Branching out

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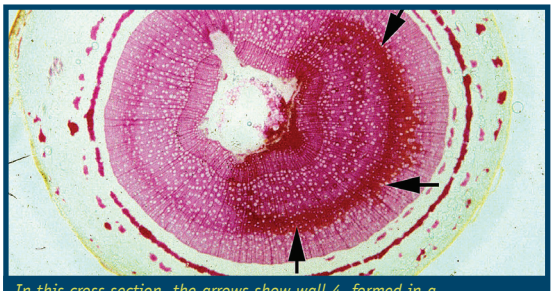
Compartmentalization: a defense process in trees

Trees are constantly exposed to a multitude of microorganisms, but only a few of them (mostly fungi) are capable of causing diseases. When a microorganism invades a tree, the latter often reacts through a defense mechanism known as compartmentalization. Researchers at the Canadian Forest Service have been studying this phenomenon for several years in trees that have sustained different types of damage, notably from maple tree tapping.

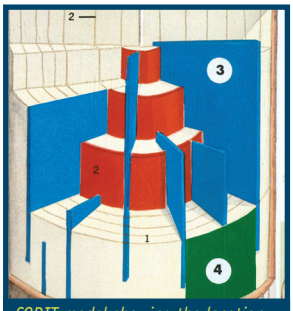
Wall-to-wall protection

To better understand the phenomenon of compartmentalization and its applications, it is helpful to refer to the CODIT model (Compartmentalization Of Decay In Trees). This model developed by Shigo and Marx (1977)[1] depicts compartmentalization as a series of anatomical changes initiated by injury or infection. The tree develops four walls that isolate the affected area and form a watertight compartment.

- **Wall 1**: plugs the conducting elements of the wood (e.g. vessels).
- **Wall 2**: owes its effectiveness to the thick walls of the last cells to form in each growth ring.
- **Wall 3**: discontinuous wall made up of sheets of ray cells.
- **Wall 4**: forms after the tree is wounded or infected; it consists of a band of cells that varies in width and often contains antibiotic compounds that strongly inhibit microorganisms. This wall separates the affected tissues from the healthy wood.



In this cross section, the arrows show wall 4, formed in a balsam poplar in response to inoculation with the causal agent of Dutch elm disease.
Photo: D. Rioux (CFS)



CODIT model showing the location of the four walls in wood (adapted from Shigo and Marx 1977).

Air as a triggering mechanism

Studies now show that it is the presence of air in the woody tissues, rather than the presence of microorganisms, that triggers the compartmentalization process. Since fungi do not grow well in a water-saturated, low-oxygen environment, compartmentalization helps wall off tissues into which air has penetrated in order to protect adjacent water-filled tissues.

Knowledge about compartmentalization and tree defense mechanisms is therefore applied in studies aimed at enhancing our understanding of tree diseases and evaluating treatments for tree wounds, including those caused by tap holes in maple trees and pruning. Research is also carried out on the hormones that play a role in the compartmentalization process and on ways of stimulating defense mechanisms in trees.

1. Shigo, A.L., and Marx, H.G. 1977. Compartmentalization of decay in trees. USDA Forest Service Bulletin No 405, Washington, D.C.

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Compartmentalization in practice

Scleroderris canker

Scleroderris canker is a disease that mainly affects pines, causing major losses in nurseries and plantations. Two strains of the fungus (*Gremmeniella abietina*) are responsible for the damage: the American strain and the European strain. Whereas red pine is vulnerable to both strains, jack pine is resistant to the European strain, but susceptible to the American strain. In jack pines infected with the European strain, colonization by the fungus is stopped primarily by the barriers that form during compartmentalization.

Dutch elm disease

Some non-host species were artificially inoculated with the fungus that causes Dutch elm disease in order to compare their response to the reactions seen in American elms. Balsam poplar responds by compartmentalizing the entire affected area. In elm trees, however, wall 4 is almost never present and when this barrier does form, it is often discontinuous, which allows the fungus to propagate and kill the tree.

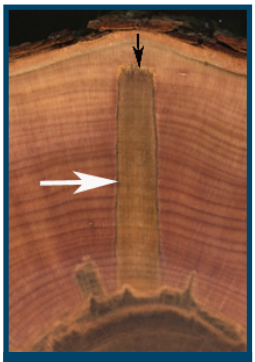
Tapping of maple trees

In general, maples are very effective at walling off tap hole wounds. However, new tap holes sometimes breach compartmentalized zones (often formed in response to earlier tap holes), leading to a more extensive area of discoloured and decayed wood. Findings such as these have contributed to the development of new tapping standards.

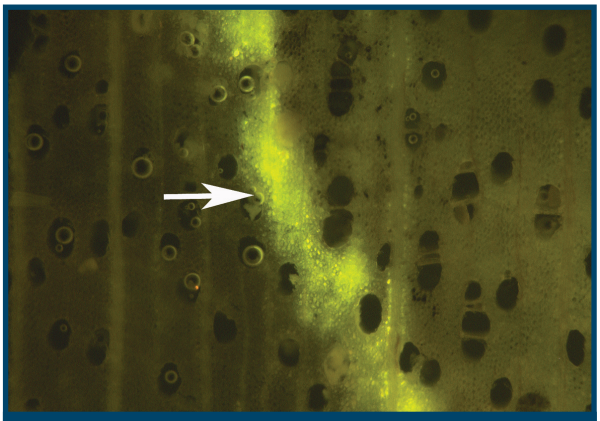
USEFUL LINK:

On sugar maple cultivation, including tapping standards (in French only):
http://www.centreacer.qc.ca

Repeated tapping in this maple has breached compartmentalization barriers (arrows). Sap yield is low in such a tree.
Photo: A.L. Shigo



Wood affected by tapping in sugar maples. Walls 3 (white arrow) and 4 (black arrow) limit the development of coloured wood.
Photo: Centre ACER



The tree produces autofluorescent phenolics (arrow) that permeate wall 3. These compounds are not easily degraded by fungi.
Photo: D. Rioux (CFS)

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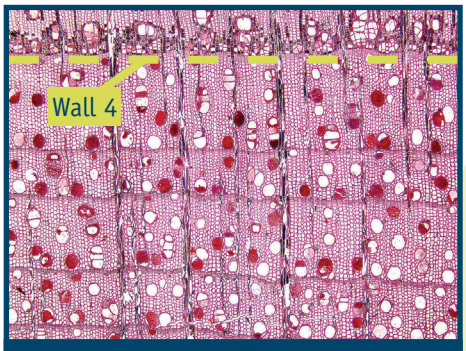

Wall 4 and several vessels (wall 1) obstructed by red-coloured gels.
Photo: J. Grondin (CFS)

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