Botany for Master Gardeners

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What is a plant?

- Living organism
- Contains chlorophyll
- Can manufacture its own food
- Multicellular with rigid cell walls
- Growth by meristematic tissue
Classification by temperature or day length requirement

- Tropical plants vs. Sub-tropical vs. Temperate-zone plants
- Cool season plants vs. Warm season plants
- Long day plants vs. Short day plants
- Cold hardiness zone – What USDA zone are you in?
- Sunset zone
- Heat zone - Used for southern regions
USDA zones

Average Annual Minimum Temperature

<table>
<thead>
<tr>
<th>ZONE</th>
<th>Temperature</th>
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<tr>
<td>1</td>
<td>Below -50 F</td>
</tr>
<tr>
<td>2a</td>
<td>-50 to -45 F</td>
</tr>
<tr>
<td>2b</td>
<td>-45 to -40 F</td>
</tr>
<tr>
<td>3a</td>
<td>-40 to -35 F</td>
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<tr>
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<td>-30 to -25 F</td>
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<tr>
<td>4b</td>
<td>-25 to -20 F</td>
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<tr>
<td>5a</td>
<td>-20 to -15 F</td>
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<td>5b</td>
<td>-15 to -10 F</td>
</tr>
<tr>
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<td>6b</td>
<td>-5 to 0 F</td>
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<tr>
<td>7a</td>
<td>0 to 5 F</td>
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<td>7b</td>
<td>5 to 10 F</td>
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<tr>
<td>8a</td>
<td>10 to 15 F</td>
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<td>10b</td>
<td>35 to 40 F</td>
</tr>
<tr>
<td>11</td>
<td>Above 40 F</td>
</tr>
</tbody>
</table>
Differences between 1990 USDA hardiness zones and 2006 arborday.org hardiness zones reflect warmer climate

Zone Change
- +2
- +1
- no change
- -1
- -2

1990 Map
2006 Map

After USDA Plant Hardiness Zone Map, USDA Miscellaneous Publication No. 1475, Issued January 1990
National Arbor Day Foundation Plant Hardiness Zone Map published in 2006.
Sunset climate zones (Sunset Western Garden Book)
Temperature Variation In and Around Flagstaff, AZ
Minimum daily temperature compared to the temperature at Pulliam Airport

Data: Temperatures recorded 4/10/02-4/14/02 at 24-hour intervals by a variety of methods

Projection: UTM 12N
Map producer: Hattie Braun, May 1, 2002
Classification by ecological adaptation

- Alpine plants
- Prairie plants
- Ponderosa pine forest plants
- Pinyon/Juniper forest plants
- Riparian plants
- Xeric plants
- Succulents
- Desert plants
Classification by taxonomy

• Plant kingdom divided into two groups
  – Non-vascular plants - mosses and liverworts
  – Vascular plants – have a vascular system
    • Most vascular plants produce seeds as a way to propagate or reproduce themselves
    • A few vascular plants, like horsetail and ferns, do not produce seeds

• Nearly all of the plants we use in horticulture are vascular plants
Seed Plants

- Photosynthesize (produce sugars)
- Have a vascular system consisting of a xylem and phloem which transport water and dissolved materials
- Reproduce by seed
- Can be divided into two groups or subdivisions
  - Gymnosperms (Gymnospermae)
  - Angiosperms (Angiospermae)
Gymnosperms

- do not have true flowers
- seeds are not enclosed in fruits
- most seeds are produced in cones
Angiosperms

- produce flowers
- develop fruits that contain seeds
- can be divided into monocots and dicots
Monocotyledons (Monocots)

**MONOCOTS**

- **Cotyledons**: One cotyledon
- **Veins in leaves**: Usually parallel
- **Flower parts**: Usually in multiples of three
- **Arrangement of primary vascular bundles in stem**: Scattered
Dicotyledons (Dicots)

DICOTS
Two cotyledons

Usually netlike

Usually in fours or fives

In a ring
Basic Classification Scheme

- Species
- Genus
- Family
- Order
- Class
- Subdivision
- Division
- Kingdom
Buffalo burr  
*Solanum rostratum*

*Solanum rostratum* is a member of the Solanaceae family. Buffalobur, like other poisonous nightshades (*Solanum* spp.), contains the deadly glycoalkaloid solanine.
Example: Woods rose (*Rosa woodsii*)

- Specific epithet or species name --- *woodsii*
- Genus --- *Rosa*
- Family --- Rosaceae
- Order --- Rosales
- Class --- Dicotyledonae
- Subdivision --- Angiospermae
- Division --- Spermatophyta
- Kingdom --- Plantae
Binomial System of Nomenclature

Basis for defining species (a reproductively isolated population of plants)

Example - *Rosa woodsii*

*Rosa* is the genus

*woodsii* is the specific epithet

Together they are the species, expressed as a Latin binomial

*Woods rose* is the common name
Binomial System of Nomenclature

Carl Linnaeus - laid the foundations for the modern scheme of binomial nomenclature, father of modern taxonomy. Published Species Plantarum 1753. Started with 24 plant families.

Florist’s carnation

*Dianthus floribus solitaris squamis calycinus subovatus breyissimis*

OR

*Dianthus caryophyllus L.*
Good knowledge of plant names helps with questions such as:

A. Which species of chokeberry will have black fruit? 
   *Aronia melanocarpa* vs. *Aronia arbutifolia*

B. Which species of maple is a good choice for an open, cold, windy site?

C. What is the size of the plant?
   *Viburnum opulus* vs. the cultivar *V. opulus* ‘Compactum’ vs. the cultivar *V. opulus* ‘Nanum’

D. Are chokeberries susceptible to bacterial fireblight?
Some rules

• Genus species names should always be **underlined** or *italicized*

• Genus name is always **Capitalized**, but the species name is not

• Use *sp.* to indicate a single unidentified species and *spp.* to indicates multiple species

• Genus and species names are universal while common names are often local in use – over 250 species of ‘bluebells’
And some thoughts on latin names

• “Latin is a language as dead as dead can be. First it killed the Romans: Now it’s killing me.”

• It doesn’t matter how you pronounce the name – just try it – go to www.taunton.com/finegardening/ for an online pronunciation guide

• For a dictionary of Botanical Epithets go to www.calflora.net/botanicalnames (California plants only)
Variety vs. Cultivar

- **Variety** - sub-grouping of a species were individuals displaying unique differences in natural, inheritable
- *Acer saccharum var. conicum*

- **Cultivar** - sub-grouping of cultivated plants (cultivated variety) displaying unique differences, inherited or asexually propagated
- *Acer saccharum* ‘Columnare’
- Enclosed cultivar names in single quotes and not italicized
- ‘Early Girl’ and ‘Big Boy’ are cultivars of tomatoes
Classification by stem and leaf texture

- Herbaceous plants
- Woody plants
- Deciduous plants
- Evergreen plants
- Semi-evergreen
- Broadleaf
- Grass-like
- Succulents
Classification by stem and leaf texture

Herbaceous – non-woody stems

Coreopsis lanceolata

Woody – woody stems that generally live for several years

Buddleia davidii
Classification by stem and leaf texture

Deciduous

Plants that shed their leaves every year

Cornus stolonifera
Classification by stem and leaf texture

Evergreen

Plants that hold their leaves for more than a year, usually green year-round

Evergreen does not always coniferous

*Juniperus horizontalis*
Classification by stem and leaf texture

Broadleaf

Narrowleaf
Classification by life cycle

- Annuals
- Biennials
- Perennials
• Pass through entire life cycle from seed germination to seed production in one growing season.

• Summer annuals

• Winter annuals
Start from seed to produce vegetative structures and food storage organs the first season. Winter’s cold temperatures stimulate the production of flowers, fruit and seeds the second season (to complete the life cycle).
Perennials

Plants that live for 3 or more years. Once mature, they generally produce flowers and seeds each year.

**Herbaceous:** tops die back to the ground each winter and new stems grow from the roots each spring.

**Woody:** Top growth persists from year to year and develops woody tissue.
Principal Parts of a Vascular Plant
Roots
Principle Root Functions

- to absorb water and minerals
- to anchor the plant
- to provide physical support for the stem
- to store products of photosynthesis (sugars and starches)
- for propagation
- winter survival of perennials
Parts of a Root

- Lateral root
- Primary root
- Root hairs
- Root tip
- Root cap

Zone of maturation

Zone of elongation

Meristematic zone
Root hairs

- Are thinner than a hair
- Increase the surface area of roots
- Important for water and nutrient uptake
- Easily damaged when transplanting
- Live only a few days
Fibrous and taproot systems
Dandelion – taproot is storage system for carbohydrates

Cheatgrass – fibrous root system

Weeds often have large, fast growing root systems
Field bindweed – spreading root system
Depth and spread of roots

• On compacted and clayey soils, roots will be shallow, remaining near the surface where oxygen is available.
• On droughty soils, the root system will spread farther, mining a larger soil area for moisture and minerals.

Typical rooting pattern of trees, shallow and spreading.

Typical rooting depths
12 to 24 inches for flowers
12 inches for turf
18 inches for vegetables
24 to 60 inches for shade trees
Beneficial Microorganism Associations

Mycorrhizae
- occur on roots
- fungal hyphae
- increase surface area
- increase absorption

Root nodules formed by *Rhizobium* on cowpea

mycorrhizae inoculation
Last summer during a home remodeling project we raised the soil level 12 inches in the yard. This summer my trees look stressed with small yellowish leaves. I don’t see any insects. Could the problems be related to the soil change? My contractor assured us that trees are deep rooted.
What’s wrong with this Austrian pine?

damaged tips

healthy tips
Stems
Principle function of stems

- **main axis** gives plants their upright form
- **supports** buds and leaves
- serve as **channels** for carrying water, minerals and sugars
The **stem** is the main axis of a plant. All stems have nodes and internodes (roots do not).

**Node:** An enlarged region of the stem where leaves are attached and buds arise.

**Internode:** The region between 2 nodes.
Growth Habit

Stems help us define/describe a plant’s habit of growth

**Trees**
- perennial woody plant
- 1 main stem called a trunk
- usually over 25 feet tall

**Shrubs**
- perennial woody plant
- 1 or more main stems
- less than 25 feet

**Vines**
- annual or perennial
- long trailing stems
- aerial roots, tendrils, discs (tendrils with adhesive discs like suction cups).
The vascular system is composed of 2 types of tissue:

1. **Xylem**: Conducts water and minerals upward.

2. **Phloem**: Conducts “food” manufactured in the plant to wherever they are needed.
   
   “food” = starches, sugars

In older dicot stems, the **vascular cambium** is located between the xylem and phloem. It is the site of cell division and active growth and is responsible for the stem’s increase in girth.
Cross section of simple dicot stem.

Roots also have a phloem and a xylem
While all vascular systems contain xylem and phloem, they are arranged differently

1. Monocots: the xylem and phloem are arranged in bundles.
2. Dicots and Gymnosperms: the vascular system forms rings inside the stems. The ring of phloem is nearest the bark or external cover of the stem. The xylem forms the inner ring; it develops into wood in woody plants.
Bark

Phloem

Cambium zone

Open vessels,
Conducting sapwood

Non-conducting sapwood

Heartwood

*Quercus alba* – White Oak
Meristematic Tissues

- **Apical meristem**
  - Located at the tip of a shoot or root

- **Lateral meristem**
  - Formed in stems and roots of many plants
  - Allows plant to grow in diameter
  - Vascular cambium is a lateral meristem
Primary growth
Apical meristems (buds)

Secondary growth
Cambium differentiates into phloem and xylem
Diversified Stem Development

All stems have one thing in common.

They all have nodes divided by internodes.
Modified Stems - above-ground: crowns, stolons, spurs

**Crowns:** compressed stem with short internodes.
Examples: strawberries, dandelions and African violets

*runner (stolon) forms new plants at nodes*

**Stolons:** horizontal stem that lies along the top of the ground.
Examples: strawberries, spider plants, ground ivy, and some grasses
**Stolons:** Horizontal stem that lies along the top of the ground. Examples: Strawberries and Spider Plants.

*coral bells and ground ivy also have stolons*
Buffalograss with stolons - *Buchloe dactyloides*
Modified Stems - below-ground: bulbs, corms, rhizomes, tubers

Bulbs: Shortened, compressed, underground stems surrounded by fleshy leaves that envelop a central bud located at the tip of the stem. Examples: Tulips, Lilies, Daffodils and Onions
**Rhizomes:** Stems which grow horizontally at or just below the soil surface.
Examples: Iris and Quackgrass
Kentucky Bluegrass forms sod because of below ground rhizomes.
Blue grama grass has short rhizomes and can be sod-like
**Tubers:** An enlarged portion of an under-ground stem
Example: White Potatoes

**Tuberous Roots:** Underground storage organs without nodes and internodes; true roots
Examples: Dahlia, Sweet Potato

Eyes are actually the nodes on the stem; each eye contains a cluster of buds

Sweet Potato - tuberous root
Over the winter, something girdled my tree all the way around down to the wood. My neighbor said it would die, but it leafed out nicely. Will it be okay?
Hotline questions

- My irises aren’t blooming very much? Can I fertilize them more to make them bloom?
Leaves
Leaves

1. Capture and conserve light energy through the process of **photosynthesis**
2. Take up carbon dioxide for photosynthesis and release oxygen for use in **cellular respiration**
3. Store conserved energy in “food” molecules -- **sucrose** and **starch**
4. Control water use and leaf temperature through **transpiration**
5. Photosynthesis, respiration, transpiration are essential functions for plant growth and development
Photosynthesis

- The source of all food and oxygen on the planet
- Involves an input of light energy from the sun
- Converts light energy into chemical energy (carbohydrates, then proteins, fats, and nucleic acids)
- Requires light, carbon dioxide (CO2), and water (H2O).
- Products are sugar (C6H12O6), and oxygen (O2).
- Occurs in plant structures called chloroplasts that are rich with the pigment chlorophyll
Photosynthesis means to put together with light

\[ \text{water} + \text{CO}_2 \xrightarrow{\text{sunlight}} \text{sugar} + \text{O}_2 \]

Requires green tissue
**Respiration** is the process by which sugars and starches are oxidized to release energy.

\[
\text{Sugar} + \text{O}_2 \rightarrow \text{CO}_2 + \text{H}_2\text{O} + \text{Energy}
\]

Requires oxygen
Comparison of photosynthesis and respiration

<table>
<thead>
<tr>
<th>Photosynthesis</th>
<th>Respiration</th>
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<tbody>
<tr>
<td>Produces sugars from light energy</td>
<td>Burns sugars for energy</td>
</tr>
<tr>
<td>Stores energy</td>
<td>Burns sugars for energy</td>
</tr>
<tr>
<td>Releases oxygen</td>
<td>Uses oxygen</td>
</tr>
<tr>
<td>Uses water</td>
<td>Produces water</td>
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<tr>
<td>Uses carbon dioxide</td>
<td>Produces carbon dioxide</td>
</tr>
<tr>
<td>Requires light</td>
<td>Occurs in dark and light</td>
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</table>
• Photosynthesis and respiration in the plant
Edema in geranium
Transpiration is the process by which a plant loses water, primarily through leaf stomates.

- temperature
- humidity
- wind

Transpiration is the process by which about 90% of the water that enters plant roots is lost through the stomates. Water is pulled up into plants providing for mineral transport form the soil into the plant, for cooling of plant parts through evaporation, for the translocating of sugars and plant chemicals, and maintaining turgor pressure.
Transpiration is the process by which a plant loses water, primarily through leaf stomates

- Water enters the plant through the roots and exits through the stomata.
- 10% of the water is used for photosynthesis and 90% to keep the plant cells turgid.
- The water moving into the plant and up through the xylem also transports mineral nutrients.
- Environmental factors (temperature, air movement, and humidity) can affect amounts of water transpired at any given time.
Evapotranspiration

loss of water from the soil both by evaporation and by transpiration from the plants growing thereon
Types of leaves

• scale leaves (found on rhizomes also enclose and protect buds)
• cotyledons (seedling leaves)
• spines (protect the plant)
• tendrils (support the stem)
• storage leaves (bulbs, succulents)
• bracts (poinsettias, dogwoods)
Leaves as a Means of Identifying Plants

- simple
  - Simple
  - Palmate Compound
- compound
  - Pinnate Compound
  - Double Pinnate Compound
<table>
<thead>
<tr>
<th>Leaves as Food</th>
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<tbody>
<tr>
<td>chives</td>
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<tr>
<td>cabbage</td>
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Last spring my tulips were magnificent. As blooms faded, I removed the blossoms and foliage so it wouldn't detract from other spring flowers coming into bloom. This year, most of the tulips didn't come back. Why?
I don’t have that much sun in my yard. Are there any vegetables that I can grow?
Flowers
Flowers

- the showiest part of plants
- important for sexual reproduction
- often fragrant and/or colorful to attract pollinators
- flowering often dependent on stimuli (day length, cold, plant maturity, etc...)
Parts of a Flower

- Stigma
- Style
- Ovary
- Pistil or Carpels (Gynoecium)
- Placenta
- Ovules
- Anther
- Filament
- Stamen (Androecium)
- Petal (Corolla)
- Sepal (Calyx)
- Perianth
Types of Flowers

**Complete:** Flowers with pistils and stamens, petals and sepals

**Perfect:** Flowers containing functional stamens and pistils

**Incomplete:** Flowers lacking pistils, stamens, petals, or sepals

**Imperfect:** Flowers missing functional stamens or pistils.

**Monoecious:** Plants in which imperfect, pistillate (female) and staminate (male) flowers occur on the same plant

**Dioecious:** Pistillate and staminate flowers occur on separate plants

**Hermaphroditic:** Plants with perfect flowers
Dioecious

Monoecious

Female flower

Male flower
Pollination is the transfer of pollen from an anther to a stigma.

- bats
- wind
- insects
- rain
- birds

‘Big Boy’ tomato blossom
How Seeds Form

The pollen grain grows a tube down through the style to the ovules in the ovary.

- **Self Fertile:** Producing viable seed when fertilized with its own pollen
- **Cross-Pollination:** The transfer of pollen from the anther of the flower of one plant to the flowers of a different plant
Hotline question

- My zucchini is blooming but doesn’t set any fruit. Why?