California Tree Academy

After School Youth Program Manual

California Tree Academy

An Introduction to Basic Tree Biology & Photosynthesis, Environmental Benefits of Trees and Carbon Cycle

Part 1 - Basic Tree Biology & Photosynthesis

Part 2 - Environmental Benefits of Trees

Part 3 - Carbon Cycle

Key Learning Objectives:

1. Know the "Life Cycle of a Tree" - be able to draw and label a simple diagram of this "cycle"
2. Know the basic simple "formula" of photosynthesis
    a. Know what is produced in the leaves that is needed for root growth, bud production, stem and trunk growth
    b. Know the most important thing that is taken up by roots that is needed by the leaves in photosynthesis
    c. Know what photosynthesis produces that we humans and other animals need to live on this planet
3. Know how trees grow tall and branches get longer and why this is important to understand
4. Know how tree trunks and other branches get bigger in diameter each year and why this is important to understand
5. Know the difference between evergreen and deciduous trees
6. Know why leaf litter can be useful for tree growth if left on the ground
7. Know the function of flowers on a tree
8. Know the role of pollination in producing fruit
9. Know how roots typically grow in urban soils (how deep and how far they grow away from the tree trunk)
10. Know the function of a tap root
11. Know some of the environmental benefits that come from healthy trees
12. Understand the carbon cycle and the role of trees in the carbon cycle

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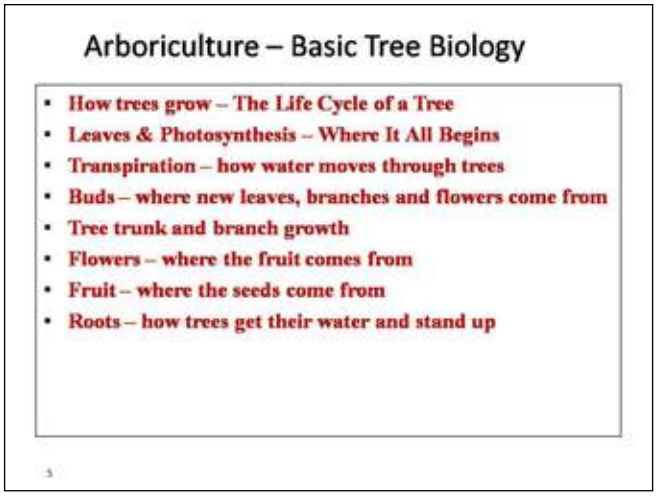
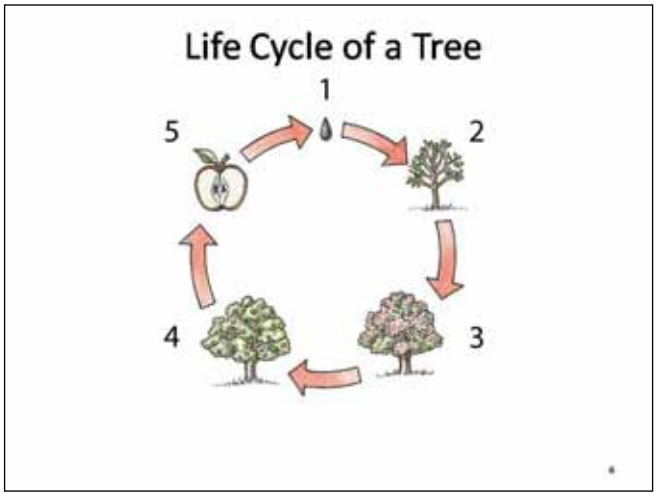
After School Program Part 1: Basic Tree Biology & Photosynthesis



Arboriculture - Basic Tree Biology

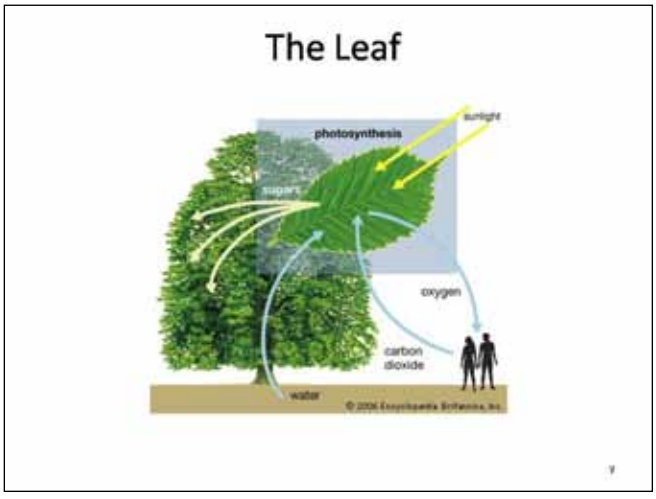
1. Arboriculture includes the science of basic tree biology
2. The topics listed in the slide are the ones we will cover in this Part of our lesson
3. Hopefully, you will leave here looking at the trees around you in a way you have never done before
4. Understanding this basic tree biology will help you understand:
   a. Why certain trees do better in different types of environments and spaces
   b. Why we plant trees the way we do
   c. How we care for trees, especially how we prune trees
   d. What might be happening when you see a tree that is not doing too well



Life Cycle of a Tree

All trees have this same basic life cycle:

1. It begins with a seed that germinates and
2. Grows to become a young tree that
3. Produces flowers which
4. Turn into fruit that
5. Drops to the ground or is otherwise dispersed by wind, birds, or other animals.
6. As the fruit is eaten or decomposes it releases seeds that, under the right conditions, will germinate and start the cycle all over again

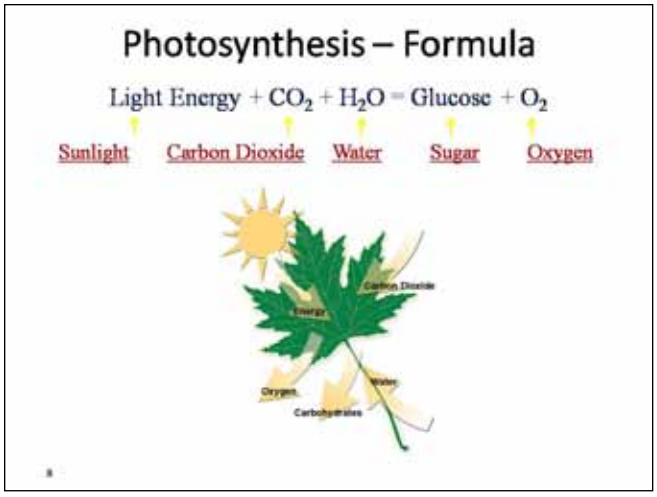


The Leaf

Even though the previous diagram shows the "Life Cycle of a Tree" beginning with the seed, our discussion of the various parts of a tree will begin with the LEAF.

1. Leaves are needed to produce the food (sugar) they need to grow more leaves, grow new branches, add new wood to their existing branches, produce flowers or fruit.
2. If they never produce fruit then they cannot produce seed, and without seed there can be no new trees. So you see, it all begins at the LEAF.
3. And it is in the LEAF that a very important process called photosynthesis takes place.
4. This is the process that the tree uses to produce the sugar it needs to do all of the things we just mentioned.
5. Let's take a closer look at this process in the next slide.

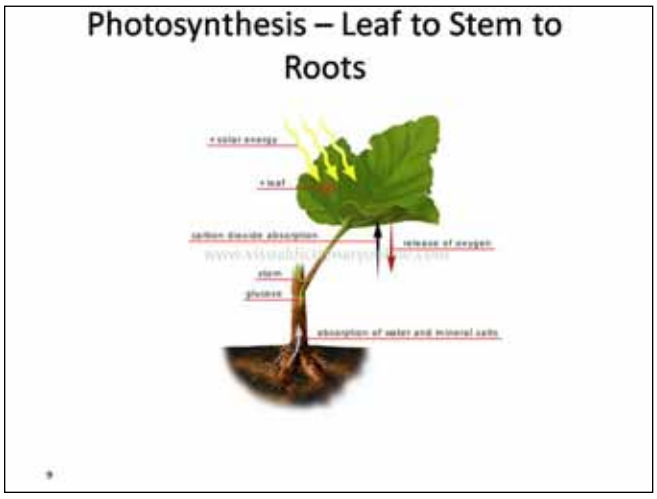
After School Program Part 1: Basic Tree Biology & Photosynthesis



Photosynthesis - Formula

Photosynthesis is the process trees and other plants use to convert the sun's energy into sugar for their own growth and development, and oxygen that animals use to breathe

1. A simplified version of this formula is as follows:
   Light Energy + CO2 + H2O = Glucose + O2
2. CO2 is the molecular formula for carbon dioxide and H2O is the molecular formula for water. Glucose is the type of sugar produced. O2 is oxygen.
3. Trees take in light energy from the sun, carbon dioxide through the leaves and water up from the roots to
4. Produce glucose (a type of sugar) and oxygen
5. Glucose moves out of the leaf and into the nearby branches in a mixture of water that we know as sap.
6. Glucose is used by the tree to produce new branches, new leaves, and add wood to existing branches (including the tree trunk itself).
7. It is also used to produce flowers and fruit
8. The oxygen produced is released to the atmosphere and used by animals to breathe.



Photosynthesis - Leaf to Stem to Roots

This illustration shows the same process of photosynthesis. It also shows how the water that is needed for photosynthesis is absorbed through the roots and moves up into the tree and into the leaves.

1. Solar energy is used by the leaf to produce oxygen and absorb carbon dioxide.
2. You can see that the glucose moves down through the tree to the roots where it is used for root growth and absorption of water and nutrients from the soil.

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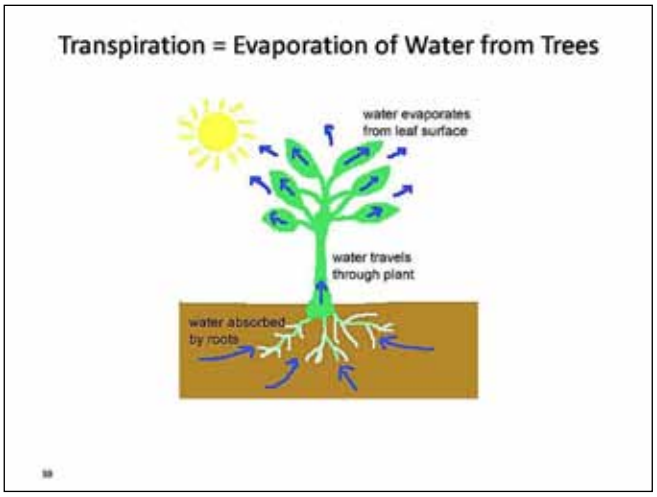
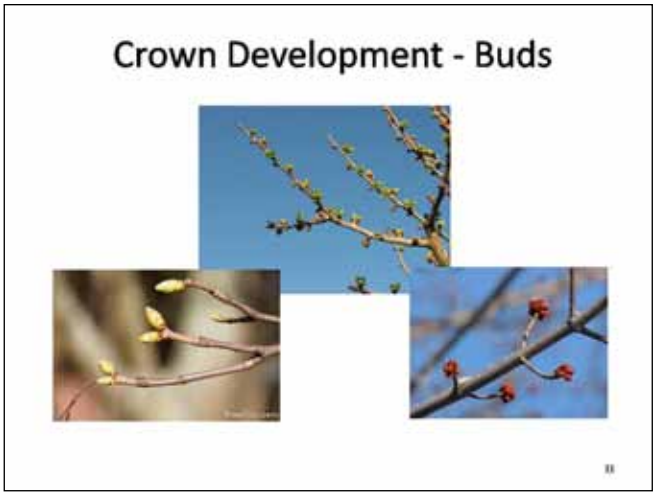


Transpiration = Evaporation of Water from Trees

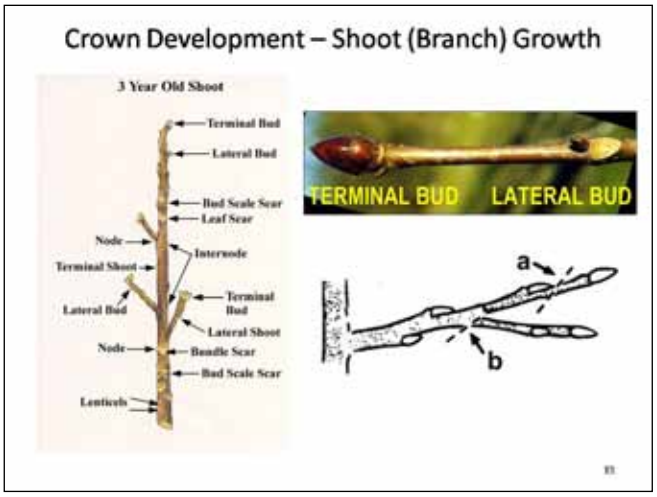
Transpiration is the process by which water is evaporated from leaves.

1. Water is literally pulled to the top of trees by transpiration – this is critical because water is needed in the leaves for photosynthesis.
2. Transpiration cools leaves and increases the rates of water and mineral uptake and distribution through the tree



Crown Development - Buds Grow Into Leaves, Branches & Flowers

1. A bud is an unopened shoot or flower
2. Buds produce leaves and new branches or flowers
3. All healthy trees produce buds
4. Trees use some of the sugar produced in photosynthesis to create buds in the fall and early winter before they become dormant during the winter months
5. In the Spring growth of new leaves and branches will come out of some of these buds, and flowers will emerge from other buds



Understanding Branch Growth Key to Proper Pruning

1. Tree trunks and branches grow longer by adding new growth that are borne (comes out of) the terminal bud during each growing season
2. A bud scale scar is left at the terminal bud location after the new growth comes out
3. You can count these bud scale scars on each branch to determine the age of each branch. The new terminal bud that forms in the fall marks the end of that year's growth.
4. Lateral branches are borne (comes out of) lateral buds.
5. Reduction cuts as shown in "a" in the lower right image are always made right above a lateral bud
6. Never make a cut right below a terminal bud - if you do, the branch above the cut will die back to the next lateral bud and could cause an infection along the entire branch
7. Removal cuts are made where the branch to be removed is attached to its parent branch

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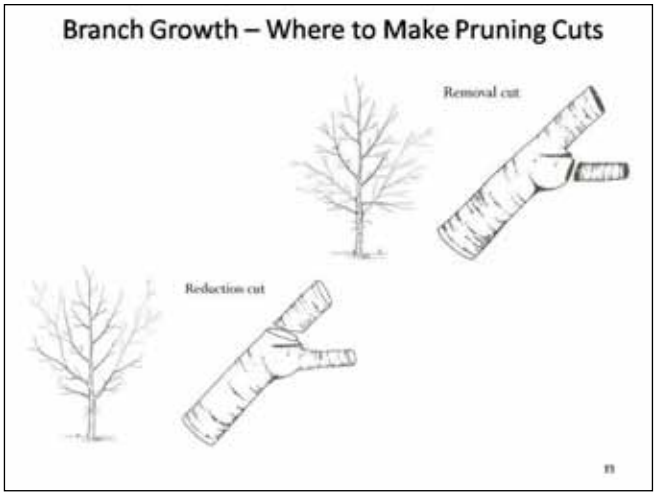
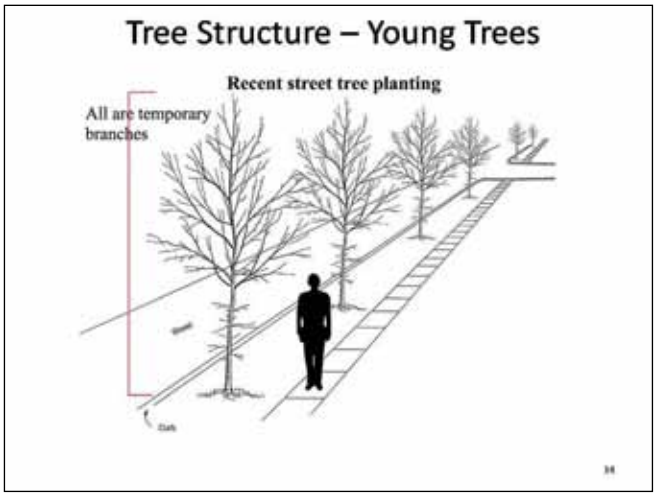


Branch Growth - More on Where to Make Pruning Cuts

1. A reduction cut shortens the length of a stem by pruning back to a smaller limb, as can be seen in the diagram in the lower left
2. In the image in the upper right, a removal cut prunes a branch back to the trunk or parent branch – in this case the cut is made just outside the slight swelling where the smaller branch meets the parent branch



Understanding Young Tree Structure

1. All existing branches on these recently planted beautiful trees will eventually be removed to provide clearance for buses, garbage trucks, and tractor trailers.
2. That is because the location of lateral branches along the trunk cannot change once they emerge (are borne) from lateral buds along the trunk
3. However, new lateral branches can grow from new lateral buds further up the tree trunk (the main trunk is also called the centeral leader) as the tree grows taller each year - remember the tree trunk grows taller as new branch growth emerges from the terminal bud.
4. Therefore, the key to getting new lateral branches that will be clear of trucks (14 feet off the ground), we need to make sure that a central leader (the main trunk) grows taller as quickly as possible.
5. We do this by making reduction cuts (see the previous slide) along lateral branches that may be competing with the main trunk (central leader)
6. When we do this the tree will put more growth into the central leader.

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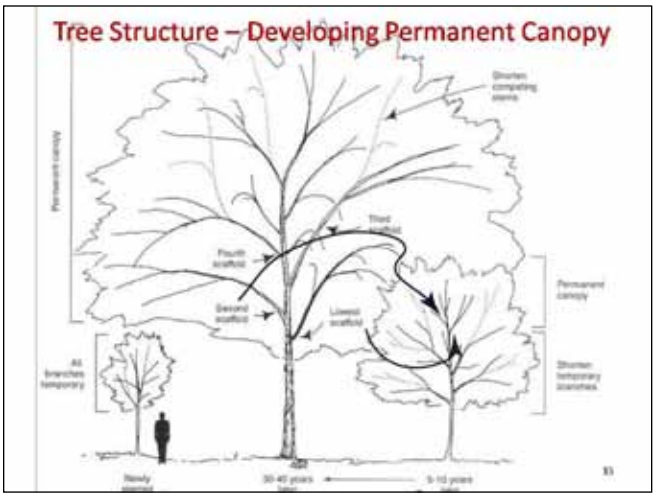
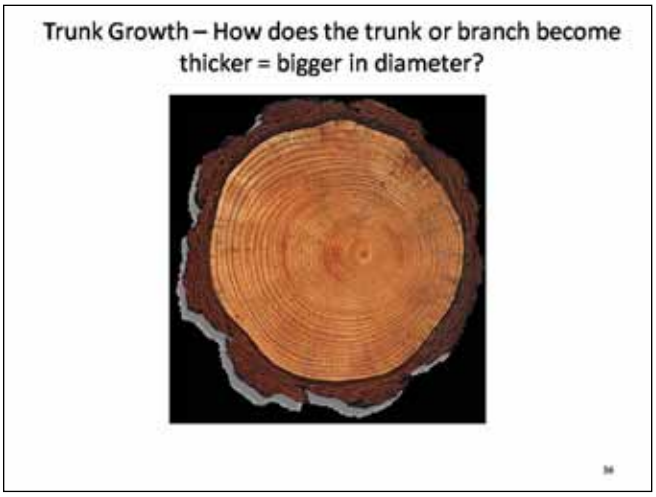


Tree Structure - Developing Permanent Canopy

1. This slide shows how that type of pruning strategy is actually executed
2. If you look closely you can see the reduction cuts in the tree in the lower left
3. This is done so that the tree will put more energy into growing the central leader taller so that the future permanent scaffold branches will be able to grow from lateral buds much higher off of the ground
4. If you look at the tree in the lower right of the image 5-10 years later you can see that the canopy is now tall enough to allow for new branches to grow at a height on the tree that will be high enough to be left on as permanent scaffold branches
5. So, you can finally see that in the mature tree in the middle of the image 30-40 years later the formation of the lowest permanent scaffold and the second scaffold
6. Both of these branches started growing in the tree to the right
7. They stayed at the same height off of the ground, but were able to grow into larger (thicker and longer) permanent branches



Trunk Growth - How does the trunk or branch become thicker (bigger in diameter)?

1. Tree trunks and branches also grow bigger in diameter (as shown in this diagram) by adding a new ring of woody tissue each year
2. Each ring has a light brown and darker brown ring, so to count the rings you count alternating dark brown rings or alternating light brown rings
3. There are several factors that can determine how thick each annual ring of growth may be
    a. Trees under stress from lack of water, pests, or disease may exhibit narrower rings of growth
    b. A shorter growing season can result in a narrower growth ring
    c. For this reason, tree rings have been studied to track climate change over a period of 4 or more millenium using especially long-lived tree species like Bristlecone Pine that can live to over 4,000 years old

Trunk Growth - How to Determine Age of the Tree

1. A tool called an INCREMENT BORER can be used to take samples from trees to determine their age
2. With the borer you can extract a sample of a cross-section of the tree from its outer edge to its inner core
3. The photos here depict the process, which ends with a close-up view of a section of tree rings that can be counted to determine the age of the tree

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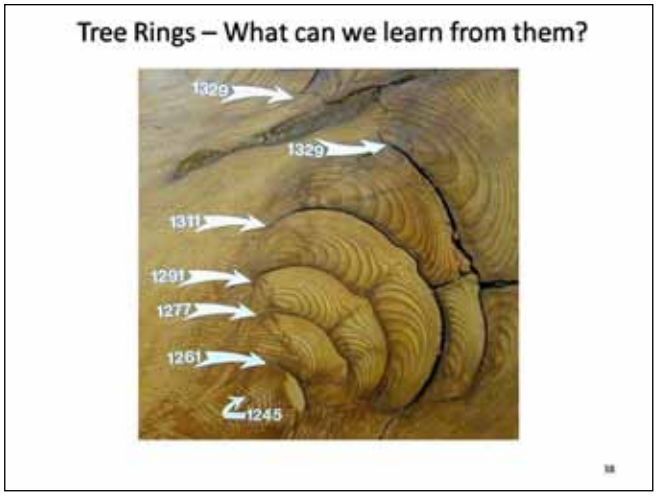
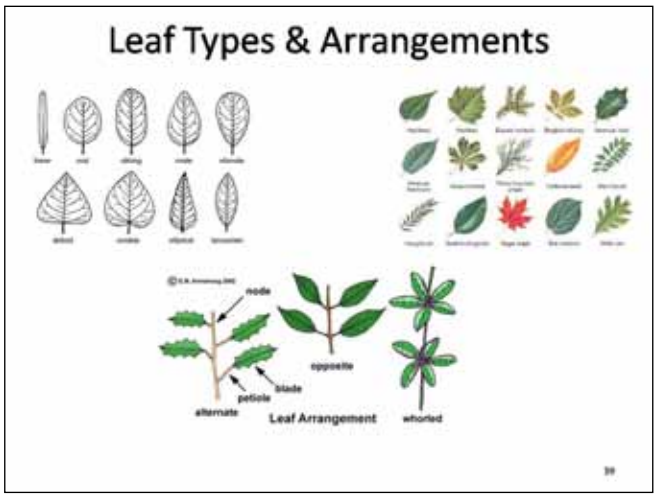


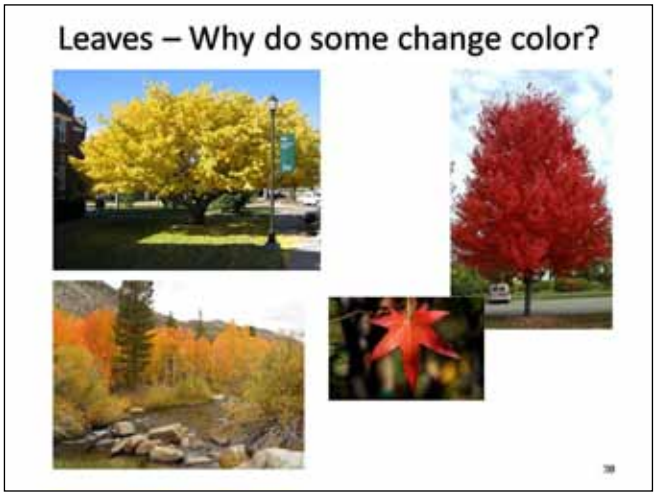
Tree Rings - What can we learn from them?

1. Tree ring patterns can also be studied to detect and age fire events, like those that can be seen in this cross section from a Giant Sequoia
2. What can be seen in this photo are the tree rings that have grown over the fire scars that damaged the then outer layer of the tree
3. This tree trunks section shows that California's western Sierra Nevada mountain range where these Sequoia trees grown had more frequent fires between 800 and 1300 than at any time in the past 3,000 years



Leaf Types & Arrangements

1. Leaves come in all shapes and sizes, with different arrangements on a stem, and different edges.
2. Understanding leaf types is critical to being able to identify different species of trees



Leaves - Why do some change color

1. As the days get shorter in the fall and winter and daytime temperatures begin to cool, it is a signal to trees to begin slowing down photosynthesis
2. For deciduous trees this means that the chlorophyll cells in the leaves become inactive causing trees to lose their green pigment (color)
3. The tree begins to move its remaining glucose into forming buds that will protect the cells that will become new leaves, branches and flowers when the weather warms up and the days get longer in the spring
4. As the green chlorophyll disappears from the leaves, the other pigments that have been in the leaves all along begin to show through - yellow, orange, red, purple colors

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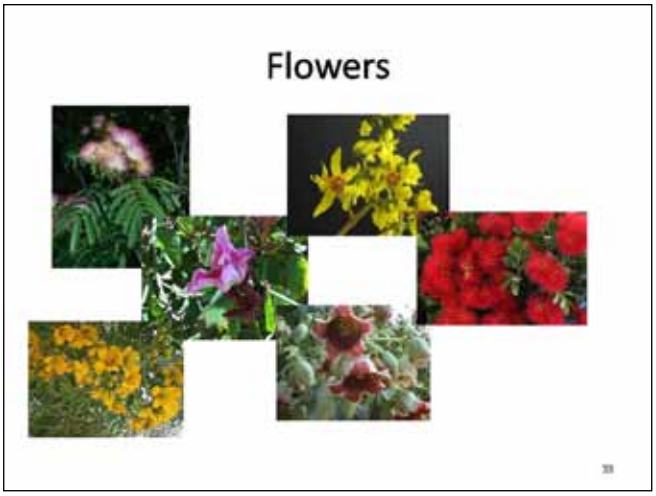
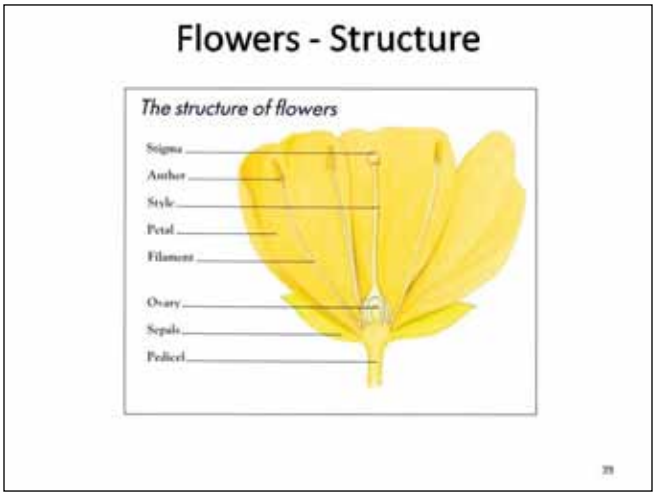
Leaves - Natural Mulch

1. As leaves turn color in the fall they begin to fall, and eventually by the middle of winter all of the leaves on deciduous trees have fallen to the ground.
2. This leaf litter is rich in carbon and nitrogen; as this natural mulch decomposes it provides nutrients that tree roots can take up to help trees grow.
3. Unfortunately, in most of our urban areas we tend to "blow" these trees away and throw them away with the trash.
4. It is much healthier for the environment when we use these leaves as natural mulch instead of using fertilizers that are made from fossil fuels like oil and natural gas.



Flowers

1. As with leaves, flowers come in a vast variety of types, shapes, arrangements, structures, and colors. Many trees are highly valued because of the flowers they produce.
2. While we value flowers for how beautiful they are, the colors, shapes and scents that the flowers give off are designed to attract pollinators such as bees, butterflies and hummingbirds.
3. Without pollination the flowers cannot develop into fruit that contains the seed that can eventually become a new tree
4. The images in the next few slides will help us to understand this process better



Flowers - Structure

1. Most trees are considered to be in the division of plants known as the flowering plants that are called angiosperms. This includes all broad-leaved trees - deciduous or evergreen - and all palms.
2. Of the flowering trees, about 90% have flowers that contain both the female and male parts in the same flower structure as shown in this illustration. These are called bisexual monoecious flowering trees.
3. The other 10% have either the male and female parts in separate flowers on the same tree (unisexual monoecious flowering trees), or male and female flowers on separate trees (dioecious flowering trees).
4. The flower shown in this illustration contains both female and male parts within the same flower. The male parts include the filament & anther that together make up the stamen. The female parts in include the stigma, style, and ovary.

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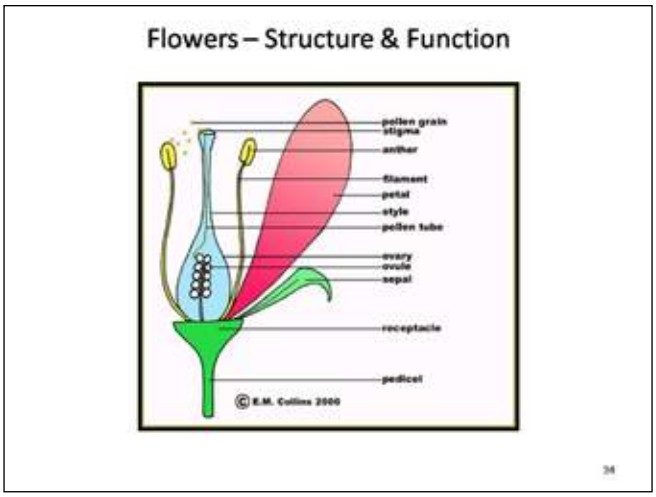
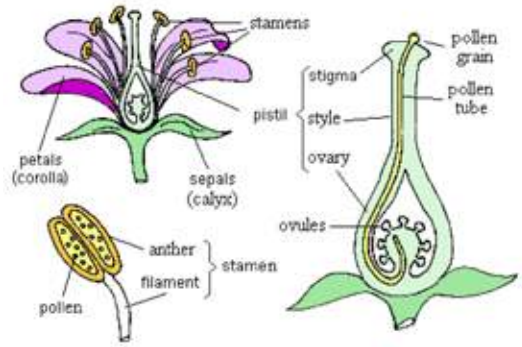


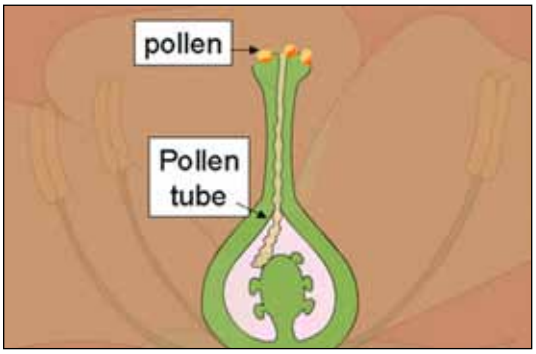
Flowers - Structure & Function

1. The diagram above shows how the pollen can be blown from the top of the anther to the top of the stigma and move its way down the style through the pollen tube to the ovary to pollinate an ovule in the ovary.
2. This is called "self-pollination"
3. The ovary will eventually become the fruit.
4. The ovule(s) will become the seed(s) within the fruit.
5. Pollen can also be transferred by wind, or by pollinators like bees and butterflies between different flowers on the same tree or between different flowers on different trees.



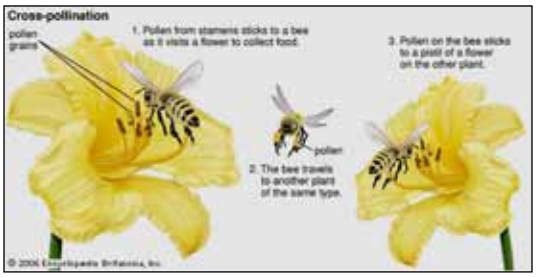
Flowers - Pollination & Formation of Pollen Tube

1. This diagram again shows both the male and female parts of the flower.
2. It also shows how pollen that is attached to the stigma can form a pollen tube and move down into the ovary where it fertilizes the ovules.



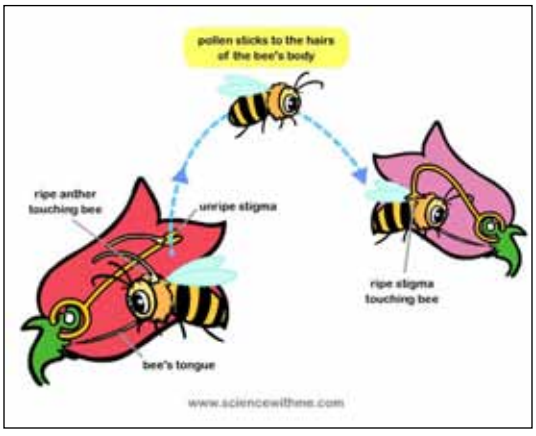
Flowers - Pollen Tube

1. Once the pollen lands on the stigma or the style as shown here, a pollen tube forms to move the pollen to the ovary where it can fertilize the ovule(s).
2. The ovules will become the seed and the ovary will become the fruit.



Flowers - Cross-Pollination by Bees

1. The image above shows bees carrying pollen from one flower to the next.
2. The pollen attaches itself to the bee as the bee is actually feeding on the flower's nectar.



Flowers - Cross-Pollination by Bees

1. Another image where you can see the pollen from the ripe anther sticks to the bee while it is feeding on one flower's nectar.
2. The bee then goes to another flower to feed on more nectar and the pollen is transferred from the bee to the stigma where it can form a pollen tube as seen in the diagrams to the left.

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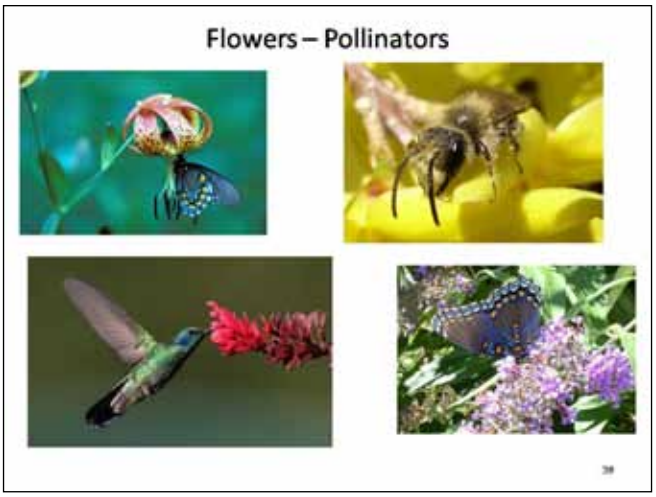
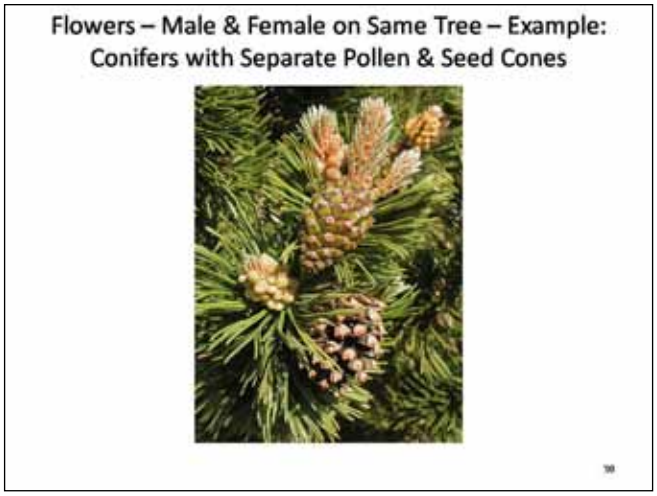


Flowers - Pollinators

1. Pollinators are responsible for 1 out of every 3 bites of food that you eat.
2. The most common are bees, butterflies and birds
3. However, they can include less common pollinators like:
   - Ants
   - Beetles
   - Bats
   - Flies
   - Moths
   - Wasps
   - Mammals



Flowers - Male & Female on Same Tree - Conifers

1. Conifers, which include pine trees, fir trees, and junipers do not produce flowers like we have just described for flowering trees.
2. Rather, they produce male and female cones that are almost always found on the same tree.
3. In this photo you can see the male cones that contain pollen (they are the cones in the top of the photo to the right) and the female cones that have scales (the cone with the green scales and the cone with the brown scales in the photo).
4. Male pollen cones are short lived and break up soon after the pollen is dispersed by the wind onto the sticky outside scales of the female cones.

Flowers - Male & Female Flowers on Different Trees - Date Palms

1. Palm trees like the date palms shown here are considered trees, but the way they grow makes them more closely related to grass and bamboo
2. Palm trunks do not grow wider as they get taller like other trees - they stay the same width for their entire life span
3. Palms do not grow lateral branches off of the main trunk like other trees; they only have terminal buds at the end of the trunk where new leaves come out
4. However, they do produce flowers and fruit like other trees
5. The date palms shown here in the slide to the right have the male (see the image on the left) and female flowers (see image on the right) growing on separate trees – this, as mentioned before, is relatively rare among flowering trees

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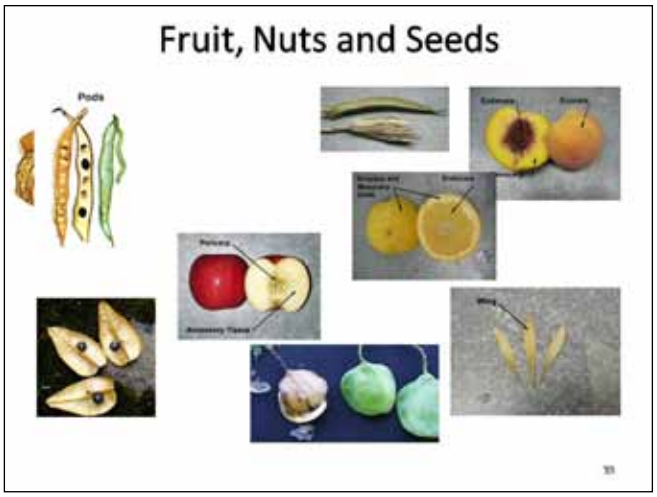
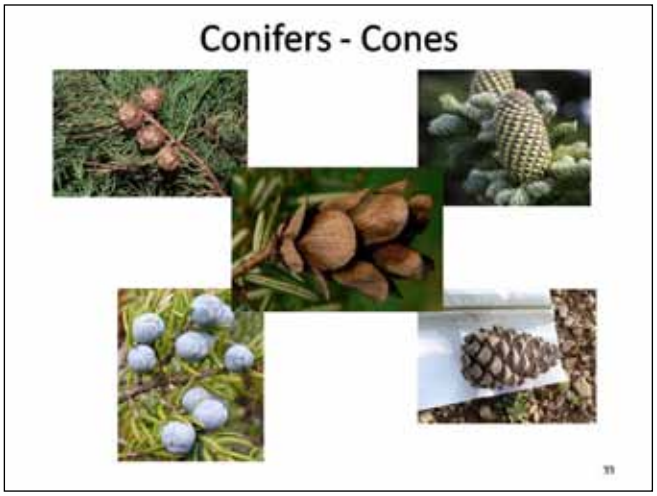


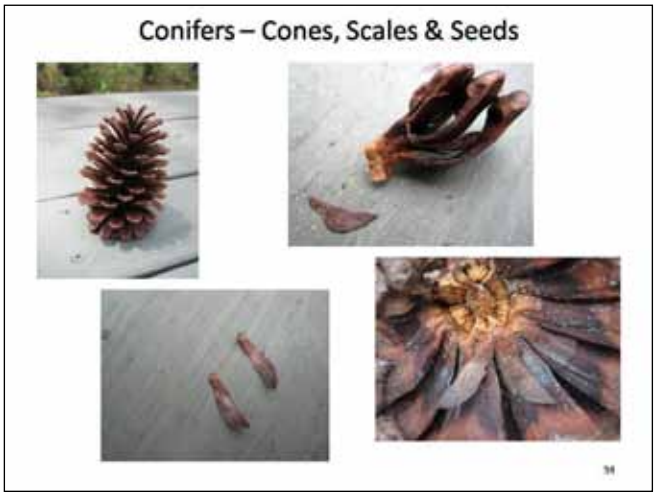
Fruit, Nuts and Seeds

1. Just as with leaves and flowers, fruit (seed carrying structures of flowering trees) come in a wide variety of types; This slide shows just a sampling of the many different types of fruit produced by flowering trees
2. The fruit of a plant, including trees, is created when pollen fertilizes an ovule within the ovary of a flower, as we saw in earlier slides.
3. The fertilized ovule(s) become the seed(s).
4. The ovary eventually grow into a fruit that will eventually fall to the ground and disintegrate either naturally or by being eaten by some type of animal.
5. If the seeds are not eaten then they are left on the ground and can eventually germinate and grow into a new tree under the right environmental conditions.



Conifers - Cones

1. Conifers as mentioned earlier do not produce flowers and fruit like the flowering trees.
2. Rather, they produce male and female cones.
3. The photos shown in this slide show some of the types of female cones that are produced by different species of conifers.
4. In the upper left you see the cones from a cedar tree; in the middle we see the cone from a western hemlock tree; in the upper right you see the image of a spruce tree cone; in the lower right that of a pine cone; and in the lower left you see the small berry-like cones of a juniper tree.

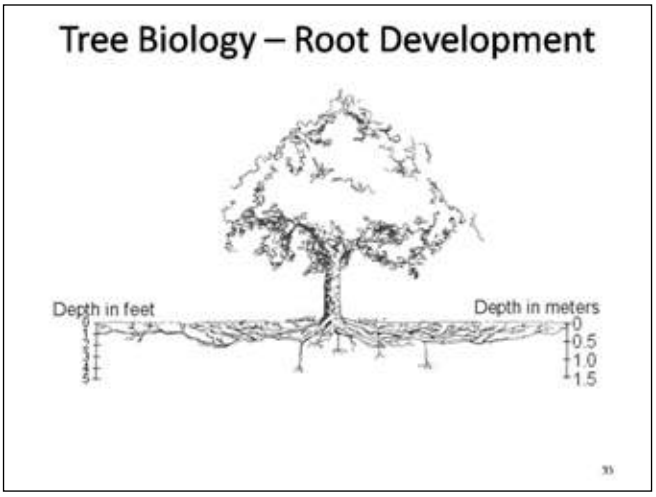


Conifers - Cones, Scales & Seeds

1. The images shown in this slide give you a better idea of where the seeds are located within the female pine cone.
2. You see the intact female cone in the upper left image.
3. In the upper right photo you can see a section of the cone broken off, and if you look closely you can see the seed embedded between two scales.
4. In the lower right image we are looking down at a cross section of the pine cone and you can see the seeds laying on top of a lower layer of scales.
5. The lower left image shows what the seeds look like when they have separated from being attached between the scales in the pine cone .

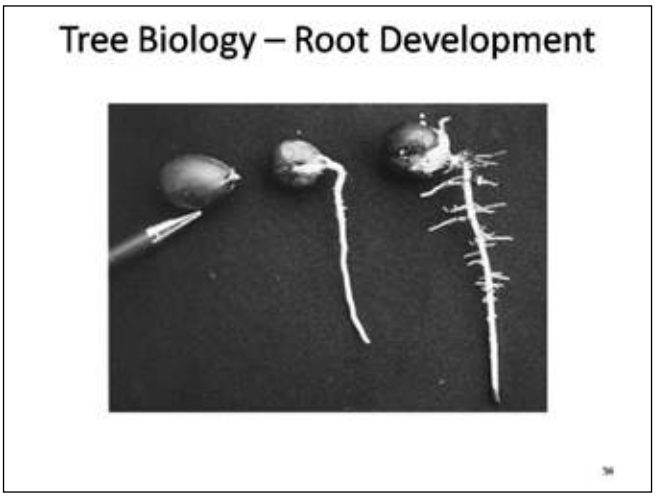
California Tree Academy

After School Program Part 1: Basic Tree Biology & Photosynthesis



Tree Biology - Root Development - Urban Trees

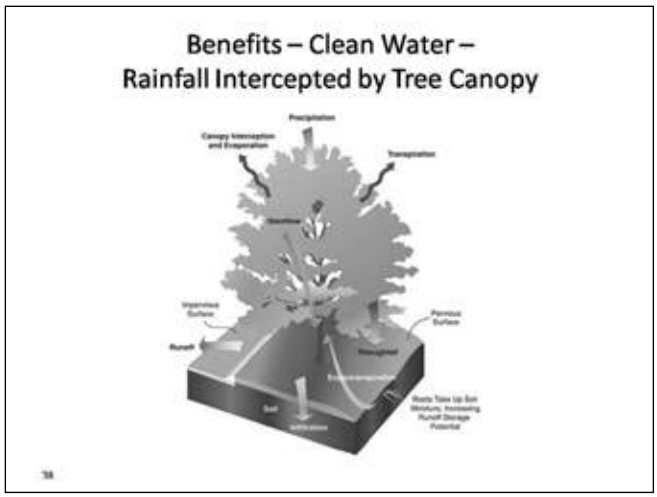
1. Finally, we come to tree roots in our tree biology lesson
2. Good root growth from newly planted trees is critical for trees in all climate zones, but is especially so for trees in semi-arid environments or in soils that are relatively poor in structure.
3. Poor structure soils are fairly common in our cities.
4. Such soil can be a tough environment for newly planted trees.
5. Consequently, we need to give these trees as much help as we can by making the planting hole at least three times the size of the root ball, and by watering the trees so that the water can drain deeper into the soil.
6. Studies have shown that the vast majority of urban tree root systems grow in the top 2 feet of soil, and extend out away from the tree well beyond the edge of the tree canopy as shown in the sketch in the slide to the left.

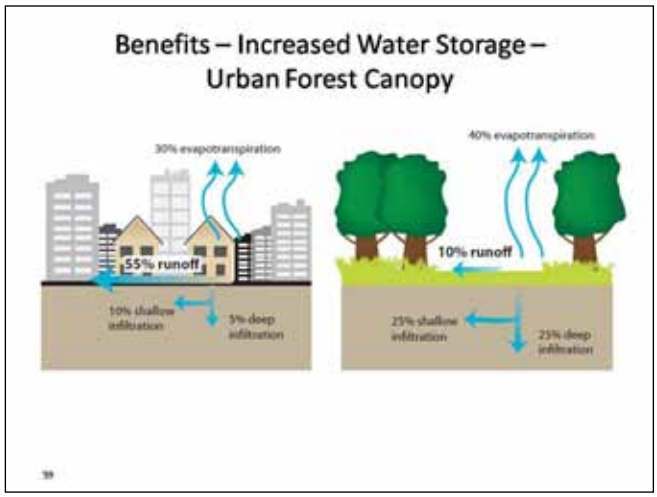


Tree Biology - Root Development - Tap Root

1. This is not the case when trees grow from seed in natural conditions. Trees have evolved a number of ways of ensuring that new roots grow deeper into the soil to be able to reach adequate soil moisture even during the dry season after they germinate.
2. For example, oak acorns shown in this photo send out tap roots under the right soil moisture conditions with the earliest rains. The tap root can extend many feet deep before the sapling emerges from the acorn and begins to leaf out.
3. By sending the roots so deep the new tree has maximized the chance the new roots will survive and be able to have access to water and nutrients during the drier late spring and summer months.

After School Program Part 2: Environmental Benefits of Trees





Trees - Why are they important?

Trees are very important to our quality of life for many reasons.

1. They can help provide cleaner water.
2. They can help provide cleaner air
3. The presence of trees can reduce air temperatures in urban environments
4. Trees can help improve soil quality through the action of its roots and from the decomposition of leaves, fruit and flowers that fall from the tree
5. Trees provide habitat for birds, squirrels and other mammals, butterflies and other insects and reptiles
6. Trees can help save energy by shading buildings thereby reducing the amount of energy needed for air conditioning
7. Trees can be very beautiful if well-maintained.
8. Mature, well-maintained trees can increase the value of your home
9. Trees store carbon in their branches, trunk and roots, thereby removing some of the carbon from the atmosphere that can contribute to climate change.

Benefits - Clean Water

1. This diagram shows how trees can help contribute to a clean water supply
2. Rainfall is intercepted by the tree's canopy which
3. Allows more water to infiltrate into the soil
4. Rainfall that reaches soil is absorbed by tree roots
5. The water that continues to percolate through the soil is cleaned
6. Water that is taken up by the roots and transpires up through the tree and out of the canopy into the atmosphere is also cleaned
7. There is always water stored in cell tissue of a living tree
8. Canopy and roots together reduce soil erosion = less sediment clogging up storm drains and causing flooding

Benefits - Increased Water Storage

1. This diagram shows that landscaped areas with trees reduce stormwater runoff and allow for more water to infiltrate deep underground and back into our underground water supply
2. Tree roots & leaf litter create the better conditions that allow this water to infiltrate into our water supply
3. Where there are very few or no trees and landscape or natural areas in a city, there is more runoff from rainfall and less water infiltrating to recharge our water supply

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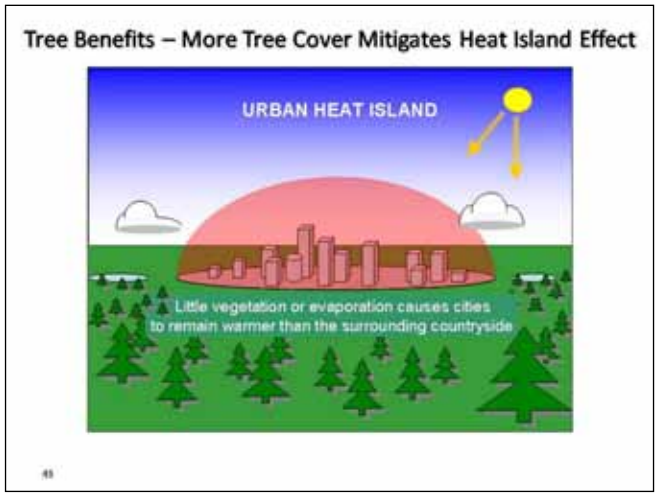
After School Program Part 2: Environmental Benefits of Trees

Tree Benefits - Clean Air

1. This diagram illustrates how trees improve air quality by absorbing chemicals that are produced in the burning of fossil fuels by factories, energy power plants, and gas or diesel powered vehicles.
2. The drawing shows trees absorbing carbon dioxide, a greenhouse gas, from the atmosphere. We will be discussing this in more detail in a few minutes when we present the carbon cycle.
3. This diagram also shows how trees improve air quality by
   a. Absorbing sulfur oxides (SO) and nitrous oxides (NO) that contribute to urban smog, and
   b. Filtering dust, or what is known as particulate matter (PM), out of the atmosphere.



Tree Benefits - Trees Mitigate Heat Island Effect

1. The “heat island effect” refers to the fact that highly urbanized areas have been found to be generally warmer than surrounding areas.
2. This is because many such urban areas are covered in concrete, asphalt and high density residential, commercial and industrial areas. Such surfaces and areas absorb and retain more heat than nearby areas with more tree cover.
3. It has been found that significantly increasing the canopy cover in such urban areas can reduce the amount of heat absorbed, thereby reducing the air temperatures in these “heat island” areas.
4. This overall reduction in temperature can also act to improve air quality

Tree Benefits - Mulch from Tree Litter Improves Soil

Applying mulch to landscape areas and especially beneath the canopy of trees is a very cost effective ways of providing the following environmental benefits:

1. Improved soil structure
2. Increased oxygen capacity of soil
3. More moderate soil temperature
4. Conserved soil moisture
5. Less soil compaction
6. Increased soil nutrient content
7. Less weeds and grass growing up against the tree

After School Program Part 2: Environmental Benefits of Trees

Tree Benefits - Erosion Control

1. Trees, through their extensive root growth, provide a very important erosion control benefit in hillside habitat and landscape areas.
2. Roots hold the soil in place and help prevent landslides
3. Tree canopy cover prevents soil loss during rain storms

Tree Benefits - Habitat

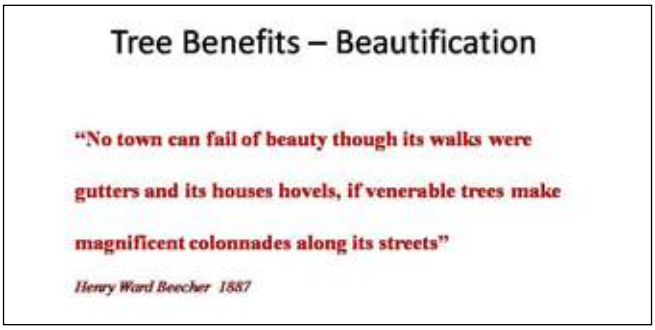
1. The photos in this slide show the role of trees in providing habitat. Older urban trees in naturalized urban park settings provide nesting habitat in pockets of decay in the tree.
2. Urban trees can provide very important habitat for urban wildlife, including a wide variety of birds, butterflies, honey bees, and other insects as well as squirrels, possums and other mammals.
3. Trees provide nourishment for deer, and other mammals that forage on tree leaves. They also provide much needed shade and shelter for these very same animals.

Tree Benefits - Energy Conservation

1. This photo shows evergreen trees planted on the south and west side of single family home. Such plantings can provide energy savings by reducing the amount of air conditioning needed during hot summer months. This is a good strategy in places with a very warm summer season and relatively mild winters.
2. In cities with colder winters, planting deciduous trees on south and west facing sides of buildings can provide energy savings in both the summer and winter. Deciduous trees retain all of their leaves during the hot summer months, thereby providing much needed shade. However, in the cold winter months deciduous trees have lost all of their leaves, thereby allowing the sun to provide much needed heat during the cold winters. This reduces the amount of heating oil or gas that needs to be used to heat up the buildings during those months.

After School Program Part 2: Environmental Benefits of Trees

California Tree Academy



Tree Benefits - Beautification

1. Of course, trees have long been valued for the beauty they provide home landscapes, our streets, our neighborhoods, and almost anywhere where they have been observed.
2. With proper tree selection and good care, there is almost no limit to the amount of beautification trees bring to our communities.
3. The quote from Henry Ward Beecher shown in this slide sums it up well.

Beautification

These next few slides show some of the most beautiful tree scenes you could imagine – enjoy!

After School Program Part 2: Environmental Benefits of Trees

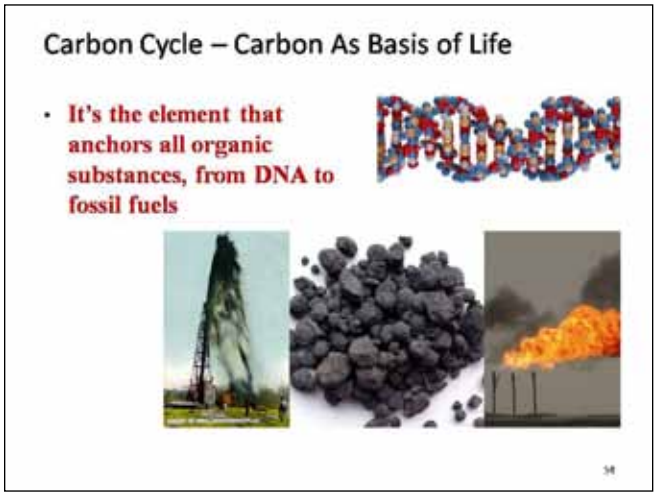
Tree Benefits - Improves Property Value

1. Money may not grown on trees, but TREES ARE MONEY!
2. Trees have been shown to directly increase property values, especially if a neighborhood consists of well-placed, thriving large stature mature trees on both private property and along the streets and in other public spaces of a community.
3. The table shown in the slide shows that studies have found increases in property values associated with higher numbers of good condition trees and higher levels of overall tree cover present from this higher number of well-maintained trees.

Tree Benefits - Carbon Storage

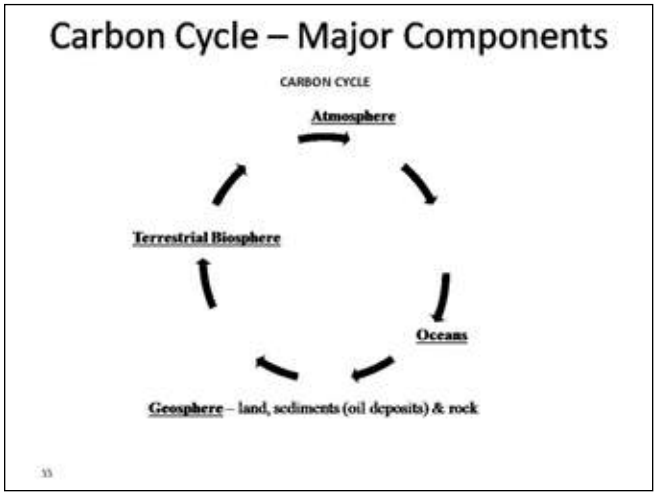
1. As we will discuss in more detail in the next section on "Carbon Cycle", trees can take in and store large amounts of carbon - a large stature mature tree can store a thousand pounds of carbon or more.
2. This illustration shows a 45 foot tall sycamore tree that is estimated to store 1 ton of carbon – this is the amount of carbon that has accumulated and is now stored in the tree over its entire life
3. As you can see the vast majority of carbon is stored in the woody parts of the tree – the main trunk, the rest of the branches and the roots = 99% of the stored carbon
4. Studies have shown that 1 ton of carbon stored in a tree such as this offsets 3.67 tons of carbon dioxide that would otherwise exist in the atmosphere
5. In light of the fact that we are rapidly increasing the amount of carbon dioxide in the atmosphere through the burning of fossil fuels, it is clear that planting and growing such large stature trees can help offset this increase in carbon dioxide.

After School Program Part 3: Carbon Cycle



Carbon Cycle - Carbon As Basis of Life

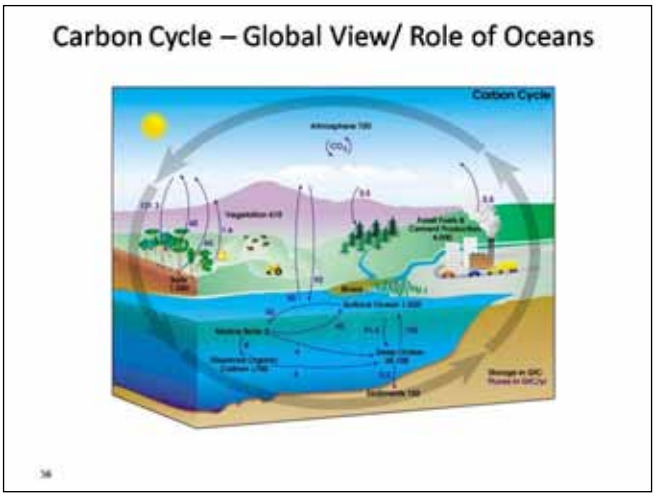
1. Carbon is the basis for all life on this planet – that includes plants, animals, fungi; from single cell life to elephants, blue whales and giant sequoia trees.
2. It is contained in DNA (see the model of DNA in the upper right image
3. Carbon is also contained in all fossil fuels as you would expect because oil (lower left), coal (middle) and gas (lower right) all come from fossilized remains of plants and animals that existed on this planet millions of years ago



Carbon Cycle - Reservoirs - Where is All the Carbon?

1. The CARBON CYCLE involves the transfer of carbon from one RESERVOIR to another.
2. As seen in the diagram to the right, there are four (4) major RESERVOIRS (also called SINKS) of carbon in the CARBON CYCLE
3. RESERVOIR #1 is the ATMOSPHERE where carbon exists as CARBON DIOXIDE, a greenhouse gas that you may have heard of that we will discuss in more detail in a moment
4. RESERVOIR #2 is our OCEANS where carbon exists as dissolved CARBON DIOXIDE, as calcium carbonate, and as carbon stored in plant life that are called phytoplankton; this includes ALGAE, seaweed and kelp
5. RESERVOIR #3 is our terrestrial BIOSPHERE which consists of all of the land-based plants (including trees) and animals, as well as the DECOMPOSERS that live in our soil
6. RESERVOIR #4 is the GEOSPHERE (sometimes also called the LITHOSPHERE), which includes sediments containing carbon, like LIMESTONE and dolomite, as well as the coal, oil and gas deposits that are mined and burned as FOSSIL FUELS; the GEOSPHERE also contains CARBON DIOXIDE that is stored in very deep sedimentary rock

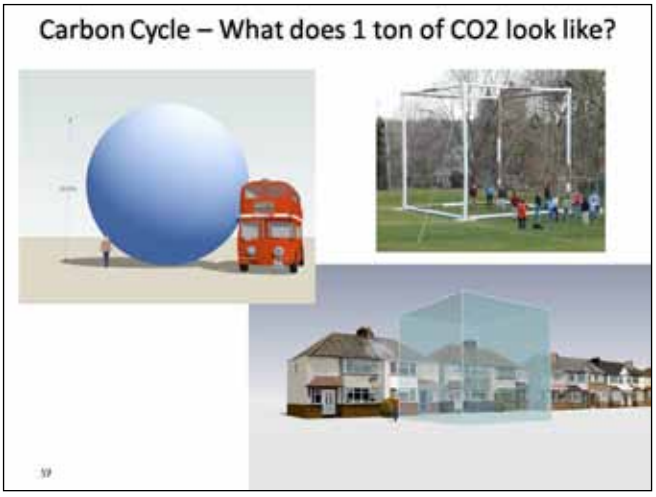
After School Program Part 3: Carbon Cycle



In the diagram above the black numbers indicate how much carbon is stored in each RESERVOIR, in billions of tons (1 billion tons = 1 GIGA-TON) of carbon ("GtC" = GIGATONS of Carbon). The dark blue numbers indicate how much carbon moves between RESERVOIRS each year.

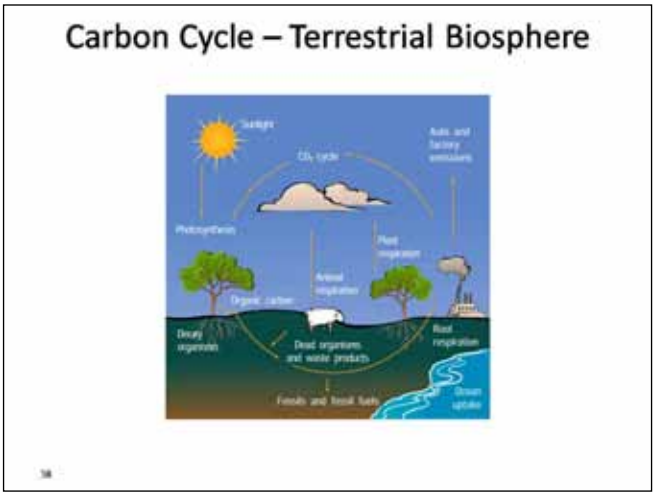
Carbon Cycle - Global View/ Role of Oceans

1. OCEANS contain the most carbon of all the RESERVOIRS
2. As an example the OCEANS contain over 50 times more carbon than can be found in the ATMOSPHERE.
3. There are 38,000 GIGATONS of CARBON DIOXIDE in the deep ocean vs. 750 GIGATONS of CARBON DIOXIDE in the ATMOSPHERE.
4. Plant life that lives near the surface of the OCEANS called ALGAE plays a signficant role in the CARBON CYCLE
5. Small soil particles eroded from water washing over silica rock are deposited as SEDIMENTS at deltas (areas where rivers meet the ocean), eventually getting buried and forming LIMESTONE.
6. LIMESTONE is a type of rock that is burned to produce cement.



Carbon Cycle - What does 1 ton of CO2 look like?

1. The three images in this slide give you an idea of what 1 ton of CO2 would look like relative to people, a double decker bus and a block of 2-story homes.
2. Now try to imagine:
   a. 15 of these (what an average household in the U.S. produces each year)
   b. 1 billion of these (= 1 GIGATON)
   c. 5.5 billion of these (the amount released into the atmosphere from burning fossil fuels each year)
   d. 610 billion of these (amount stored in vegetation on the planet)
   e. 121 billion of these are taken in by terrestrial plant material and the same amount is released by animals, the cutting down of trees, and soil decomposition
   f. 38,000 billion of these (amount stored in the deep ocean)



Carbon Cycle - Terrestrial Biosphere

1. In this RESERVOIR, trees and other plants are storing carbon dioxide through the process of PHOTOSYNTHESIS , a process the plants are using to produce sugar and oxygen.
2. Meanwhile, animals and humans use the biological process known as RESPIRATION to take in oxygen and breathe out CARBON DIOXIDE.
3. Decaying organisms – plants and animals – release CARBON DIOXIDE through the action of microorganisms called DECOMPOSERS.
4. Fecal matter produced by animals such as cows produces METHANE GAS which is converted into carbon dioxide in our atmosphere.
5. Plant material that is deposited in landfills and other organic waste produces methane.

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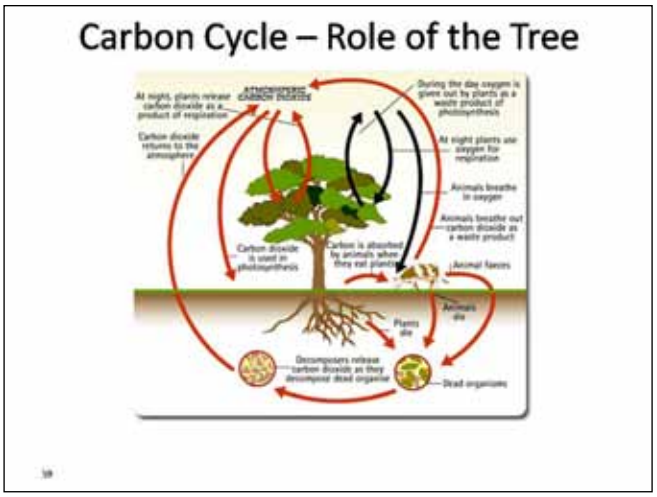
After School Program Part 3: Carbon Cycle



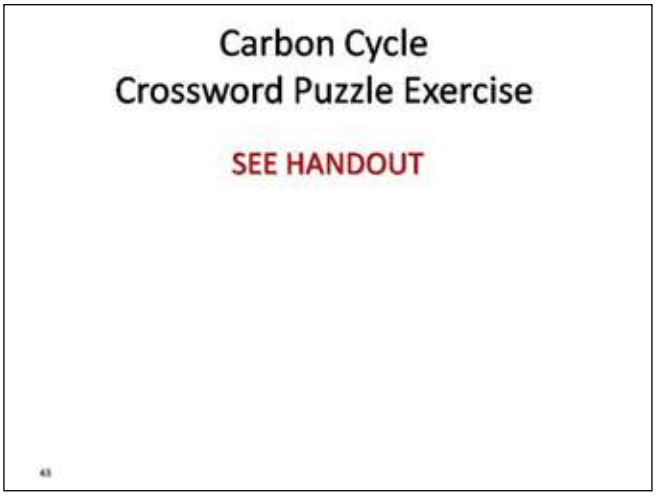
Carbon Cycle - Role of the Tree

And now we circle back finally to the single tree as shown here.

1. The role of the tree is that the tree absorbs CARBON DIOXIDE from the atmosphere and releases oxygen back to the ATMOSPHERE through PHOTOSYNTHESIS while the tree is alive.
2. When the tree dies, the carbon stored in the tree over its lifetime gets released back to the ATMOSPHERE
3. This could happen rapidly as with a forest fire
4. It could happen very slowly as when the tree is cut down and used to build homes or furniture or as telephone poles
5. It could happen in both a relatively short time and geologic time as with natural decay, decomposition, and fossilization – in this case some carbon is released to the ATMOSPHERE in the decomposition process; however, some of that carbon could end up being buried under sediment and go through a long fossilization process as has happened with plant and animal life that lived millions of years ago

Carbon Cycle Video

We are now going to watch an 8 minute video that does a good job of summarizing the CARBON CYCLE while also discussing why many scientists believe we are entering a global warming trend that is related to how much carbon we release to the atmosphere from burning fossil fuels.



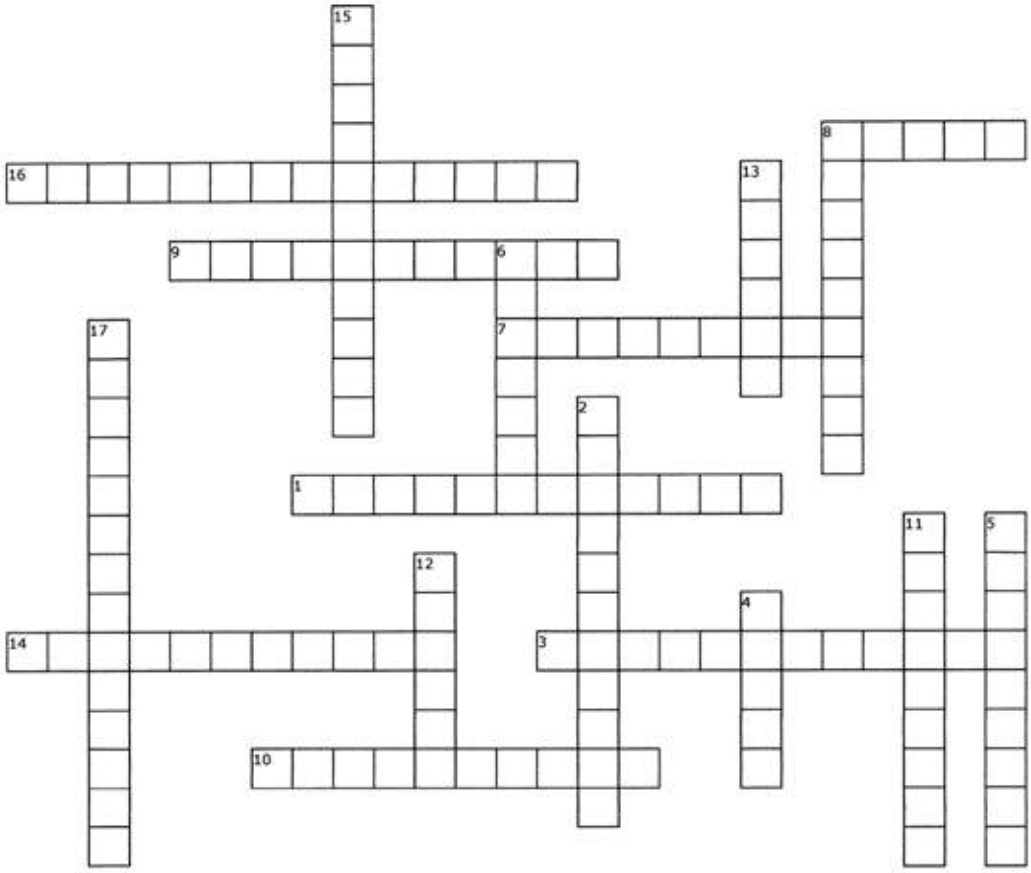
Carbon Cycle Crossword Puzzle Instructions:

1. We are now going to handout a "Carbon Cycle Crossword Puzzle" - the same one that is shown on the next page
2. All of the answers can be found in this last Section of this Lesson - Part 3
3. The answers are words that are in **BOLD ALL CAPS**
4. You need to match the answer with the clue for that numbered entry in the crossword puzzle
5. For example, the clue to #1 Across can be found under the column labeled "Across", and is: "Involves the transfer of carbon from one reservoir to another"
6. The answers may be one or two words; if it is two words then leave a space between each word
7. You have 20 minutes to complete the crossword puzzle

After School Program Part 3: Carbon Cycle

Carbon Cycle

Please complete the crossword puzzle below



Across:

1. involves the transfer of carbon from one reservoir to another
3. non-renewable carbon-based resource of energy
7. carbon dioxide is stored in sedimentary rock in this carbon sink
8. reservoirs are sometimes called this in the carbon cycle
9. gas from cows
10. sink where carbon dioxide exists only as a gas
14. fossil fuels mined from here
16. gas used by plants to make food

Down:

2. microorganisms that release carbon dioxide as they decompose dead organisms
4. plant life that lives near the surface of the ocean and plays signficant role in the carbon cycle
5. carbon sink that contains plants, animals and soil
6. a unit of measure equal to 1 billion tons
8. small soil pacticles that are carried by water and deposited at a delta; deposits
11. type of rock burned to produce cement
12. most of the carbon in the carbon cycle is found here
13. gas given off by plants
15. biological process animals use to take in oxygen and dispel carbon dioxide
17. process plants use to produce sugar and oxygen

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