Chapter 5. How Trees Defend Themselves from Microbes

Rev.17 John Kelsey 2024.Apr.

Professional literature on disease in plants is hard for us growers to read. In the following chapter I will try to avoid the technical terminology (as if I even knew). Since our goal is growing veneer black walnut trees, we hate defects. It will be helpful to know at least a little about how a tree's defenses work, and what we might do to help.

For openers, a tree's defensive processes are quite different from an animal's. If you treat a tree's injury like it was a human child, you will likely do more harm than good. The main difference between animals and trees is that trees' defensive strategy is exclusively damage control. Tree tissues contain preventative structural and chemical defenses. If the defenses are breached, the tree immediately abandons the infected tissue, and begins building new covering tissue. They never try to recover lost territory. Our black walnut trees have evolved a multitude of defensive strategies. However ugly a tree's defenses might look; it is very unlikely our well-meaning actions could improve the situation.

> The subject of this chapter is a tree's defenses, but the internals of a tree are so amazing, I have trouble keeping my mind on task. I'll include my divergent thoughts in these little tan boxes.

The various tissues: outer bark, inner bark, cambium, sapwood and heartwood have defenses, unique to each tissue type. Despite their clever adaptations, plants still can't run away. They have to stand and defend themselves. Plants are the masters of defensive chemistry. Trees have developed defenses for enemies with whom they have evolved. However, they will likely be caught off guard by new unfamiliar invasive threats. One way black walnuts are like humans is that they have a life expectancy. They don't just croak after some age. After a about a century, their defenses start weakening and their enemies slowly take them apart.

Our veneer growing goals require flawless wood, advertised by flawless bark. The veneer industry's main interest is the heartwood. For us, any problem in the woody layers is too late to address and likely a lost cause. Just like a tree, our strategy should be preventative, and if that fails abandonment. Our remedy often is coppice or culling. Our focus should be tree health and protecting the bark. In this chapter the focus will be on how the internal decayed wood came to be, and how to minimize those occurrences. Industry is interested in the inside of old trees; we need to worry about the outside of young trees.

Figure 1. This was a perfectly healthy tree with decayed wood safely encapsulated inside. It was meeting all of its biological needs, but of zero interest to a veneer buyer.

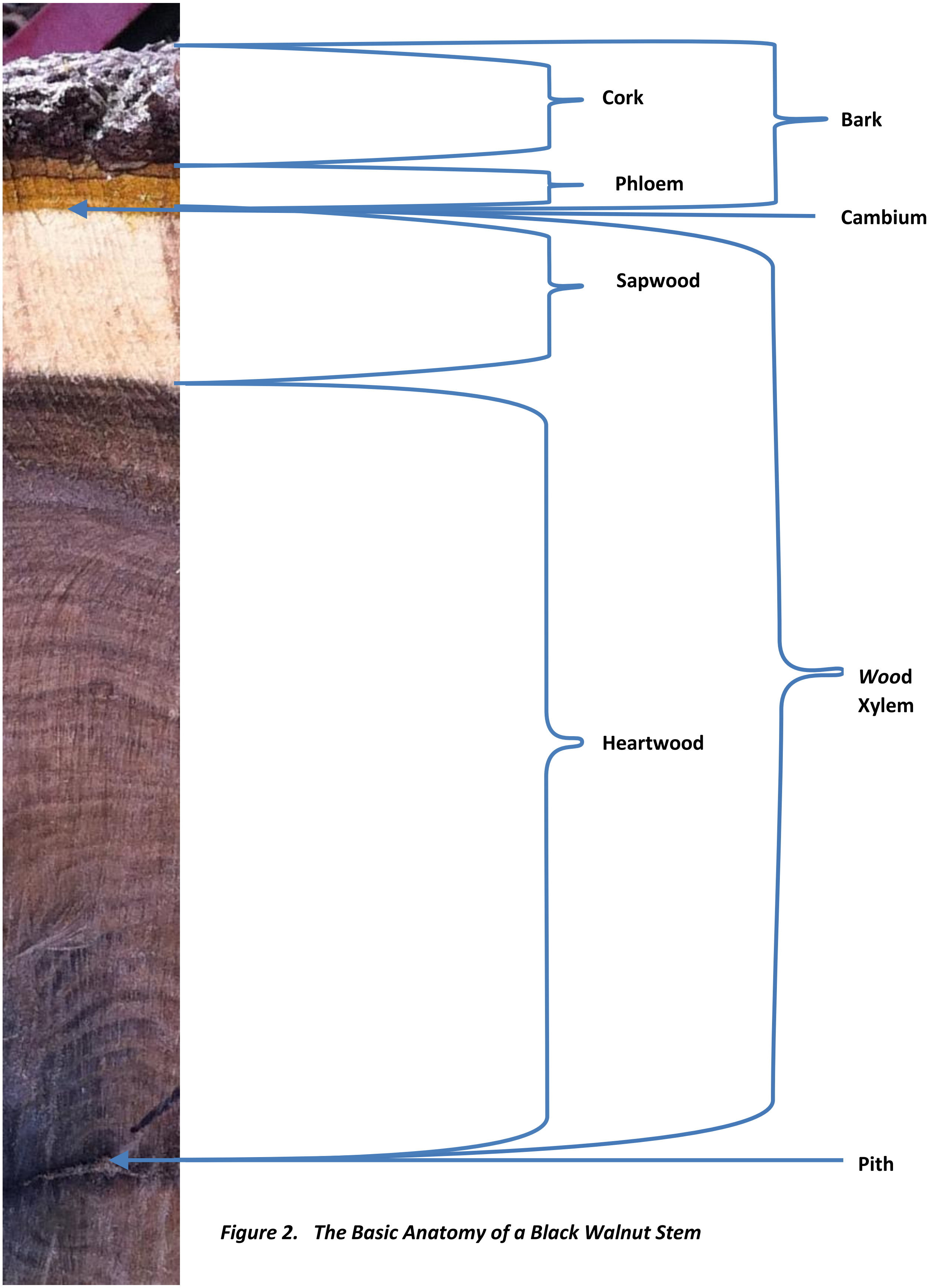


Figure 2. The Basic Anatomy of a Black Walnut Stem

The same general structural arrangement, cork, phloem, cambium, xylem, is repeated at large and tiny scales throughout the tree, including roots, leafstalks (petioles) and the central stems of catkins. A leaf needs water and a way to deliver its sugar, so a tiny petiole needs all the same plumbing as the tree's big trunk.

THE OUTER BARK:

The outer bark, also called cork, completely surrounds the older parts of the trees including the roots. Bark is generated by a second (and usually ignored) cambium layer (the cork cambium) which is outside the inner bark. The new cork cells soon die; however, this tissue is incredibly important to the tree's water retention and defenses. This dead outer bark is the first and most effective line of defense. It is packed with tough fiber and toxic, nasty tasting chemicals. Just beneath the outer bark is the inner bark full of juicy capillaries transporting sugars throughout the tree. What microbe wouldn't like to get their hands on that? There is every conceivable kind of life growing on the outer bark, wanting to get in to the juice in there with 1 or 2 percent sugar, like a living Petri dish. Healthy trees easily deal with these threats. Few enemies can penetrate the barrier. Some enemies that can defeat the outer bark include: frost cracks, sap suckers, a few species of beetles, antler rub, and tractors. Even shiitake mushrooms need somebody to drill holes through the outer bark.

As the cork cells die, they are infused with antibiotic chemicals. These chemicals are called extractives, because they can be extracted with various solvents. Although the extractive chemicals are toxic to native enemies, some are inadvertently useful for us Homo sapiens. Some examples are latex, cinnamon, tannin, quinine, root beer from sassafras bark and aspirin from willow bark.

The recent big black walnut scare, the Thousand Canker Disease, was vectored into black walnut trees by the walnut twig beetle. These tiny beetles had mouth parts that could penetrate black walnut's outer bark. Luckily, these beetles were native, not invasive, so healthy black walnut knew how to deal with them. I'm guessing there was an extractive chemical in the outer bark that the twig beetle just couldn't stomach. It turned out that only stressed trees were infected. How do trees become stressed? They lose in the competition for sunlight, they are on a bad site, or they are past maturity. The horrifying episode of the Thousand Canker Disease emphasizes the importance of keeping our black walnut trees growing and healthy.

> The original peoples of the new world had difficulty working with mature wood, because they didn't have metal tools. Bark was much easier, especially in the spring. Their homes, canoes, cordage, and what else were made from bark. I'm guessing they also made their medicines (not-to-mention recreational drugs) from bark extractives. One could make a life's work trying to recover this lost knowledge.

One has to dig deep to find details about bark. Traditionally, bark had many uses. Currently, bark is a waste product of the lumber industry, and the main interest is how to get rid of it. We need to focus on protecting the bark. Frost cracks, sap suckers, and antler rub are discussed in chapter 19, Protection. Tractors and brush hogs are discussed in chapter 17, Layout and Planting.

Figure 3. Trees have evolved no defense against tractors or mowers.

THE INNER BARK:

The function of the inner bark, also called *phloem*, is to transport throughout the tree sugars generated by green leaves.

> If you don't use the word "phloem", it's time to add it to your vocabulary. I'm not going to use "inner bark" again. "Phloem" makes me sound a bit like a scientist.

The phloem is formed by the vascular cambium, which is between the woody part of the tree and the bark. The phloem has capillaries going an all directions, but mostly downward. Besides delivering energy, the phloem also distributes messenger and growth regulating hormones. In case of an outer bark breach, the phloem reacts by synthesizing antibiotic chemicals and blocking nearby capillaries. Blocking stops microbe invasion, but also stops delivery of photosynthetic products. If the blockage completely surrounds the tree, there are no nutrients getting past to the roots and it is unlikely the tree will survive.

In Figure 4, notice the trunk diameter is larger above the surrounding girdling cut than below. The girdling cut severed the phloem and cambium, but much of the sapwood is still connected. The remaining sapwood carries water and minerals up to the tree crown, which conducts its photosynthesis business as usual. The phloem carries sugar down from the crown and nourishes all tissues but hits a dead end at the girdle. The upper part of the tree is doing fine, but tissues below the girdle including cambium are starved and doomed. They can get water from below, but no energy from above. With no energy from phloem above, the lower cambium died, no growth, the bark became detached, defenses vanished, and microbial enemies prospered. When infection stops the lower sapwood delivering water upward, it's death for the upper part of the tree as well.

Figure 4. A culled tulip poplar demonstrating the function, direction, and importance of phloem.

THE VASCULAR CAMBIUM:

The Vascular cambium (typically just call the cambium) is a layer of reproducing cells between the wood and the bark. A microscope is needed to see the cambium. When a cambium cell divides one of the new pair of cells becomes a new (mother) cambium cell with reproductive capability. There are three possible outcomes for the second new (child) cell: 1. The cell might be on the inside becoming some sapwood structure. 2. The cell might be on the outside becoming some phloem structure. 3. The cell might also be a new mother cambium cell, to expand the cambium layer. The timber industry is mostly interested in case #1, i.e., making more wood. The vascular cambium creates sapwood (case #1) and phloem (case #2) which are both full of capillaries, hence the name “vascular” cambium – ignoring case #3.

> Since phloem and sapwood cells are vascular tissue without reproductive capabilities, I wonder if they even have a full set of chromosomes? Do they meet the criteria for being “alive”, since they can’t reproduce? Or half alive, because they have metabolism?

New vascular cells are delicate, but slowly assemble cellulose and lignin structures to gain mechanical strength. In the meantime, they are structurally weak. In the spring, it only takes a small bump on a black walnut tree to knock the bark loose at the juicy cambium layer. Such accidents are tragic, because trees will abandon and isolate the entire exposed area. Damage is never repaired, just barricaded and hopefully soon covered.

I have heard of success in quickly putting the bark back in place. Walnut Council member Paul Christofferson from Iowa was successful <u>once</u> using bungee cords. It hasn’t worked for me. Cambium cells exposed to the dry air will be dead within minutes. Paul’s success was based on how quickly and tightly he was able to get the bark back in place. Paul is an expert grafter, which is all about connecting and protecting cambium. Paul once told me that the cambium layer had the thickness of cigarette paper, and part of the art of grafting was to quickly match the cambiums of the rootstock and scion.

> Above ground cambium cell division is active in the spring and summer and inactive in the fall and winter. Since a living tree is saturated with water, it seems a bit strange that the cambium cell activity is related to rainfall, but this relationship is the basis of dendrochronology (tree ring dating).
>
> The explanation is that the photosynthesis process requires water.
>
> **H2O** + C02 + sunshine => O2 + sugar
>
> No rain => no water => no sugar => no growth.

In case you slept through the first day of high school chemistry class, chemistry is divided into two great parts:

1. One great part involves element number 12, Carbon, Organic Chemistry.
2. The other great part of chemistry is everything else.

In case you slept through the first day of Organic Chemistry class, Organic Chemistry is divided into two great parts:

1. The Paraffins, chain molecules. Example: gasoline and sugar
2. The Aromatics, ring molecules. Example: benzene and pectin

The attachment of water to a simple paraffin creates a carbo-hydrate. The basic carbohydrates are sugars. Example: glucose. They all end with "ose". Green leaves make simple sugars and oxygen from water, atmospheric CO_2, and sunshine – magic! Sugars are monomers, meaning they can be the building blocks (like Lego bricks) of giant carbohydrates, like starch and cellulose (polymers). Sugars can polymerize to make starch which is a reversible reaction, hence starch is for energy storage. Sugars can polymerize to make cellulose which is not reversible, hence cellulose is for mechanical strength.

In case you slept through the first day of Biochemistry, proteins assembled by DNA can synthesize aromatic compounds. Example: lignin and juglone. Juglone and most-or-all other defensive compounds are aromatics. Lignin and pectin are also aromatics, but function like structural adhesives.

The later section below titled "CALLUS" explains the cambium's role in reacting to infection and injury.

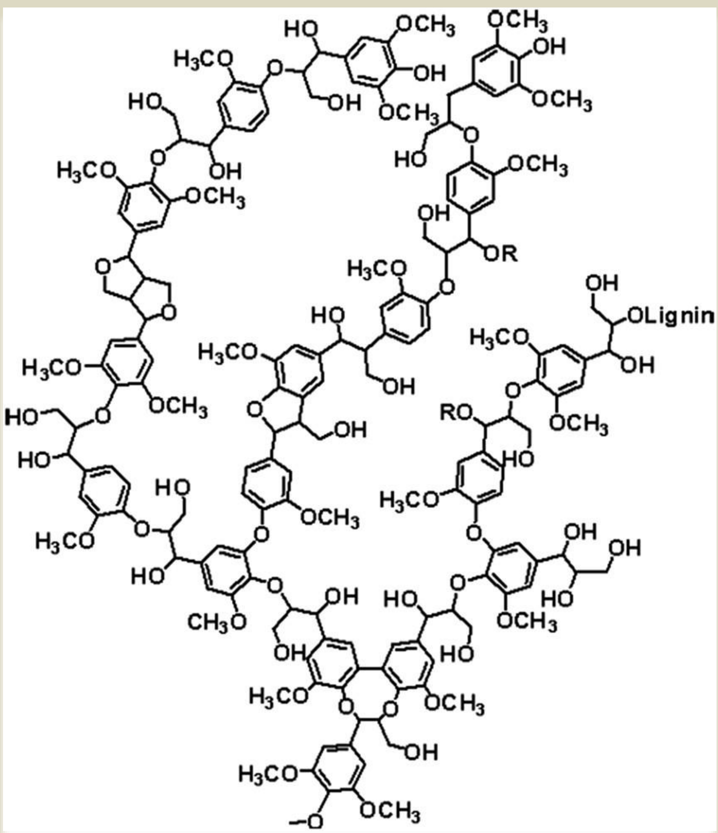
THE SAPWOOD:

The basic function of the sapwood, is to transport water, minerals, and stored nutrients upward to leaves and stems. Sapwood is generated by cambium cell division on the inside of the cambium. Each year there is a new annual ring of sapwood. The early growth has larger capillaries than the summer growth. There is no fall or winter above ground sapwood growth. Beside vertical capillaries, there are radial capillaries to take sugars inward from the phloem for use and storage. There are also tangential capillaries. The vertical capillaries are obvious, but it takes some magnification to see the radial and tangential capillaries in black walnut.

When new sapwood cells are formed, they are structurally very weak. While new shoot cells are in this flexible stage, some cells elongate an incredible amount. That is how shoots shoot. Later in the summer, sugars energy delivered to the new sapwood cells is used to create cellulose fibers and the lignin (glue) that make the cell walls rigid and stop shoot elongation.

In the late winter and early spring, the stored sugar from sapwood cells is retrieved and added to the upward flow of water. As syrup makers and sapsuckers know, hard maple sap during this time has about 2% sugar – black walnut a little less. This upward flush of stored sugar is to build new leaves after dormancy. At least in black cherry, there is enough stored sugar in the sapwood to refoliate the tree twice. I have seen this happen when tent worms completely defoliate cherry trees soon after the first set of leaves emerge.

Lignin is an interesting substance, and wood is loaded with lignin. Wood (and paper) is typically 25% lignin. I've added a diagram of its chemical structure, just to show the complexity of compounds sapwood cells can synthesize from sugars, which have not a single ring. Ring compounds are stinky, and often toxic, depending on the enemy species that tries to eat the wood. I only know fungi and the microbes in a termite's gut that like this stuff.



There is an old joke when I was growing up on a farm: Little by little a farmer was teaching his cow to eat sawdust. After all, wood is mostly cellulose just like grass. Just as he had her trained, the experiment was ruined due to the cow's death. Lignin got her!

All of the above are the normal functions of sapwood. As long as the bark is intact, the sapwood has no need for defenses. But bark breaches happen by accident or deliberately. When the bark is breached, the sapwood reacts basically in two ways.

1. Sapwood barricades off the damaged or infected tissue; plugging the capillaries by synthesizing fibers and gels (pectin).

2. Sapwood also synthesizes antibiotic chemicals to hold microbes back from the barricade enclosure. Due to the major direction of the sapwood plumbing, infection tends to go vertically more than horizontally. The plugging process is not fast. The bigger the capillary diameter, the more difficult it is to plug.

For more on tree's defenses see: Compartmentalization of Decay in Trees by Alex L. Shigo

Compartmentalization of decay in trees (usda.gov)

Figure 6. A horizontal section of black walnut sapwood. Sapwood is transitioning to heart wood on the left. Phloem is transitioning to cork on the right. In the sapwood the spring growth has larger pores than the summer growth, which make the growth rings visible. In black walnut ten years of sapwood is typical, although this sample has only seven.

Pore plugging barricades are also used in a more natural way when no bark breach is involved. When a side branch begins to use more energy that it produces, the sapwood supplying water and minerals to the branch is plugged. The tree murders the non-producing branch. "Abandons" might be a nicer word, but the branch wouldn't know the difference. This abandonment process is central to our veneer growing goal, and is the subject of the next chapter.

During the late winter upward sugar rush, a tree's sapwood is sometimes tapped (a wound) for syrup making. Pectin is generated in the sapwood pores to block microbe advance from the bored hole. Of course, that also blocks the outward flow of sap that syrup maker wants. The pectin stoppage is not fast. The sap might flow for a couple of weeks in cold weather before it is stopped.

When a black walnut is tapped, there is a lot more pectin than in maple sap. Pectin is a curse for black walnut syrup makers. Such sap quickly plugs the syrup filters – plugging sap flow is why the tree invented pectin. In hard maple there is little pectin in the sap, but still the sap flow will be stopped in a few weeks depending on the weather. If you ever made jelly on a stove, you know that heat really coagulates pectin. Sunny days and freezing nights keep the sap flowing, but a few warm nights and capillaries are plugged, and the syrup season is over.

Figure 7. As an experiment, I tapped some cull black walnuts. Crop trees have a blue ring. This idea was a big mistake. I removed big globs of pectin from the sap with a strainer, plugged 6 coffee filters, and got a pint of very dark syrup from 10 trees. I will never tap a black walnut again – not even a cull. I often change my mind about who is a crop tree and who is a cull. These tapping wounds will become infected and barricaded. They will never change in the wood, only become covered over with new growth.

THE HEARTWOOD:

During the sapwood ageing, the apwood becomes less effective at transporting water and minerals upward, which is its main occupation. The tree does not abide its non-productive parts, and slowly murders the sapwood tissue. When black walnut sapwood is about 10 years old it becomes heartwood. During the slow abandonment, complex antibiotic chemicals are synthesized in the cells for their future protection. Just as in the outer bark, these chemicals are called extractives. If you soak a piece of black walnut heartwood in water for a couple of hours, the water will turn brown. That dye is an extractive. Another antibiotic extractive in black walnut is juglone, which is nasty even for humans.

Non-living heartwood cells, being dead, have no reactive defensive weapons, only the passive residual extractives. Heartwood is structurally important to hold the tree upright, so it would not be left defenseless. When heartwood is exposed, no antibiotic chemicals are synthesized and no pectin is deposited. The heartwood is only protected passively by antibiotic extractives left behind in the cells when they died at the sapwood-to-heartwood transition.

Incidental to their antibiotic function, extractives also produce the heartwood's characteristic smell and color (lucky for us black walnut woodworkers). Black walnut heartwood has relatively good decay resistance from these extractives. If a whole tree dies, the sapwood decays first. Both the sapwood and heartwood are then dead. The dead sapwood can no longer react (by synthesizing and barricading) to invasion, and only the heartwood has the antibiotic extractives.

One day I was sawing white oak. A visitor commented that the wood smelled like Kentucky bourbon. Haha! That's exactly backwards. An example of another defensive extractive that is inadvertently useful to a non-target species.

Someone once ask me: "Why won't the French buy our white oak for their wine barrels?"
Ans: If you can tell the difference between bourbon and a good claret, you would know – different extractive.

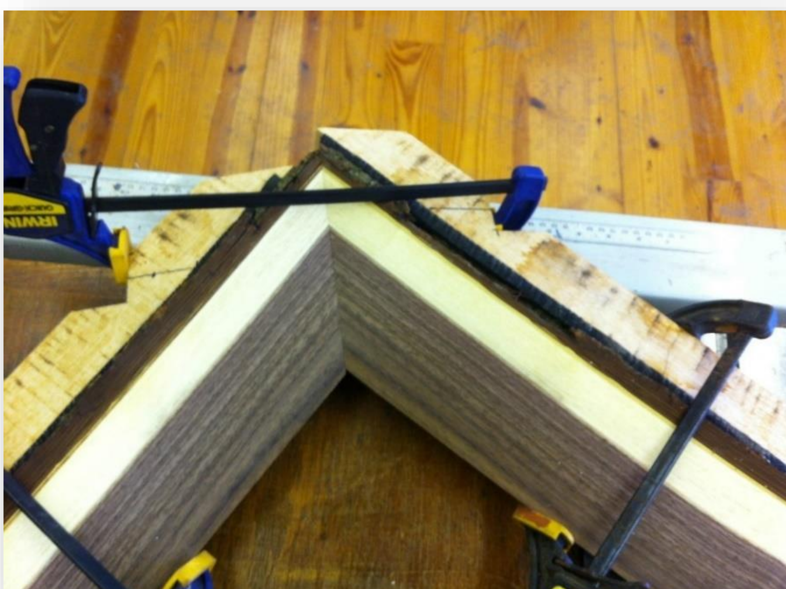


Figure 8. A black walnut picture frame which includes bark, sapwood, and heartwood. The extractive-colored black walnut heartwood is "brown gold" to the lumber industry. The sapwood is normally stained brown, attempting to match the heartwood's color. Here I went the opposite way, trying to keep the sapwood as white as possible. Such items are called "Salt and Pepper"

CALLUS TISSUE:

Another mechanism of defense is wound covering. Cambium cells around the periphery of the wound

> Foresters call the covering tissue "callus" (, not scar tissue, which is something animals do). Callus is defined as an unorganized tissue mass like a tumor or a gall. However, this wound covering tissue is completely organized, with bark, phloem, cambium, sapwood, and eventually heartwood. I think "callus" is a poor name, but since I can't think of anything better, and foresters use it, I'll stick with "callus"

are stimulated to rapid growth. A covering tissue is produced, called callus.

Callus tissue's business is to grow rapidly, and in all directions to cover the wound. Remember from the CAMBIUM section that only the cambium has reproductive capability that can generate any new tissue growth. Cambium cells divide 3 ways to create new cells inward, outward and sideways. New tissue appears to be "inflated" like a balloon, but all the new growth is near the outside. All that is outside of the cambium is phloem and some thin cork, a tree's main defenses. Cambium "wooden be caught dead" without its phloem and bark defenses. The live cambium cells adjacent to the damage react to the nearby exposure by producing more defensive phloem cells outward. To make room for the abundance of phloem, the tissue bulges and curls inward toward the wound. Eventually, the expanding tissue curls completely around with new thin bark pressed against the wound. In cross section this callus growth looks like half of a small tree.

Figure 9. Callus tissue growth starts expanding from cambium around the border of the damage. . The expansion tissue pushes the old bark away and presses the new bark

against the infected wood.

The new phloem tissue has a thin covering of bark with antimicrobial extractives. It is this thin layer of bark that gets trapped against the infected wood and forms the "boundary zone" (4 in figure 10). The boundary zone of dead bark with its extractives effectively keeps infection from expanding outward into the new callus growth. The boundary zone is black and visible without magnification.

Figure 10.   Arrow 2 points to a decay zone in an injured red oak. Arrow 4 is the boundary zone keeping the decay from spreading out into the accelerated new callus growth.   This photo shows how the callus growth curled around on itself leaving a thin layer of dead bark on the inside to form the boundary zone. It also shows how effective a microbial barrier the boundary zone is.

(From USDA document gtr_ne82.pdf p79. The wound was a shotgun blast.)

Figure 11. A 3-inch wound

2009 Apr A 3-inch branch removal

2012 – Year 4 Closing mostly from the sides

2013 – Year 5 Sides meet at the bottom. The growth is from the sides, which are fed energy from above. The bottom never grew at all.

2018 - Year 10 The wound probably closed in year 6. Now we have a nice catface.

2023 – Year 15 The catface is getting harder to spot. The catface bark is starting to get vertical fractures. The catface pattern is twice as wide side-to-side as the original wound. It makes sense. The tree is twice as big. The bark has to expand with the stem diameter growth. The catface bark expands horizontally like the rest of the bark and is the same percentage of the circumference as the original wound.

Figure 12. A 5-inch wound

2017 – Year 0. A pruned 5-inch diameter codominant branch. It was exactly half the tree. The heartwood was 1.5 inches in diameter. Both branches were 5-inch diameter, and the diameter was 7 inches below the crotch.

2018 – Year 1. About ½ inch of callus growth, but it is all outside the original wound. All of the exposed woody tissue is still exposed

2019 – Year 2. About an inch of callus growth with more on the top than the bottom. I must have cut off some of the lower branch collar. Lots of callus growth, but not much wound closure. Some animal is chewing on the callus bark. The bark here is very thin, and the sweet phloem is just underneath.

2020 – Year 3. About 1-1/4 inch of callus growth and little near the bottom. The exposure opening is about 4.5 inches. The slow growth at the bottom is a phloem problem. Cellular nourishment comes from above. The top and sides get fed downward from above. The bottom only gets weakly fed by lateral phloem flow, which is sparse. It is lucky to be alive in the shadow this large wound.

2021 – Year 4. About a 3.5-inch exposure opening

The phloem capillaries at the bottom have lost their source, which originally came from the lower side of the detached branch. I hate to use an animal metaphor, but these capillaries are like a dog's tail with no dog. Their energy source is no more - - - dog gone!

2022 – Year 5. About a 2.5-inch exposure opening

2023 – year 6. About 2-inch exposure opening. A callus growth of ¼ in./yr. on each side gives a 1/2 inch of wound closure per year. It has 4 years to go for complete closure. Still little growth on the bottom. The stem diameter above the wound is 8.8 inches, and below the wound is 9.7 inches. The 6-year-old callus bark is starting to look corky.

The several photos on the previous pages show the annual growth progress of callus tissue covering a large wound. The width of the exposed area closed 3 inches in 6 years or 0.5 inch per year. During the same time interval, the tree diameter below the wound grew 2.7 inches or 0.45 inch per year. The callus growth had a very slow start and then was only typical for the tree's growth rate, no acceleration. A branch collar would have done much better than this. A branch collar gives a quick start and accelerated growth. I must have cut off the entire branch collar. I didn't know any better.

Figure 13. There is no cork or phloem left on this utility pole, but the photo shows clear traces of how nutrients were delivered to the bottom of the branch collar – the part I cut off. (From USDA document gtr_ne82.pdf p163)

The branch collar's function is to rapidly seal off the stub of a naturally missing branch. Of course, the branch is dead and the branch collar is alive. To perform its function, it is obvious that the branch collar must be fed from the tree, not the branch.

Fluid-wise the branch collar is connected to the tree trunk's phloem, not the branch's. In figure 13 there are three distinct tissue flow patterns in the area of a branch connection:

1. Away from the branch the phloem swerves around the branch heading for the roots. The tree never feeds a branch. The branch must feed the tree, or it is killed.

2. At the center circle, the branch phloem flowed straight inward from the former branch into the main stem, turned down, and headed for the roots.

3. The branch collar phloem is fed from above. It tightly encircles the branch, but is not connected. The phloem meets at the bottom center of the branch collar. The flow does not feed the branch, it only feeds the bottom part of the branch collar.

In figures 11 and 12, there is almost no callus growth at the bottom of the wound. When I unwisely cut off the lower branch collar phloem, I removed the main energy supply to that area. The branch collar exists in anticipation of natural branch death. Natural branch failure never injures the branch collar. If the dead branch breaks off at or inside the branch collar, the intact branch collar cambium kicks off accelerated tissue growth that covers the dead tissue equally from all sides.

Figure 14. When the branch collar isn't damaged, the covering callus growth is equally rapid from all directions

What happens at final wound closure when bark press against bark? I am completely baffled by the microscopic details, but the results are easily visible – see figure 15. When bark comes against bark, there is a build-up of pressure. At some spacing, cambium "whiskers" penetrate the phloem and dead bark and join up with the other side (see the dot-dot-dot at the center of figures 13 and 15). Cambium is never voluntarily exposed, so the cambium whiskers must be protected by phloem cells as they push through the dead bark tissue. But to continue normal growth beyond the closure, the left cambium must flawlessly join the right with nothing in between. Of course, I could be wrong.

Figure 15. The upper left photo shows a summer-time frost crack with many spots of growth that penetrate through and across the bark-against-bark barrier. These erratic growth spots are the beginning of how the cambium finally bridges through the embedded bark to completely close the wound and restore normal outward growth.

Upper Right: In the case of a frost crack, unfortunately, cold weather shrinks the tree's circumference which tears apart last summer's bridging tissue.

Right: A frost crack at +8 degF.

Trees routinely abandon non-producing branches. All branches have branch collars designed to handle the natural abandonment event. The branch collars are completely unprepared for a pruning saw. Branch collars are especially adept at triggering, supporting, and accelerating callus growth to close the missing branch site. I say "site" rather than wound, because natural pruning is self-inflicted. Unlike a wound, the capillary plugging is the first step, not a reaction to an injury. Plugging the capillaries is how the tree kills its nonproductive branches. In un-natural (manual) branch removal, if the branch collar cambium is wrecked, callus growth is seriously delayed. Cells will need to be differentiated to perform unexpected new tasks.

The next chapter explains the natural pruning process in detail and how it can produce the high-quality timber we are trying to grow.

IF ALL ELSE FAILS – SPROUT!

When there are major life failures in a tree, the organism tries to survive by sprouting. The sprouts erupt from latent buds, which like branch collars are normally just waiting for failure.

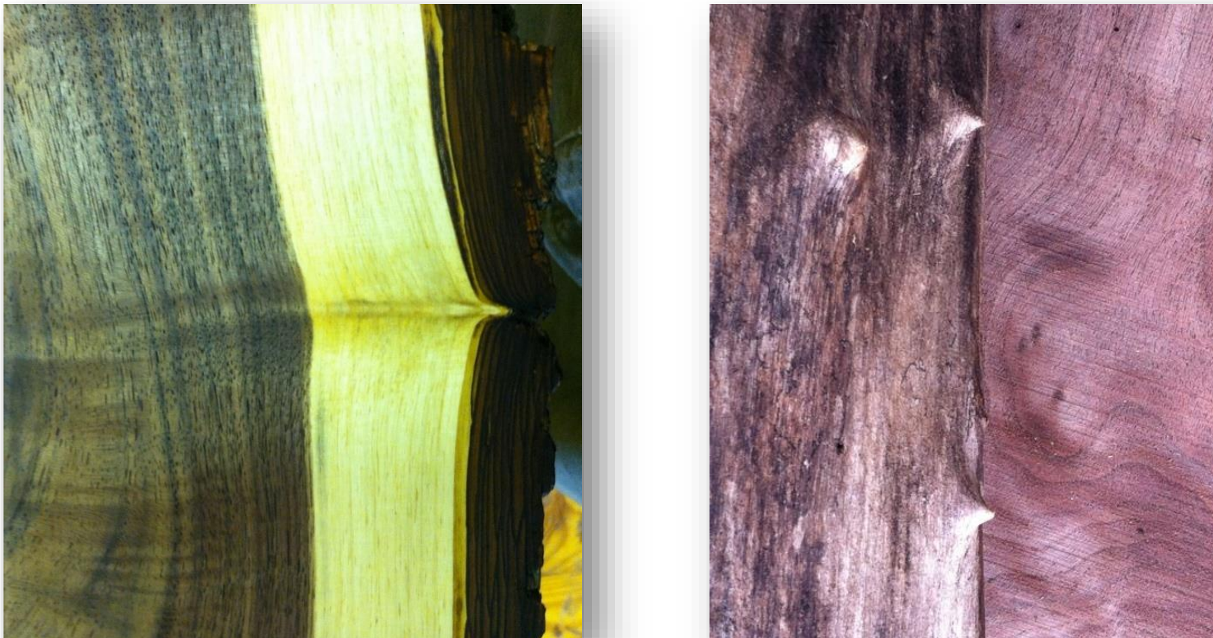


Figure 16. On the left is a radial section through a latent bud. The trace of the latent bud is visible all the way to the pith. The right photo shows the outside of 3 latent buds on a dead black walnut with the bark off. Further right on the sawn board are 3 latent buds in cross section. Latent buds add to the figure in black walnut, but veneer factories don't like latent buds, because they are cross-grained and often fall out of the thin veneer.

There are two kinds of non-sexual reproducing cells in a tree. One type is in the very heart of growing terminal buds and called apical cambium cells. The other kind, which we have been talking about until now is the non-apical cambium cells. During the later growing season apical cambium cells produce a hormone called auxin which suppresses bud growth. The auxin hormone from terminal buds is delivered downward by the phloem throughout the tree. In the spring, latent buds grow outward to keep up with new radial growth, but by mid-summer they are stopped by auxin coming down from apical buds. If the auxin doesn't arrive, the latent buds keep growing right through the bark becoming epicormic sprouts (no longer latent).

The key to growing veneer quality stems is that the tree self-kills its lower branches when they are about ½-inch diameter. Then they break off inside the branch collar - something no pruning saw can do! I have tried to think of a simple way to get a tree to kill a healthy branch. I know the trigger. It's low light => low sugar in the branch's returning phloem. In finer detail, there might be a hormonal trigger. That could lead to a breakthrough.

I could put shade cloth on the branch, but that is a lot of work. Pruning is easier. I could defoliate the branch in the spring, but it would probably need to be done twice. I could girdle or strangle the branch near the branch collar to wreck the phloem. This is going nowhere!

Figure 17. The phloem in the region below the branch wound formerly came from terminal buds of the branch – now gone. There was little energy in the area for lower callus growth and little auxin to suppress latent bud eruption. We call this "the armpit effect."

There is one contagious disease in black walnuts called witches broom or bunch disease. The pathogen must somehow stop the production of auxin, because every reserve bud sprouts and every latent bud erupts through the bark together forming a dense bunch of sprouts. If you are faced with this disease, you need to act like a walnut tree. Don't try to save it. Cut it down and burn it.

It is a pain to go back after pruning to remove epicormic sprouts. Years ago, I had the brainy idea to solve the problem chemically. Artificial auxins are available on the market, for example 2,4 D. My idea was to stop latent bud growth in the early spring well before terminal buds did their auxin job later. My idea was that latent buds would stop growing early and get buried under sapwood; they would be forever stuck. The plan would not only eliminate epicormic sprouts, if young tree could be treated, latent buds might be eliminated in all but the very center of the wood. Veneer factories would love me!

In 2009 I tried it on an ugly tree in late March using auxin sold for tobacco suckering at the recommended rate for tobacco. The tree survived and there were no sprouts. There are not always sprouts after pruning, so it doesn't prove much. In statistics, a single observation, n = 1, is called anecdotal, but it's slightly better than n = 0, a conjecture, or still worse, a hoax.

I should go back and cut off all the limbs (no natural auxin) to see if the tree has any viable latent buds below its 2009 height. Can it still sprout or will it just die?

Each set of a black walnut's genes have all the instructions needed to build both a tree and a nut. Here is how a nut is constructed. The tree has two copies of all its genes, but the nut only has one copy, along with a copy (pollen) caught on the wind from a papa's catkin. These joined copies are at the nut's center (the "germ"). The germ is surrounded with kernel made with oil preservative and enough starch-stored energy to give the embryo a kick start before it has any photosynthesis of its own. The kernel is surrounded with a cast iron like cellulose shell. The black walnut shell is famous for its devotion to protect what's inside. How is that for a Lego construction? And if that wasn't enough protection, the shell is surrounded by a hull, packed with stinky, toxic aromatic compounds. At the center of this elaborate space-pod is a single cell with all the instructions needed to create another grand black walnut tree. Apart from the germ, the rest of the nut's sole function is to defend the immortal gene's exposure during its risky escape to the next generation of black walnut.

Saying the genes in a single germ cell contain the "instructions" is a gross understatement. Blueprints can't build a factory. Sheet music doesn't make an opera. The set of genes are more than knowhow, they actually do it. They recruit the energy, keep replicating, and build a tree. "Synthesizing", building complex chemicals from simple chemicals, is something only the tree's DNA manages. Besides synthesizing the tree, genes synthesize chemicals that affect the tree's surroundings – chemicals to keep their enemies away and attract the tree's friends. A tree's friends include root fungi who get sugar in exchange for dissolved minerals and squirrels who transport the gene package, since it has no legs of its own. The tree does nothing that is not chemically orchestrated by the tree's genome. After some thought, it's backwards to say "the tree's genome". It would be more accurate to say "the genome's tree". Who is running this show anyway?

Many of the details of how all this works are understood, but there are plenty of mysteries left for the future to unravel.

CONCLUSION:

Black walnut trees never cure damaged or infected tissue. They just try to restrict the spread by walling off the area and synthesizing suppressing chemicals. Over millions of years, trees have evolved a defensive strategy which includes synthesizing nasty chemicals to suppress or even kill a specific local enemy. However, they can be completely tricked by invasives. Stressed trees have diminished defenses. We can help by keeping our trees growing and healthy, fighting invasives, and doing no harm. Details of these helpful activities are scattered throughout the remainder of this book.

One objective in this chapter has been to demonstrate the folly of treating a tree like an animal. Despite many temptations, I have religiously avoided using any animal analogies – until now! If I have failed to convince you, and you still think trees are like humans, you should not be much offended by reversing roles. What kind of shape would you be in if only your skin was alive, everything inside was dead, and you still had all the infections you ever had, (just boxed in so they couldn't spread)? If that wasn't bad enough, your feet are superglued to the ground somewhere out in the weather. You are blind, deaf, brainless, without a single neuron. All your enemies are buzzing around wanting your blood – including trees, who come around wanting part of your sap for their pancakes. I rest my case.