Parts that make up a Tree

Like all plants, a tree begins from a **seed**. Inside each tree seed is a tree waiting to be born!
A seed must have food, water and light to grow. Once the seed sprouts, it grows into a seedling that grows into a sapling and eventually saplings grow into trees that produce their own seeds.
All trees have **roots**, which have two important jobs to do.
They anchor the tree to the ground so that it can stand upright, and they absorb water, minerals and nutrients (tree food) from the **soil**. The trunk of a tree, which is protected by a tough outer covering of **bark**, connects the roots to the **branches** and transports water and minerals from the soil to the rest of the tree. The trunk supports the tree and as it grows taller than the plants around it, it is able to reach more sunlight, which is essential for growth.
Branches connect the trunk to the **leaves** and transport water and minerals to the leaves. The leaves, which are held up by branches, are arranged in a way that captures maximum sunlight. The tips of branches are known as **twigs** and these are the growing ends of the tree. Leaves grow on the twigs and produce food for the whole tree, but can only do this in sunlight. Leaves use energy from the sun to convert **carbon dioxide** in the air and water from the soil into sugars to feed the tree. This process is known as **photosynthesis**. Trees release **oxygen** into the air during photosynthesis. This is very important, as all animals -- including us humans -- need oxygen to survive.

In general, there are five different types of trees. The two most common types are known as **coniferous** trees (or conifers), and **broadleaved** trees. They are different in numerous ways.

Coniferous Trees

Coniferous trees grow upward rather than outward and have a triangular shape. The leaves on a coniferous tree are either long, pointed needles, or are small, flat scales. Seeds of coniferous trees grow in **cones**. When a cone opens its scales, the seeds fall out. There are three major groups of conifers -- **firs, spruces and pines** -- and they can be identified by their needles. The firs have short needles with blunt tips. The spruces have four-sided needles that are very sharp. The pines have needles that grow in bunches, wrapped together at the base.

Broadleaved Trees

Broadleaved trees spread out as they grow and have a rounded shape. These trees have wide, thin leaves that catch a lot of light but cannot survive without warmth and water.
Seeds of most broadleaved trees are protected inside a hard nut or fleshy fruit. The seeds are dispersed when the fruits or nuts are eaten by animals. Since the seeds inside the fruit are not digestible, the animal eventually passes them out through its droppings, and often far away from the parent tree. This allows the seedling to grow in an area that is not overshadowed by its parent.
Two common examples of broadleaved trees are the **oaks** and **maples**.
Broadleaved trees in regions that experience cold, dry winters, like Canada, are known as **deciduous trees**. When summer ends and winter approaches, the leaves of deciduous trees die and as you've seen every autumn, turn brilliant red, fiery orange, shimmering yellow, gold and brown before they fall to the ground.

What Is An Evergreen?

Coniferous trees are known as **evergreen** trees because they are always green and never bare. Even in cold climates, coniferous trees are able to retain their leaves/needles because they are protected by a waxy coat that does not allow a lot of water to escape from the tree. Broadleaved trees can also be evergreen but only in countries where there is plenty of warmth and water all year round.

Tree Survival Tactics

Trees can do some pretty interesting things to survive. For example, the baobab tree that lives in parts of Africa, where it is hot and dry for long periods, stores water in its thick trunk during the rainy season.
When the rains have stopped and it is hot and dry again the trunk shrinks as the tree uses up the stored water.
To protect from damage and damp, conifers produce resin, a sticky substance. When the tree is damaged resin keeps wood eating insects out and kills bacteria and fungi that could infect the wounded tree.

Some trees are even covered with spikes for protection, like this tree species in Honduras.

WHAT IS TREE GROWTH?

Trees have six organs: leaves, stems, and roots (known as vegetative structures) and flowers, fruits, and seeds (known as reproductive structures). This bulletin discusses vegetative growth--that is the growth of leaves, stems, and roots.
Tree growth is the increase in size and number of leaves, stems, and roots.

WHAT KINDS OF TREES ARE THERE?

Trees are seed plants - that is they reproduce by seed. They are classified into gymnosperms and angiosperms. Gymnosperms are trees with seeds that develop on the surface or tip of an appendage such as a cone. Examples are cypress and pines. Angiosperms are trees with seeds borne within structures such as fruits (the seed is enclosed). Examples are oaks, elms, maples, and palms. This bulletin describes growth of both gymnosperms and angiosperms. Also, there's one more division among angiosperms that is necessary. Palms are angiosperms but they are different than oaks, maples, and elms, which are dicots, because palms are monocots and are related to grasses. This bulletin first reviews growth of gymnosperms and dicots; then because they grow very differently, a special section looks at palms.

WHAT CONTROLS GROWTH?

Tree growth is a response to the environment and to the tree's genetic make-up. The environment is made up of factors such as water, light, temperature, air, pests, and cultural practices. These factors impact physiological processes such as photosynthesis and respiration, and the final response is the tree grows vigorously or slowly. A tree's genetic make-up also influences the way a tree grows. Genetics means the species, seed source, or variety (Did it come from south Florida or North Carolina?), and family (Who were its parents?). These genetic characteristics along with its environment determine how a tree grows.

WHERE DOES GROWTH OCCUR?

Growth occurs in meristems. A meristem is a tissue that contains cells that have the capacity to divide and make new cells. Some of these new cells continue to function as meristematic cells. Other new cells grow and differentiate into structures such as roots and shoots.

Meristems can also produce new meristems--these are called primordia. For example, an apical meristem in a bud produces new meristems called leaf primordia - each single primordium will grow into a new leaf. Root primordia grow inlo new roots.

GROWTH ABOVE GROUND

Tree growth above ground includes shoot elongation, leaf growth, and diameter growth.

Shoot Elongation

Shoots grow in height or length in apical meristems located at the tips of branches (figure 1). What happens is - apical meristem cells divide, elongate, and differentiate. The steps that we can see are: (1) the bud at the tip of the branch opens, (2) leaves emerge and enlarge, and (3) the area between the leaves expands, namely the stem grows. Lateral (side) buds grow in the same way but often are dormant and do not grow until they are triggered to grow. Activities such as pruning can serve as this trigger.

Leaf Growth

On the surface of the apical meristem in the bud, a new meristem is formed. This new meristem is called a leaf primordium, and this is where cells divide and grow to form a leaf. The number of meristems on a leaf influence leaf shape (figure 2).

Soon after leaves develop, a new bud primordium (meristem) is formed at the base of each leaf stem. Once formed, this axillary bud has the capacity to become a branch, but may lie dormant for many years.

Diameter Growth

Between the wood and bark is a thin layer of dividing cells called the vascular cambium. This vascular cambium is a meristem which is only a few cells thick. This meristem divides, creating wood on the inside and bark on the outside (figure 3). Layer by layer these new cells increase the diameter of the trunk and branches. The wood cells are called xylem, which means wood in Greek; they carry water and minerals up from the roots. The bark cells are called phloem, meaning bark in Greek. These cells carry sugars and other materials produced by the plant.

Annual Rings

New layers of wood are added each year between the bark and the previous year's wood. These are called growth rings or annual rings and may be used to age a tree. Annual rings vary in size and thickness according to the season and environmental conditions when they are formed. Cells produced in the spring are larger with thinner cell walls. These are the light-colored rings, and the wood is called early or spring wood. Cells produced in the summer are smaller, and this late or summer wood has a higher density and darker color.

Bark

Trees have bark that protects the tree from pest attacks and environmental impacts such as fire and mechanical injury. Trees with thick bark are more resistant to injury than those with thin bark. As the tree grows in diameter, the bark has to give, forming ridges and cracks. Eventually the outer bark sloughs off.

GROWTH BELOW GROUND

Roots can grow in length (root elongation) and diameter, and new lateral roots can form.

Root Elongation

Root Elongation
At the tip of a root is the root cap (figure 4). This cap protects the root, and it must be constantly replaced as it pushes through the soil. Behind the root cap is a meristem, which produces new cells for the root cap and for root elongation. These new cells elongate, divide, and differentiate into root parts. The root grows in length and pushes through the soil.

Root Diameter Growth
Many people don't think that roots grow in diameter, but they do! And root diameter growth is similar to growth in the stem with the vascular cambium producing wood (xylem) and bark (phloem). A couple differences between root and shoot diameter growth are: (1) diameter growth is much more irregular in roots, resulting in roots that are oval or irregular shape, and (2) there is greater variation in root diameter with age and with horizontal roots comparcd to vertical roots.

New Root Growth
Roots can also grow new lateral roots that branch off the main root. Some cells located in a layer inside the root produce a new root primordium (figure 4). This new meristem divides and elongates, pushing the new root out through the parent root and into the soil.

EXAMPLES OF THE URBAN ENVIRONMENT'S INFLUENCE ON GROWTH
Urban trees are often subjected to a tremendous amount of stress. Soils are compacted, trees are over - or incorrectly - pruned, roots are given very little space to grow, trees are improperly staked, and on and on. A few of the stress-induced practices and environmental conditions are discussed briefly along with how they affect growth.

Pruning
What happens when you prune a tree? If you prune the apical buds, the lateral buds are released and new shoots grow. If you prune older, large-diameter stems, two things may happen: (1) dormant buds, produced long ago during primary growth, can now grow into new branches, and (2)new meristems arise and produce new buds and shoots. This growth of new branches is most likely to occur in angiosperms - everyone has seen sprouts from the stump of a freshly cut oak, maple, or elm. Pine trees, however, do not have these dormant buds and will not sprout. Of course, if you remove the apical bud from a palm, it will die--remember? most palms only have one bud at the top of the tree.

Staking
How does staking affect growth? When trees are planted, they are often staked. However, studies have shown that trees that are allowed to sway in the wind are sturdier. Staked trees tend to be less stable and sometimes topple when stakes are removed and trees are exposed to wind. This can be explained by looking at growth differences. When trees blow in the wind there is a redistribution of the amount and nature of diameter growth on the leeward and windward sides of the tree trunk. Reaction wood is formed, and this wood has larger and thicker walled cells than other wood. Hence when exposed to wind a tree becomes sturdier and can tolerate wind better. For this reason, do not stake young trees unless they absolutely will not stand up without a stake. Remember palms do not have cambial (diameter) growth, so staking palms is okay and often necessary until new roots stabilize the palm in the landscape.

Compacting the Soil

Soil conditions in urban plantings are often ignored, resulting in many tree health problems. Trees often have limited rooting space and are similar to large potted plants. Soil compaction can occur due to such things as construction equipment, sidewalks and streets, and footsteps. What happens to growth when tree roots are in compacted soil? Studies show that trees grown in highly compacted soil have less root volume and weight because roots cannot penetrate compacted soil. And this translates into reduced shoot height and overall growth. Compacted soil in the city means roots cannot grow, water cannot permeate into the soil, and nutrient uptake is reduced, resulting in poor tree growth. Of course, the ultimate effect is poor tree health and death. Some ways to avoid compaction are: (1) mix organic matter into the soil, (2) prevent vehicles from operating beneath the tree canopy, and (3) when construction traffic must work around trees make sure it is when the soil is dry (wet soil is more easily compacted) or spread a thick layer of coarse mulch beneath the canopy.

SECTION CONCLUSIONS

Trees grow in response to their environment and genetic make-up. Envirorimental factors such as high temperature or soil compaction influence physiological processes such as photosynthesis and, in turn; impact growth. Meristems are areas within the tree where growth occurs. Most trees grow in shoot length and diameter and root length and diameter. Palms, however, have only one growing tip and do not grow in diameter. A tree's form is controlled by branch orientation and by the amount of apical dominance. Altering the environment or management practices to decrease stress, and selecting the right tree for the right place will promote growth and longevity.

And,finally, as the tree ages and grows, does the birdhouse move up the tree and out of your reach? No! Why not? Remember a tree only grows in height at apical meristems at the tips of branches. At the height of the bird-house only trunk diameter growth is occurring.

Trees And Sidewalks

What's the problem?

- Trees often ruin sidewalks, and sidewalk repair often kills trees.
- This conflict comes from the fact that sidewalks and trees have competing needs.
  Trees need a soil that is moist and loose, and that they can push aside as they grow.
  Sidewalks need to be smooth (but not flat) on a soil that will not shift with a load.
- Trees and sidewalks are costly and valuable, so both needs must be taken seriously.

How do they damage each other?

- Most of the damage to sidewalks is caused as roots become thicker through secondary growth.
  Sidewalk damage is often caused not by the tree but by the soil in its expansion and contraction.
  The buttress roots supporting the tree cause the worst damage.
  Roots often follow cracks, because there they find the water and air they need.
- Most of the damage to trees comes when the main roots are cut close to the trunk.
  When larger roots are cut, trees lose mechanical support from that side, and become more likely to cause harm from windthrow.
  Main root cutting also heavily reduces the flow of water and nutrients to the crown, causing especially older trees to die in 3-5 years.

How can I avoid cutting the roots?

- If a tree is in poor condition, it is best to remove the tree and replace the sidewalk.
- For trees in good condition, a sidewalk can be curved around the trunk (at least 2-3').
- In some cases, a raised edge can simply be ground down, or smoothed over with asphalt.
- The new sidewalk may be ramped up and over the roots by starting further away.
- You can also do minimal excavation, and then pour asphalt directly over the roots.
- Gravel, mulch, pavers set in sand, or asphalt can be used instead of concrete.

If I decide I have to cut the roots, how can I least harm the tree?

- The farther you cut from the trunk, the less threat to the tree's health, and the less danger of creating a hazard.
- Try not to cut roots over 2" in diameter.
- Roots recover better from being severed when you
  cut them cleanly with a saw instead of breaking them with a backhoe
  protect them from drying out while work is going on
  mulch and water well afterwards
  provide slow-release fertilizer in early fall or spring

How can future damage to sidewalks be avoided?

- Provide enough space for the species you want to plant.
- Try to keep large-growing trees in tree lawns 10' wide or greater, medium trees in lawns 6-10' wide, and small trees in 4-6' lawns. Avoid planting trees in lawns under 4' wide.
- Give species with many large surface roots (like Norway maple) lots of room.
- You can't necessarily rely on root barriers--the roots do grow down, but then often come right back up!
- Consider experimenting with a structural soil mix that will better tolerate root growth.

Codominant Stems

What does that refer to?

- The term “codominant stems” is used to describe 2 or more main stems (or “leaders”) that are about the same diameter and emerge from the same location on the main trunk.
- As the tree grows older, the stems remain similar in size without any single one becoming dominant.

Why are such stems important to recognize?

- Codominant stems tend to fail much more often than others, especially in storms.
- Though such stems may look fine to the casual observer, they may actually be dangerous.
- Early recognition of such stems allows remedial action when it does the most good.
- Many of our most common street, highway, and park trees commonly form codominant stems.
  Maples and oaks
  Conifers that have lost the terminal during development

How can you tell if there is a serious problem?

- Classifying codominant stems into 3 risk stages can aid in their management:

  Risk Stage 1: does the union between the two stems form a “V” but there are no other symptoms?
  A “V” union is much more likely to fail than a “U”
  Stems with a “V” union compress bark between them as they grow, leaving little physical connection

  Risk Stage 2: are there symptoms of decay in the union?
  Can you see rotted matter between the stems?
  Is there any fluid flowing from the union?
  Are there woody plants growing in the union?
  Do you see wide “ears” (swelling) on either side of the union?

  Risk Stage 3: is there any sign of failure?
  Can you see any cracks in the union itself?
  Is reaction wood being formed rapidly at the base of the stems?

What can be done about them?

- **Risk Stage 1**
  If the tree is young enough, prune out one of the stems; the tree will fill in the missing canopy
  For codominant stems greater than about 4" in diameter, pruning out one stem can cause more problems than it solves
  It leaves an unbalanced crown susceptible to mechanical failure
  It creates a large open wound susceptible to decay fungi

- **Risk Stage 2**
  Carry out an aerial inspection, probing the union itself to estimate its depth
  Reduce the end weight of the stems through proper crown reduction techniques
  For specimen trees, cabling and pruning can help in some situations
  You need a balanced crown and sound wood in the upper leaders for attaching hardware
  Make sure any such work follows the ANSI A300 standards
  When the stem is large and you can not cable, consider removing the tree--especially when there is a significant target such as a busy road or inhabited building

  Use a drill or other tool (such as a Resistograph®) to determine the thickness of sound wood
  There are no firm published criteria, but look for at least 1" of sound wood for each 6" of attached stem diameter
  The longer the stem above the union, the greater the breaking force, so give yourself an extra margin of safety for long stems, particularly those with lots of foliage

- **Risk Stage 3**
  If there is a crack or other indication of incipient failure, remove the tree as soon as possible--especially if there is any kind of target

NATIVE TREE SPECIES

What is a "native" tree species?

- A hard question! One answer is that native tree species grow naturally in the wild in a particular region.
- Usually, the contrast is made between a native and an exotic (or introduced) species.
- But certain trees and shrubs introduced since 1600 (e.g., common buckthorn) are now widespread.
- Also, a native in one region of the Northeast may easily not be native in another, much less in the entire country.

Why does it matter?

- In recent years, there has been heated debate about native vs. exotic species.
- Some people want to avoid an invasion of exotic species into the natural landscape.
- Others argue that native species resist pests better, and thus are easier to maintain.
- Some believe that natives are better adapted, so are less stressed by climate extremes.
- And a few people just seem to want no "foreigners" around, period!

Are these claims true about the virtues of native species?

- There is no single or simple answer to this question.
- Some exotics (like Norway maple or Tree-of-Heaven) really can be invasive.
  But some natives (like aspen, black locust, or black cherry) are also invasive.
  And invasiveness depends on a favorable and available site.
- Regional natives grown from regional seed usually resist regional pests well.
- Climate tolerance depends more on provenance or chance, not "native" status.

Which native species make good urban trees?

- Tree species native to a given region may not do well in disturbed urban sites.
- Here are some species native in much of the Northeast and often good for street tree use:
  red oak (Quercus rubra)
  sugar maple (Acer saccharum)
  hackberry (Celtis occidentalis)
  white ash (Fraxinus americana)
  scarlet oak (Quercus coccinea)
  hophornbeam (Ostrya virginiana)
- These are often good for landscape use in the Northeast:
  serviceberry (Amelanchier spp.)
  black gum (Nyssa sylvatica)
  hornbeam (Carpinus caroliniana)
  swamp white oak (Quercus bicolor)
  tulip tree (Liriodendron tulipifera)
  river birch (Betula nigra)
- Try these for poorly drained or intermittently flooded soils in the NE:
  bur oak (Quercus macrocarpa)
  tamarack (Larix laricina)
  red maple (Acer rubrum)
  green ash (Fraxinus pennsylvanica)
- Remember, though, your site must meet the cultural demands of the species.

Where can I find native tree species?

- Always try a local nursery first. Their stock is usually more regionally adapted.
- Regional wholesale nurseries often carry native species--but try to check the seed source!
  red maples grown from southern seed sources, for instance, will do less well in the north than seed from northern sources.
- For less common natives, you may have to order from catalogues of specialty nurseries.