

Plant Science
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PLANT STRUCTURE

- 1) Building blocks of the structural system
 - a) Atoms and molecules
 - b) Cells which divide to make more cells. Cells perform the chemical work of the plant.
 - c) Combinations of cells form tissues, e.g. glands that secrete scent, vascular tissue that conducts water and nutrients (the xylem)
 - d) Combinations of tissues form organs, e.g. leaves, flowers
 - e) Organs are grouped as either vegetative or reproductive

- 2) Vegetative organs – stems, leaves, buds, roots
 - a) Stems
 - i) Characteristics
 - (1) Growth is upward or horizontal, away from plant crown (crown=where stem and roots join)
 - (2) Buds and leaves occur at regular intervals (nodes) with spaces between (internodes)
 - (3) Stems of trees and shrubs may have leaf scars – marks on stem where leaf was once attached
 - ii) Functions
 - (1) Structural support of leaves, buds, and flowers
 - (2) Conduction of water and nutrients to leaves and flowers, and of manufactured food back to roots and to other plant parts
 - (3) Storage of food reserves for dormant periods
 - iii) Vascular tissue inside the stem
 - (1) Xylem - vessels that carry water and nutrients from roots upward
 - (2) Phloem - vessels that carry manufactured food downward and around
 - (3) Cambium - zone of cell division, responsible for expansion and size increase of stem. In woody plants, makes new xylem and phloem yearly
 - (4) Xylem, cambium, and phloem are grouped together into bundles, long strands of vascular tissue connecting leaves, stems, and roots
 - (a) In monocots (plants with one seed leaf), the vascular bundles are scattered throughout the stem
 - (b) In dicots (plants with two seed leaves), the vascular bundles are around the outer edge of the stem
 - (c) Trees and shrubs are dicots. The vascular bundles of these plants join together as the plant grows to make rings of vascular tissue just under the bark. The “rings” of a tree are remnants of the vascular tissue from all the years of the tree’s life.
 - iv) Stem types and nomenclature
 - (1) Herbaceous - stem dies at end of year, new stems produced next year
 - (2) Woody - stem continues to enlarge each year, does not die to ground each year
 - (a) Form of woody plant growth: tree, shrub, or vine
 - (3) Words used for woody plants referring to the age of the stem
 - (a) shoot - young stem with leaves (also used for herbaceous plants)
 - (b) twig - one-year old and no leaves (dormant)
 - (c) branch - more than one-year old
 - (d) trunk - main stem
 - v) Location of stems
 - (1) Above ground:
 - (a) aerial, in the air, e.g. most plants

- (b) stolon (horizontal, fleshy or semi-woody), e.g. strawberry
 - (c) spur - very short side shoot on aerial stem that produces flowers or leaves. Found on apple, pear, ginkgo, etc.
- (2) At ground level
 - (a) compressed stem – usually only above ground part is the leaves, e.g. hosta, coral bells, strawberry, dandelion
 - (3) Below ground
 - (a) rhizome (horizontal, slender or fleshy, at or below ground level), e.g. iris, quackgrass
 - (b) tuber (food storage), e.g. potato, caladium
 - (c) corm (swollen stem with small scaly leaves, food storage), e.g. gladiolus, crocus
 - (d) bulb (small stem (plate) with fleshy leaves, food storage), e.g. onion, tulip
- vi) Stem growth
- (1) Growth only occurs at meristems – an area where cells are dividing and increasing in number
 - (a) Apical meristems are located at the tip of a growing shoot
 - (b) Primary meristems are located on the stem at the base of the leaves. A bud is a primary meristem.
 - (c) Secondary meristems are located in the cambium of the woody plants and cause the increase in the girth of trees and shrubs.
- vii) Edible stem examples: asparagus, kohlrabi, potato, ginger root (a rhizome)
- b) Leaves
- i) Parts of a leaf
 - (1) Typically flattened surface (blade)
 - (2) Attached to stem by petiole
 - (a) The point where the leaf joins the stem is the node
 - (b) The upper angle between the petiole and stem is the leaf axil (or crotch)
 - (c) Vegetative buds are often attached to the stem at the leaf axil
 - (d) If petiole is lacking, leaf is said to be sessile
 - (3) Midrib – central vein in leaf (The midrib is a collection of vascular bundles. These bundles diverge and form veins throughout the leaf)
 - ii) Functions
 - (1) Manufacture food for the plant (photosynthesis)
 - (2) Transpiration (movement of water out of the leaf into the air)
 - (3) Gas Exchange (CO₂ and O₂)
 - iii) Leaf internal structure
 - (1) Protective skin (epidermis) with waxy protective coat (cutin), hairs, etc
 - (2) Openings (stomate, pl. stomata)
 - (a) Usually on underside for gas exchange, water loss
 - (b) Opened and closed with guard cells - respond to light, drought
 - (3) Middle layers where photosynthesis occurs and the vascular system is located
 - iv) Terms used to describe leaves. Often useful for plant identification
 - (1) Leaf types
 - (a) Typical foliage type
 - (b) Scale leaves, e.g. on stolons or enclosing buds
 - (c) Seed leaves (cotyledons)
 - (d) Spines or tendrils, e.g. pea
 - (e) Storage leaves, e.g. bulbs or succulents
 - (f) Bracts, specialized leaves just under the flowers e.g. colored leaves of poinsettia
 - (2) Venation patterns – pattern of midrib and other veins in leaf
 - (a) Parallel, e.g. dogwood, iris, grasses
 - (b) Pinnate, e.g. elm
 - (c) Palmate, e.g. sugar maple

- (3) Leaf form
 - (a) Simple - one unified blade
 - (b) Compound - divided blade (once or more than once divided), divisions called leaflets
 - (i) Pinnately compound, e.g. honeylocust
 - (ii) Palmately compound, e.g. horsechestnut, schefflera
 - (4) Leaf shape, overall, bases, apices - see diagrams
 - (5) Leaf margins - see diagrams
 - (6) Arrangement on stems
 - (a) Alternate - single leaf at each node
 - (b) Opposite - two leaves at each node
 - (c) Whorled - many leaves at each node
 - (d) Basal – arising from a short, compressed stem at ground level, hidden by soil, so leaf arrangement on stem can't be seen. May be said to form a basal rosette.
 - iv) Edible leaf examples: lettuce, spinach, celery, rhubarb, chives, onions, kale
- c) Vegetative buds
- i) Characteristics
 - (1) Undeveloped (embryonic) shoot, either vegetative (leaf) or reproductive (flower)
 - (2) Covered (e.g. temperate trees, shrubs) or naked (most herbaceous plants)
 - ii) Location
 - (1) Terminal - at end or apex of a stem (apical bud)
 - (2) Lateral - on the side of a stem
 - (3) Axillary - lateral bud in a leaf axil (most lateral buds are axillary)
 - (4) Adventitious - buds which develop in unexpected locations
 - iii) Edible bud examples: Brussels sprouts, cabbage, head lettuce.
- d) Roots
- i) Characteristics
 - (1) Growth is downward or horizontal away from plant crown usually into soil
 - (2) Do not have buds, leaves, or leaf scars
 - ii) Functions
 - (1) Absorption of water and nutrients and movement of these to aerial part of plant
 - (2) Storage of food reserves for dormant periods
 - (3) Anchorage
 - iii) Root system form, influences how the plant explores the soil for water and nutrient uptake
 - (1) Tap
 - (2) Fibrous
 - iv) Root types
 - (1) Primary, emerging from seed and continuing linear growth
 - (2) Secondary, tertiary etc., branches laterally from a primary or secondary, etc.
 - (3) Adventitious, arising from unexpected locations, e.g. roots from stems
 - (4) Specialized for storage, tuberous root (e.g. dahlia, sweet potato)
 - v) The parts of a root
 - (1) Root cap – the very tip of the root, protects the growing root tip
 - (2) Root apical meristem - tip area, just behind root cap, where cell division takes place, cells increase in number
 - (3) Region of elongation found just behind the root meristem, cells get bigger, root elongates
 - (4) Region of differentiation, cells develop specific functions, e.g. as vascular tissue, root hairs, etc.
 - (a) Root hairs absorb water and nutrients from the soil

- (b) Root hairs are extensions of the root surface and greatly increase the area of the root in contact with the soil
 - (c) Root hairs only live a few days or weeks
 - (d) Root hairs may be broken when plants are removed from the soil. If the root is undamaged, new root hairs will grow
 - (e) Some plants do not have root hairs, e.g. firs, redwoods, Scotch pine, many aquatic plants
 - (5) Mature root – functions to transport water and minerals to stem and leaves, anchor plant in soil
 - vi) Edible root examples: sweet potato, carrot, turnip, radish
- 3) Reproductive organs
- a) Flowers
 - i) Function of flower is to produce seeds to preserve the species
 - ii) An unopened flower is called a flower bud. Just like vegetative buds they may be terminal or axial.
 - (1) Edible flower buds include artichokes and broccoli.
 - iii) Flower parts
 - (1) Female parts – the pistil or botanically, the gynoecium
 - (a) Stigma & style - place for pollen to grow toward ovary
 - (b) Ovary (with ovule(s) & placenta) - protects ovules, becomes fruit
 - (c) Ovules – the eggs, though this word not usually used by gardeners. Becomes seeds.
 - (2) Male parts – stamen or botanically, the androecium
 - (a) anther (bears pollen) - opens to release pollen grains to wind or insects
 - (b) Pollen grains produce sperm cells but this term not typically used by gardeners
 - (c) filament - holds up the anther
 - (3) Perianth (protective and highly visible parts) - 2, 4, 5 in dicots, 3 in monocots
 - (a) petals (collectively, the corolla)
 - (b) sepals (collectively, the calyx)
 - iv) Descriptive terms for flowers
 - (1) Complete - all the flower parts described above are present
 - (2) Incomplete - at least one flower part missing
 - (3) Perfect - both sexes are present in a flower, but it may lack petals or sepals
 - (4) Imperfect - only one sex present in a flower
 - (a) Pistillate – flower has female reproductive parts only
 - (b) Staminate – flower has male reproductive parts only
 - (5) How imperfect flowers are organized on the plant
 - (a) Monoecious - both male and female flowers present on a single plant, eg. corn, birch, squash
 - (b) Dioecious - only one sex of flower present on one plant, eg. holly, bittersweet
 - (i) Only plants with female flowers (“female plants”) can produce fruit and seed. A male plant must be nearby to provide pollen.
 - v) Flower function - formation of seeds
 - (1) Pollen grains (with 1/2 genetic information) mature in anther sac
 - (2) Ovules (with 1/2 genetic information) mature in ovary
 - (3) Pollen grains are shed when anther opens, moved by insects, wind, gravity to stigma
 - (4) Pollen grain germinates on stigma, grows a tube through the style into the ovary
 - (5) Pollen tube and ovule unite (fertilization) restoring complete genetic information
 - (6) Fertilized egg develops into embryo (small plant), other parts of ovule develop into stored food for ovule, together they comprise the seed
 - vi) Inflorescence - how flowers are borne on the plant
 - (1) Flower stem is called a peduncle
 - (2) One flower per peduncle - solitary
 - (3) Multiple flowers per peduncle (please see diagram!)
 - (a) Cymose – top flower blooms first, then lower flowers bloom. This is called a determinate inflorescence. Upward growth of the main peduncle is stopped when the first flower opens.

- (i) Cyme and compound cyme – baby’s breath, freesia, tomato
 - (b) Racemose - lowest or outer flower blooms first. This is an indeterminate inflorescence. The lowest flower open firsts as the peduncle continues to grow and produce more flowers.
 - (i) Spikes, racemes and panicles all have vertical growth. Examples: Spike – gladiolus; raceme – snapdragon; panicle – begonia, many grasses
 - (ii) Corymbs and umbels hold their flowers horizontally. Examples: corymb – yarrow, umbel – dill, onions.
 - (iii) Heads of flowers in the aster family (“daisies” or “sunflowers”) are clustered together. The outer flower opens first. Examples: purple coneflower, sunflower, marigolds
- b) Fruits
- i) Definition - a ripened (or mature) ovary (in which the seeds are ordinarily found)
 - ii) Ovary is totally female tissue (only male contribution to fruit is in seed) thus, for example, apple flowers which are cross pollinated by a different male parent still produce fruits which are true to type
 - iii) Types of fruits
 - (1) Simple, fleshy - from a single ovary. The ovary wall has an outer, middle, and inner layer. In these fruit, some or all of the layers are fleshy.
 - (a) Berry - entire ovary wall is fleshy, e.g. tomato, grape, pepper
 - (i) Pepo – outer layer of ovary wall is a hard rind, e.g. muskmelon
 - (ii) Hesperidium - outer layer of ovary wall is a leathery rind , e.g. citrus
 - (b) Drupe - stony inner ovary wall, e.g. cherry, peach, plum, olive
 - (c) Pome - papery core layer, e.g. apple, pear, quince
 - (2) Simple, ovary wall is dry, fruit opens when ripe (dehiscent)
 - (a) Pod, e.g. pea
 - (b) Silique, e.g. cabbage
 - (c) Capsule, e.g. poppy
 - (3) Simple, ovary wall is dry, fruit does not open when ripe (indehiscent)
 - (a) Samara, e.g. maple
 - (b) Caryopsis, e.g. corn (commonly but mistakenly called a seed because ovary wall cannot be easily separated from seed. You plant the fruit, not just the seed.)
 - (c) Achene, e.g. sunflower (commonly but mistakenly called a seed. You plant the fruit, not just the seed.)
 - (d) Nut, e.g. oak (acorn)
 - (4) Aggregate - from a single flower with many ovaries , eg. strawberry (each ovary produces an achene), raspberry
 - (5) Multiple - from a tight cluster of flowers on a single structure, eg. pineapple, fig
- c) Seeds
- i) Definition - a ripened (or mature) ovule
 - ii) Parts of a seed
 - (1) Embryo - immature plant (shoot, root and one or two leaves)
 - (2) Endosperm - stored food supply (may all be in seed leaves (the cotyledons) when seeds are mature)
 - (3) Seed coat – hardened, protective outer covering
 - iii) To grow into a new plant, seeds need water, oxygen, and warmth (temperature optimum varies with plant species). This process is called seed germination.
 - iv) Steps in seed germination
 - (1) Water and gases move through seed coat to embryo
 - (2) Embryo enlarges by using stored food
 - (3) Root, then shoot emerge from the seed
 - (4) Leaves rise above soil level

- (a) In some plants (but not all) the first “leaves” above the soil are seed leaves or cotyledons. These often do not resemble the plant’s true leaves. They usually wither away as the plant grows and true leaves are produced.
- v) Why seeds don’t germinate
 - (1) The seed is dead
 - (2) Water or oxygen is lacking
 - (3) Temperature is wrong – too hot or too cold
 - (4) Seed needs special conditions such as light or the heat of fire
 - (5) The seed contains an immature embryo. Often this problem can be solved by storing the seed dry and cold for several months.
 - (6) The seed coat is too hard – water cannot get into the seed. To solve this problem, break open the seed coat, a technique called scarification.
 - (7) An inhibitor is present
 - (a) The inhibitor may be in the fleshy fruit around the seed. Remove fruit before storing seed.
 - (b) The inhibitor may be inside the seed. For many temperate plants grown in Indiana, storing the seed moist and cool will break down the inhibitors. This technique is called stratification.
- vi) Edible seed examples: peas, beans

PLANT PHYSIOLOGICAL PROCESSES

- 1) Photosynthesis - the capture of sunlight energy and its storage as food (carbohydrate, sugar)
 - a) Unique to plants, animals can only release energy stored as food by plants (through a chemical process called respiration).
 - b) Raw materials
 - i) Carbon dioxide gas (~.035% of earth's atmosphere) - enters through stomata
 - ii) Water
 - iii) Radiant energy from light
 - (1) Red and blue light is used for photosynthesis. Leaves are green because they do not absorb green light but reflect it.
 - c) Products
 - i) Sugar (carbohydrate) (from carbon & water [hydrate])
 - ii) Oxygen gas (about 21% of earth's atmosphere) - passes out through stomata
 - d) Formula:

$$6\text{CO}_2 + 6\text{H}_2\text{O} \xrightarrow{\text{light}} \text{C}_6\text{H}_{12}\text{O}_6 + 6\text{O}_2$$
 - e) Occurs in green plant parts, in cells which contain chlorophyll, in special subcellular structures called chloroplasts
 - f) As light increases, generally so does photosynthetic rate. More food and thus energy is available for growth e.g. bigger fruits, flowers, etc.
 - g) Temperature optimum for photosynthesis is 65 - 85°F, while above or below it is slowed.
 - h) The food produced is moved through phloem to the plant part that is using energy, e.g. apical meristem for upward growth, seeds.
- 2) Respiration - release of stored food energy for plant growth processes
 - a) Raw materials are carbohydrate and oxygen
 - b) Products are carbon dioxide, water, and energy
 - c) Respiration is reverse of photosynthesis, but respiration occurs day and night, photosynthesis only in daylight.
 - i) This is the same chemical process that animals use to release energy from food.

- d) Temperature dependent, faster respiration at higher temperatures, up to lethal maximum
 - e) Photosynthesis (food production) must surpass respiration (food consumption) much of the time for a plant to stay healthy and grow.
- 3) Transpiration - movement of water from soil through the plant to the atmosphere
- a) Water enters vascular system through roots
 - b) Moves through xylem to leaves
 - c) Moves through leaf cells and diffuses as vapor into air through open stomata
 - i) The evaporation of water from the leaves “pulls” water up from the roots. Water is not “pushed” up from the roots.
 - d) 90-98% of water is lost unused, 10% is used in chemical processes
 - i) This movement of water continually brings nutrients into the plant from the soil. As water is lost from the leaf’s surface, the leaf is cooled.
 - e) Important roles of water in plant growth
 - i) Chemical raw material
 - ii) Carries minerals from roots to aerial plant parts
 - iii) As a solvent, it is the support medium for cell chemical processes
 - iv) Maintains shape and form of plant organs through hydraulic pressure (turgor). When turgor is lost, a plant is said to wilt. Wilt is an indication that there is too little water in the plant.
 - f) The term “evapotranspiration” refers to the water lost from the plant and the soil. In dry climates evapotranspiration rate is measured rather than just transpiration rate because it better reflects the water that will be available for the plant.

ENVIRONMENTAL FACTORS AFFECTING PLANT GROWTH

- 1) Light
- a) Quantity - amount of energy available for capture through photosynthesis. Generally, greater light quantity results in more plant energy and growth vigor.
 - b) Quality - colors (wavelengths) of light striking plant surfaces (red, green, blue). Influences form, growth rate, appearance, and reproduction.
 - c) Duration (called photoperiod) - length of time of dark versus light periods. Controls initiation of flowers in many species, onset of dormancy. Plants measure the length of the dark period, not the length of the light period.
 - i) Long day plants begin to flower when the nights are getting shorter, typically in late spring or early summer. Examples: Dianthus (pinks), Easter lilies, clover, spinach
 - ii) Short day plants begin to flower when nights are getting longer, typically late summer and fall. Examples: poinsettias, chrysanthemums, holiday cactus
 - iii) Day neutral plants flower in response to other factors, such as temperature and plant size, but not in response to day length. Examples: tomato, rose, corn
- 2) Temperature
- a) Increasing temperature makes chemical reaction go faster, so generally photosynthesis, respiration, and transpiration go faster under higher temperatures (to a point)
 - i) Depends on plant adaptation (warm season crop versus cool season crop)
 - ii) Temperature can interact with photoperiod in control of flower initiation, dormancy
 - iii) High temperatures can kill plants. Killing temperature varies from species to species.
 - b) Low temperatures in winter can be lethal (resistance is called plant hardiness)
 - i) Plants vary in their ability to withstand low temperatures. Plants that cannot survive low temperatures are called “tender”. Plants that can survive low temperatures are called “hardy”.
 - (1) Hardiness is a relative term. Some plant species are hardy to 20°F, others to -20°F.

- (2) The USDA has divided the United States into 11 hardiness zones, based on average minimum winter temperature. Zones 3-10 occur in mainland US, Zones 1 and 2 are found in Alaska; Zone 11 is found in Hawaii.
 - ii) Cold may be needed to satisfy "rest" requirement to allow re-starting of growth in spring
 - (1) E.g. most apples can't be grown successfully very far south because they require a long period of cold which doesn't occur in the South
- 3) Water
- a) Water must be present in adequate amounts to allow life processes to proceed (see above under transpiration)
 - b) Depending on adaptation of plant, "adequate water" is a variable amount.
 - c) Inadequate amounts of water will cause plant stress and hinder photosynthesis, respiration, and most other biochemical processes.
 - d) The rate of water loss by a plant is controlled by many factors, but atmospheric relative humidity (RH) is a major factor. RH is a measure of how much water vapor the air can hold. When RH is high, transpiration rate is lower than when RH is low.
 - e) Under conditions of water stress, when water is lost by leaves through the stomata faster than the roots can supply new water, the stomata will close to help conserve moisture. This closure of stomata decreases transpiration but also slows gas exchange, resulting in a decrease in photosynthesis.

CLASSIFICATION OF HORTICULTURAL PLANTS - groupings by similarity of characteristics

- 1) Scientific system
- a) Genetic basis (as reflected in plant forms)
 - b) Critical plant parts used to judge genetic similarity
 - i) Flower
 - ii) Vascular system, leaves, buds, etc.
 - iii) Biochemical or molecular characteristics
 - c) Reflects evolutionary relationships (primitive to advanced)
 - d) Results in a unique name for every plant
 - e) Hierarchy of ever-decreasing size groups (the smaller the group, the more similar the members), (please see last page for visual representation)
 - i) Kingdom - Planta (all plants)
 - ii) Division
 - (1) Non-vascular plants (e.g. moss, liverworts)
 - (2) Spore-producing vascular plants (e.g. ferns and "fern allies" (club moss, horsetail))
 - (3) Seed-producing vascular plants (e.g. most common food and landscape plants)
 - iii) Class - (those within seed-producing vascular plants - Gymnosperms (naked seeds, e.g. conifers, ginkgo) / Angiosperms (covered seeds, the "flowering" plants))
 - (1) Sub-class - (those within Angiosperms only - Monocotyledons (one seed leaf. e.g. grasses, palms, orchids, lilies) / Dicotyledons (two seed leaves, e.g. roses, peas, asters). Short hand for these two subclasses is monocots and dicots.)
 - iv) Order - (those within Gymnosperms or Angiosperms - Cycadales, Coniferales, Rosales, etc.)
 - v) Family - (those within Rosales - Rosaceae, Fabaceae, Crassulaceae, etc.)
 - f) In horticulture and gardening the Family level is important. Knowing an unknown plant's family (based on physical characteristics) may help us identify it or make predictions about it.
 - g) A few horticulturally important families:
 - i) Pinaceae (pine, spruce) (similarity – usually evergreen with needle leaves, produces cones)
 - ii) Poaceae (grasses) (old name used: Graminae) (similarity – long, thin leaves, flowers not showy)
 - iii) Asteraceae (daisy flower plants), (old name used: Compositae) (similarity: flowers clustered into a head, fruit is an achene)
 - iv) Rosaceae (rose, apple, cotoneaster) (similarity: showy flowers, often disease prone)

- v) Solanaceae (tomato, pepper, potato) (similarity: flower structure, type of fruit)
- vi) Malvaceae (hollyhock, hibiscus) (similarity: anthers form a column, loved by Japanese beetles)
- vii) Lamiaceae (mint, salvia, bee balm) (old name used: Labiatae) (similarity: often square stems, often scented foliage, often a tendency to spread rapidly)
- h) Classification within families
 - i) Genus, (plural: genera) eg. Acer is the genus of maple, Lilium is the genus of lilies
 - ii) Species – plants that are so similar that they can breed without restriction and the offspring are similar to the parents, e.g. sugar maple, silver maple, Japanese maple
 - iii) Latin binomial: gives the genus and species designation (called the specific epithet) together, eg. Acer saccharum is sugar maple
 - (1) The second word in the scientific name is often called the “species”. This is technically incorrect. Remember that to designate a single species, you must use the two word scientific name, not just the second word.
 - iv) Groupings of greater similarity than species, that is, subsets within species
 - (1) Botanical – subspecies (abbreviated ssp. or subsp.), variety (var.), forma (f.), e.g. Viburnum plicatum var. tomentosum. If three Latin words are given for the name with no abbreviation, the third is assumed to be a subspecies designation.
 - (2) Horticultural - cultivar (cultivated variety). Cultivars are a subgroup of the species selected for a favorable characteristic such as flower color, plant shape, or disease resistance.
 - (a) Clone - vegetatively propagated
 - (b) Line - seed propagated
- i) Notes on proper nomenclature
 - i) Genus is always capitalized, written in italics or in plain type and underlined, specific epithet is lower case, written in italics or in plain type and underlined
 - (1) E.g. Acer saccharum or Acer saccharum
 - (2) The genus is a noun and can be written alone without the species name. The species name is an adjective and cannot be written alone without the genus name.
 - (3) When writing about several different species in the same genus, the genus may be abbreviated using the first letter as long as it is spelled out initially. E.g. Acer saccharum, A. saccharinum, A. palmatum, A. rubrum. Instead of Acer saccharum, Acer saccharinum, Acer palmatum, Acer rubrum.
 - ii) Additional botanical designations – subspecies, variety, forma – are not capitalized and are written in italics or in plain type and underlined. However, the abbreviations ssp., subsp., for., and var. are not italicized or underlined.
 - iii) Cultivar is written 'Red Sunset' or cv. Red Sunset, not underlined or italicized and in single quotation marks or preceded by cv.
 - iv) Hybrids are indicated with an x, such as Aquilegia x hybrida, when it is a hybrid between two species within a genus. The “x” is not italicized or underlined.
 - v) Hybrids which are inter-generic are indicated with an x before the scientific name, e.g. x Fatsyhedera lizei, which is a cross between the genus Fatsia and the genus Hedera
- j) Common name, generally not capitalized

2) Practical systems

a) Life cycles

- i) Annual – plant goes from seed to seed and dies within 12 months
- ii) Biennial – plant goes from seed to seed and dies in two years.
- iii) Perennial – plant lives three years or more. Many will produce seed each year

b) Secondary growth

- i) Herbaceous
- ii) Woody

c) Hardiness in a given locale

- i) Tender

- ii) Hardy
- d) Origin
 - i) Temperate – plant native to the region of the world between 23.5° N latitude and the Arctic Circle, or 23.5° S latitude and the Antarctic Circle (e.g. Indiana)
 - ii) Tropical – plant native to region between 23.5° N latitude and 23.5° S latitude. Often grown in Indiana as houseplants.
 - iii) Alpine – plants native to areas above the timberline
- e) Leaf retention
 - i) Deciduous
 - ii) Evergreen
 - iii) Semi-evergreen (retains its leaves for most of the winter, especially if the winter is mild. These plants are usually evergreen in warmer climates.)
- f) Use
 - i) Vegetables
 - (1) Aerial
 - (2) Root crops
 - ii) Fruits
 - (1) Temperate
 - (2) Tropical
 - (3) Tree
 - (4) Small
 - (5) Nuts
 - iii) Culinary – based on how the plant is used, NOT on the botanical plant part
 - (1) Vegetables – eaten with main part of meal
 - (2) Fruit – eaten as salad or desert
 - iv) Ornamentals
 - (1) Flowers, garden
 - (2) Flowers, greenhouse
 - (3) Foliage plants
 - (4) Landscape woody plants
 - (5) Turf grass
 - v) Miscellaneous
 - (1) Herbs & spices
 - (2) Oils
 - (3) Beverages

PLANT CLASSIFICATION HEIRARCHIES

Divisions further to the right contain more similar but fewer species than those to the left.

Kingdom

Division

Class (Gymnosperms, Angiosperms)

Sub-classes of Angiosperms: Monocotyledons, Dicotyledons

Order

Family

Genus

Species

Subspecies, variety, forma, ecotype

or

Cultivar (clone or line)