

Systematics & Classification

Taxonomy is the system used to name and classify organisms. Different authorities may offer slightly different classifications, which is why, for example, some consider Princesstree to be in the Scrophulariaceae while others place it in the Paulowniaceae.

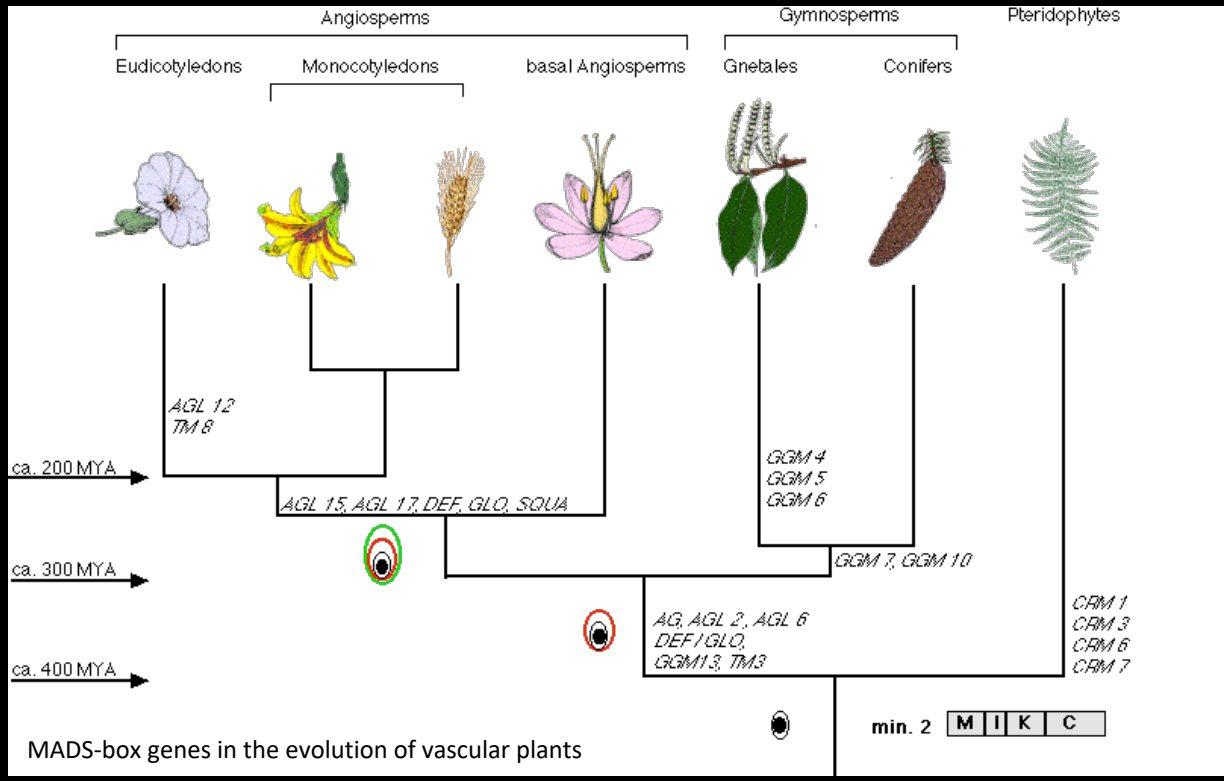
World Vascular Plant Diversity

- Worldwide: ~350,000 species of plants
- North America: ~25,000
- North Carolina: ~3,000 (natives)

Systematics & Classification

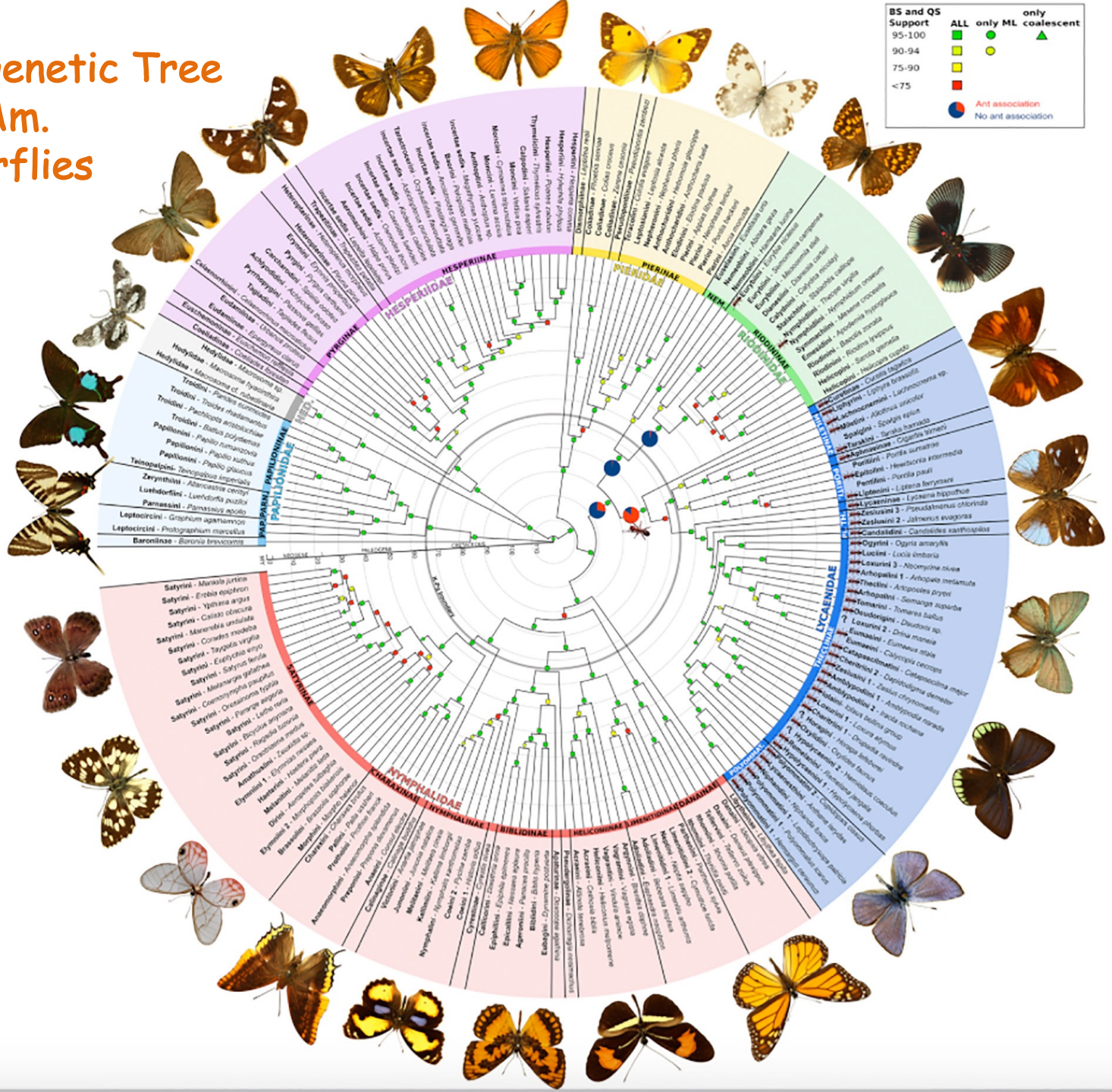
The goal of systematics is to determine the evolutionary history (phylogeny) of a group of organisms.

A phylogenetic tree is a branching diagram representing phylogenetic relationships (i.e. evolutionary history) of a group of organisms (taxa).



http://www1.biologie.uni-hamburg.de/b-online/e28_2/phylogeny.htm

Phylogenetic Tree of N.Am. Butterflies



Systematics & Classification

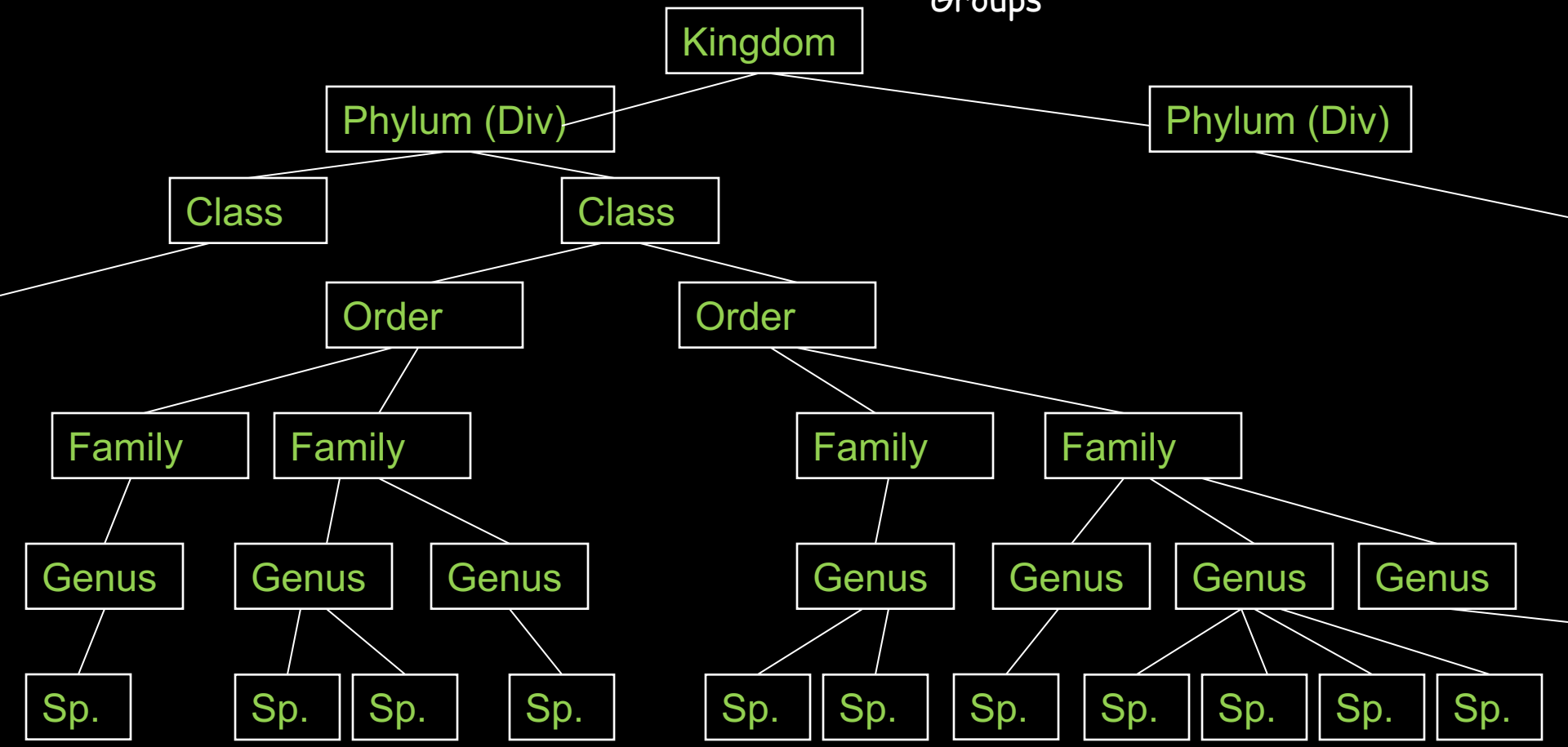
Major Classification Groups

Kingdom
Phylum
Class
Order
Family
Genus
Species

K P C O F G S

Systematics & Classification

Major Classification Groups



K P C O F G S

Systematics & Classification

Major Classification Groups

Group	Human	Am. Crow	Fish Crow	Loblolly Pine
Kingdom	Animal	Animal		Plantae
Phylum	Chordates	Chordates		Coniferophyta
Class	Mammals	Aves (Birds)		Pinopsida
Order	Primates	Passeriformes		Pinales
Family	Homonidae	Corvidae		Pinaceae
Genus	*Homo*	*Corvus*		*Pinus*
Species	*Homo sapiens*	*C. brachyrhynchos*	*C. ossifragus*	*Pinus taeda*

K P C O F G S

Scientific Names

Species names consist of TWO words, called a "binomial"

- *Genus*
- *specific epithet*

Homo sapiens *Corvus ossifragus* *Pinus taeda*

Carl Linnaeus

NOTE:
- In writing, Latin names of species should be *italicized* with the Genus Capitalized and the specific epithet lower case.

- "Species" is both singular and plural. Do NOT say "specie"!

K P C O F G S

Vascular Plant Systematics – Major Plant Groups

spores

Ferns & Allies

seeds

Conifers (Gymnosperms)

seeds

Flowering Plants (Angiosperms)

Plant Identification Primer

Tree Hugger

A Few Characters:

- Habit: tree, shrub, vine, herb
- Woody vs. non-woody
  - Woody: trees, shrubs, some vines
  - Non-woody: herbs, some vines
    - Graminoid – grasses, sedges, rushes, etc.
    - Forb: non-graminoid herb, "wildflower"
- Leaves…

Leaf Characters to evaluate

- Leaf *type*
- Leaf/branch *arrangement*
- Leaf *margin*
- Leaf *venation*

Leaf Type

Simple

Cranefly Orchid
(Tipularia discolor)

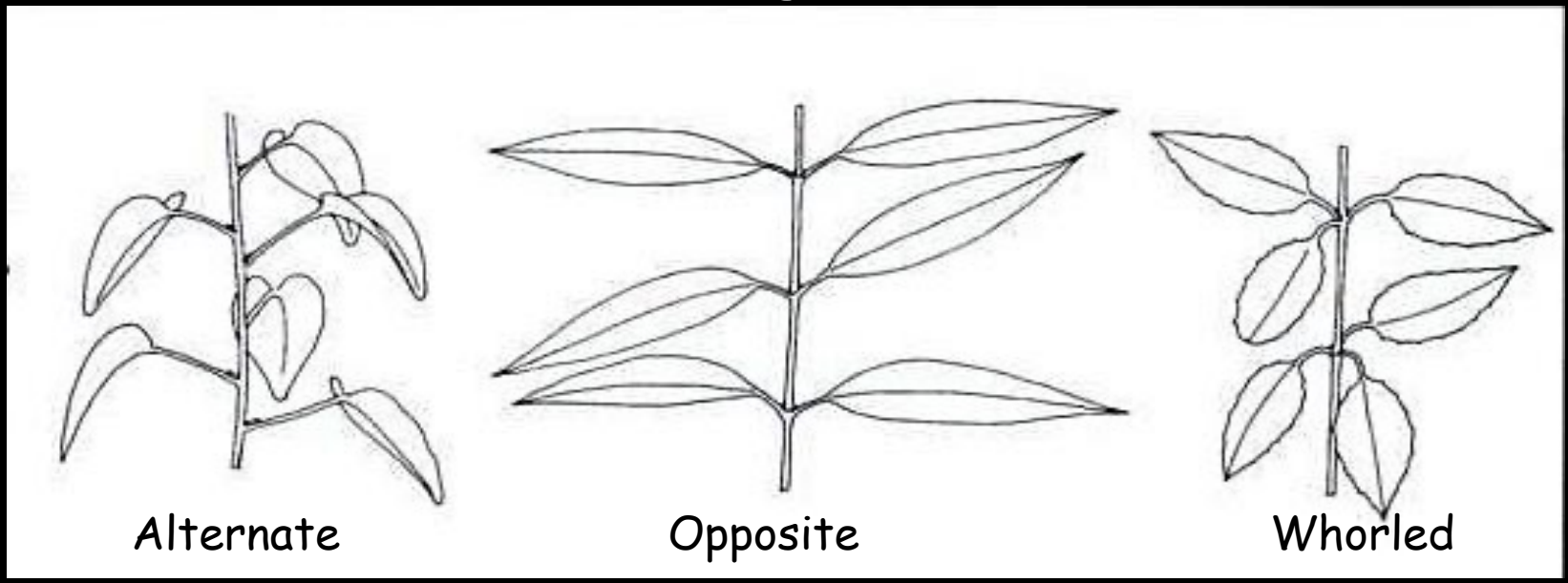
Winterberry
(Ilex verticillata)

Compound

White Ash
(Fraxinus americana)

Poison Ivy *(Toxicodendron radicans)*

Leaf Arrangement



Sourwood *(Oxydendrum arboreum)*

Hearts-a-bustin' *(Euonymus americanus)*

Hairy Bedstraw *(Galium pilosum)*

Leaf Margin and Leaf Venation

Lobed

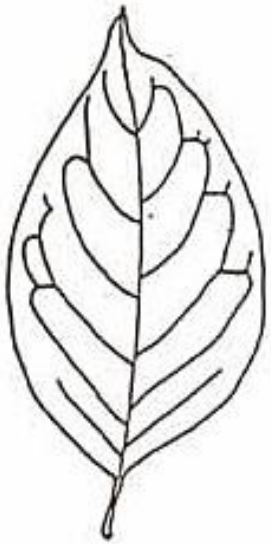
Un-lobed

Lobed

Divided into rounded or pointed sections

Toothed

A series of pointy teeth



Entire

One continuous smooth margin

http://www.barnard.edu/iue/ForestCurricula/MarginsVenations.htm

Palmate Venation

Pinnate Venation

Leaf Margin

Entire

Lewis' s Heartleaf
(Hexastylis lewisii)

Lobed

White Oak
(Quercus alba)

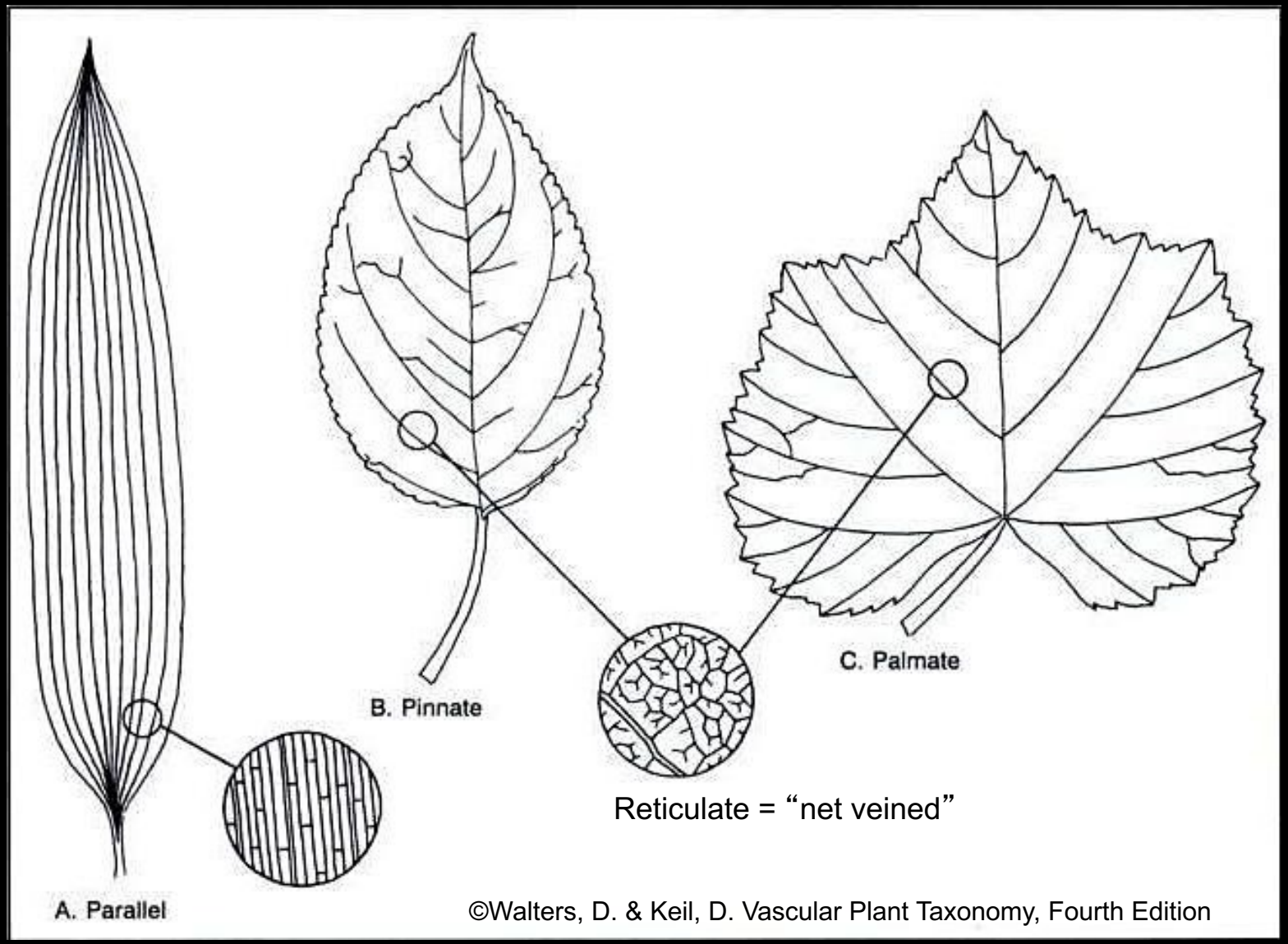
Toothed

American Holly
(Ilex opaca)

Toothed

Red Maple
(Acer rubrum)

Leaf Venation



Reticulate = “net veined”

Leaf Venation

Parallel

Cranefly Orchid
(Tipularia discolor)

Giant Cane
(Arundinaria gigantea)

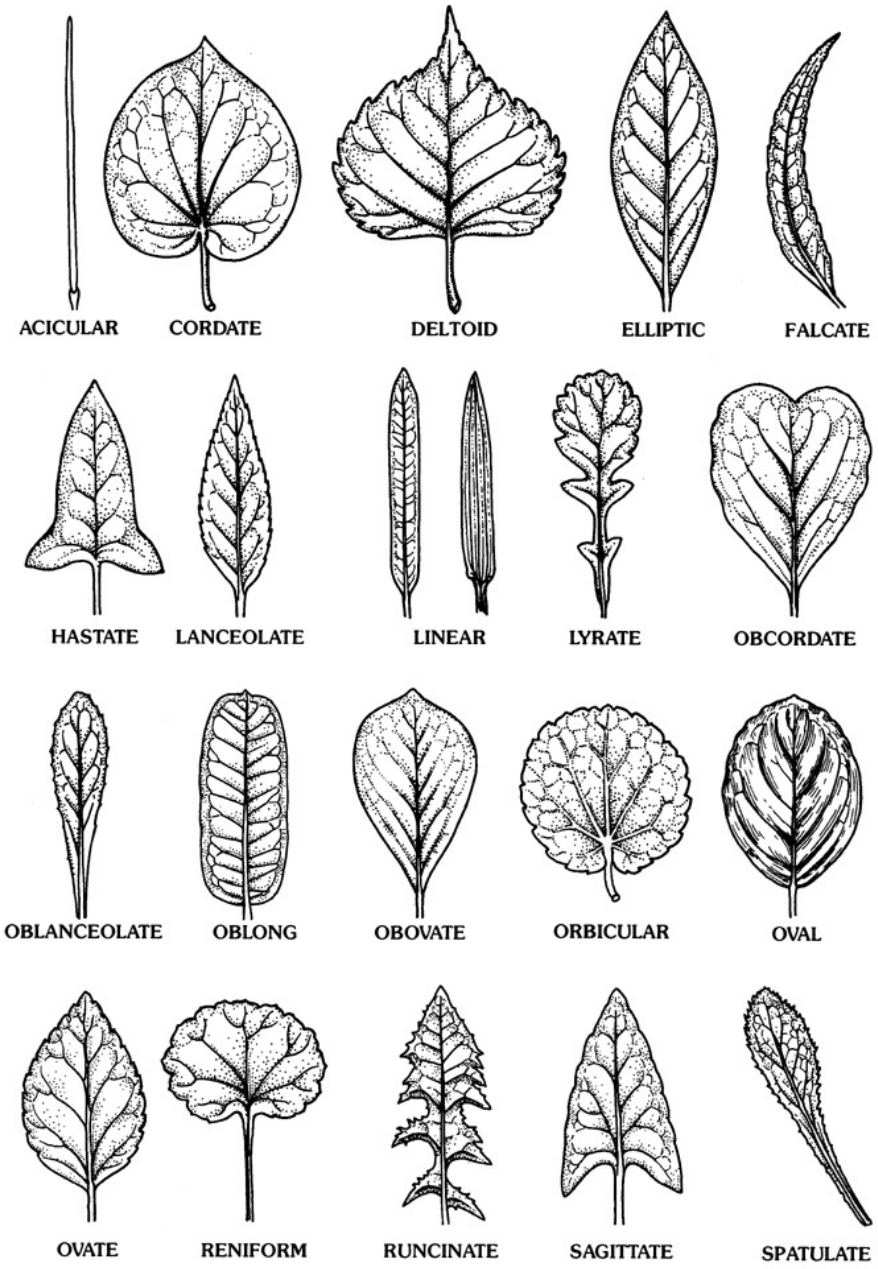
Palmate

Mountain Maple
(Acer spicatum)

Pinnate

Common Groundnut
(Apios americana)

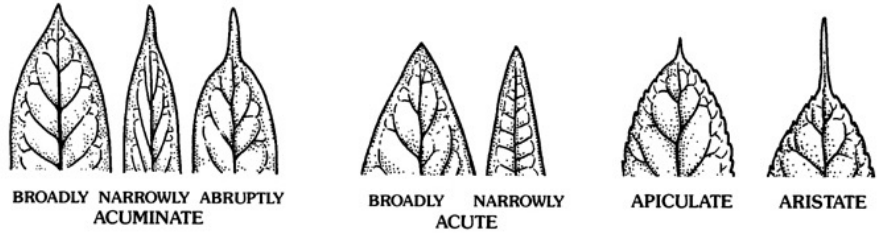
PLATE 3. LEAF SHAPES



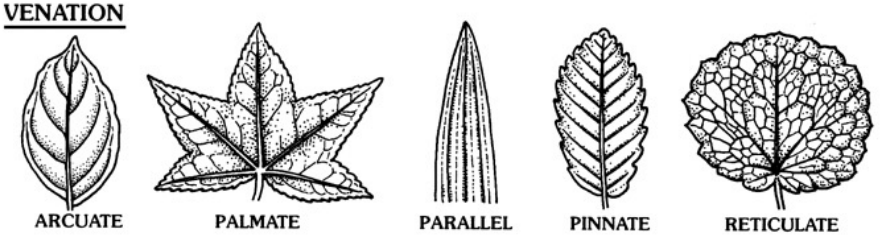
as published in Swink, F. and G. Wilhelm. 1994. *Plants of the Chicago region.* 4th ed. Indianapolis: Indiana Academy of Science.

PLATE 5. LEAF APICES, VENATION, AND BASES

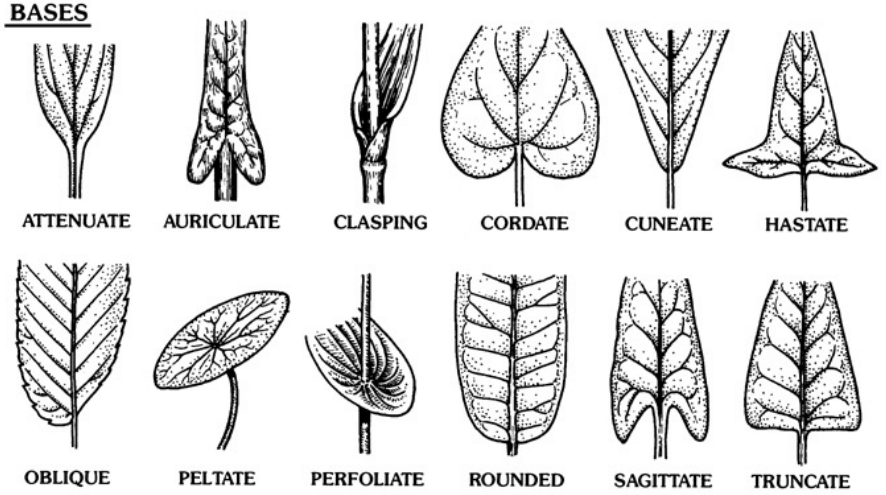
APICES



VENATION



BASES



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Systematics

The urge to classify is a fundamental human instinct; like the predisposition to sin, it accompanies us into the world at birth and stays with us to the end. (A.T. Hopwood 1959)

Field Trip!!

Virtual Field Trip or Field Trip Follow-up

Poison Ivy
(Toxicodendron radicans)

Sweetgum
(Liquidambar styraciflua)

Tuliptree, Yellow-poplar *(Liriodendron tulipifera)*

American Sycamore, Plane-tree *(Platanus occidentalis var. occidentalis)*

Common Pawpaw *(Asimina triloba)*

Eastern Red Cedar *(Juniperus virginiana)*

American Beech *(Fagus grandifolia)*

Beechdrops
(Epifagus virginiana)

Littlebrownjug, Arrowleaf Heartleaf *(Hexastylis arifolia)*