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DIT: Patterns of Life

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CODIT: Patterns of Life

1. Trees use energy from the sun to grow. They do so in a highly ordered fashion, building themselves up in compartments and breaking down in the same manner.

2. The sawyer on the left is Dr. George Hepting, a pioneer researcher on tree decay. He observed compartmentalization of decay in trees in 1935. Dissecting trees with a crosscut saw was extremely difficult. Until 1959 our view of tree decay was obtained mainly from crosscut sections.

3. With the advent of the one-man chainsaw, we could dissect large trees longitudinally,

4. providing a new vantage point for studies on decay.

5. Patterns of discolored and decayed wood could be studied on both longitudinal and crosscut surfaces.

6. Since 1959 thousands of trees have been dissected and studied this way.

7. From these studies, basic patterns of discolored and decayed wood have emerged. A major finding is that the diameter of the discolored and decayed wood is the diameter of the tree when it was wounded....

8. or when the branches died. This is true both for hardwoods....

9. and for conifers. When decay develops in wood exposed by branches, it does not move outward, even when that wood is heartwood. The arrows show the limit of decay.

10. Hollows result when microorganisms digest the wood that was present at the time of wounding.

11. Hollows are also found in trees that have heartwood, as in this black locust,

12. white pine,

13. and eucalypt.

14. The same patterns occur in roots.

15. Hollows do not always develop in the center, as evidenced in this tropical hardwood.

16. Trees compartmentalize injured and infected wood. To aid in understanding compartmentalization, we developed a model called CODIT, an acronym for Compartmentalization Of Decay In Trees.

17. The CODIT model has two parts. Part I has three walls: no. 1 resists vertical spread, no. 2 resists inward spread, and no. 3 resists lateral spread. Part II has one wall, no. 4, which separates wood present at the time of injury and infection from new wood.

18. CODIT is a model that applies to both non-heartwood and heartwood-forming trees, such as oak....

19. and eucalypt.

20. This white oak had five basal wounds. The triangular-shaped discolored and decayed wood was formed by walls 2 and 3 which resisted spread, and wall 4, which separated infected wood from healthy wood.

21. Decay was less advanced in this western hemlock.

22. The green arrows point to wall no. 1 in this red maple. In an abstract sense, each growth ring is a new tree and each tree uses the same mechanisms to resist the spread of decay.

23. This is illustrated on the crosscut face of a peach tree. The column of discolored and decayed wood is the coalescence of columns from many individual "trees."

24. Wall 4 extended entirely around the trunk of this sweetgum tree, a common, but not inevitable, occurance.

25. In this birch tree, vertical arrows show wall no. 1, while horizontal arrows point to wall no. 4.

26. This slice of western hemlock was taken from the top of a wounded area. The red

arrows show wall 4 within the growth rings. Points A and B show where wall 4 ends.

27. Wall 4 also forms after wood is infected. This elm had Dutch elm disease; the red arrows show where recent infections were walled off.

28. In response to a wound, this Norway spruce developed a wall 4, indicated by the red arrows, within the growth ring. The green arrows show how far the cells that produced resin extended.

29. Wall 4 is a model representation of a barrier zone, which is composed of strong protective tissue. This is the barrier zone from a spruce sample.

30. Though strong in one sense, the barrier zone is structurally weak and may pull apart, as it did in this white pine.

31. Barrier zones sometimes form when branches die. When the tissues separate, as they did in this cherry, a ring shake results.

32. Trees form barrier zones around hardware.

33. After a tree is wounded, a wall 4 forms, as it did in this oak. Radial shakes often develop at the edges of the wound, where the pen and pencil are pointing. When pressure occurs due to heat, cold, or felling, shakes may split outward. These splits are called frost cracks.

34. In this oak, the red arrows show the limits of an old wound. An open crack formed where callus first closed the injury. The green arrows point to radial shakes that split outward, while the blue arrows show ring shakes associated with other wounds. The purple arrows point to internal radial shakes.

35. This black walnut was wounded at the green arrows when it was 1 inch in diameter. At the red arrows the callus inroll cut into the trunk and caused an internal crack.

36. Multiple cracks form when many radial shakes associated with old wounds split outward, as in this post oak. The cracks start at the circular barrier zone.

37. When decay and cracks combine, as they did in this black locust, wall 3 is the tree's only defense against the spread of decay.

38. A decayed basal sprout on this oak was a weak spot from which a crack spread inward at the purple arrows and outward at the red arrows. "S" indicates sapwood, "H" is heartwood, and the dotted line shows the boundary between them.

39. This is a typical cracking pattern. The purple arrows point to where callus closed the wound.

40. In response to insect wounds, this maple formed wall 4. Radial cracks developed later at the blue arrows.

41. Wall 4 in this eucalypt separated to form a ring shake. Felling caused a radial crack at the 6 o'clock position.

42. Ring shakes along wall 4 are common in flush-pruned trees such as this black walnut.

43. For proper pruning, start with identifying the branch bark ridge. Instead of cutting behind it or leaving a stub, cut along the red line.

44. Within the collar that forms at the base of dying branches is a chemical protective boundary indicated by the red arrows. Removing the collar destroys the boundary. The blue arrows mark an internal view of the branch bark ridge.

45. Decay is essential for branch shedding. If decay surmounts the tree's natural chemical boundary, it will be walled off within the stub.

46. Flush cuts wound the trunk, which responds by forming wall 4. These walls often split. Microorganisms easily enter a trunk wound. Samples from an oak tree show that callus formed after it was wounded, an indication that decay did not develop.

47. Flush cuts cause discoloration of sapwood, which normally transports and stores material.

48. Decay developed above and below the 13-year-old flush cut on this black walnut.

49. The leader on this beech was killed, and a branch became the new leader. Decay developed to the width of the old leader and spread only downward.

50. When a branch containing heartwood dies or is cut, the sapwood discolors and decays first, not the heartwood.

51. If decay develops in drill holes, it starts in wood nearest to the bark, like it did in the center sample. This is true both for sapwood trees, such as the maple shown here, and for heartwood-forming trees.

52. Wound B in this maple was well-compartmentalized. Wound A weakened at wall 2, because its inner edge was too close to the central column of discolored wood.

53. The same drill patterns appear in this oak, showing that heartwood compartmentalizes injured and infected wood.

54. Decay spread to the center of the beech at left. Before it was wounded, this tree was healthy from bark to pith, while the beech on the right already had a central column of altered wood. The drill wounds reached the center of both trees, but discolored and decayed wood associated with wounds did not penetrate the central column of the altered tree.

55. An identical pattern is seen here, where the wound reached the pith, but discolored wood did not.

56. Again, the drill holes on this aspen penetrated to the red marks, yet discolored wood stopped at the arrows.

57. Here you see where a drill hole passed through sapwood, healthy heartwood, and wound-altered heartwood five years before this oak was cut. Note carefully that decay associated with the wound did not spread outward beyond wall 4, or inward through wound-altered heartwood. Heartwood and

sapwood will compartmentalize injured and infected tissue, but once they've responded they cannot respond again.

58. An example of this phenomenon is seen here, where decayed wood associated with the dead branch B did not spread into A or outward into C.

59. The heartwood is separate from the column of decayed wood on this sample, proving that microorganisms do not grow at will in trees.

60. This eucalypt had multiple columns: first a central hollow, then a band of sound heartwood, then another hollow, and finally more sound heartwood.

61. Termites quickly invade wound-altered eucalypt wood.

62. Ants, which follow the patterns established by decay, infested the wound-altered heartwood of this oak.

63. Here, healthy heartwood surrounds decayed heartwood, which, in turn surrounds a central column of healthy heartwood.

64. In a white oak severely wounded by fire, heartwood formation comes to a standstill. Wounds stop heartwood from forming, while they initiate the formation of discolored wood.

65. When a compartmentalized column 1 is ruptured by another wound, column 2 develops.

66. Holes are commonly made in trees for injections, and for tapping maple sap. The sections here are from the same maple tree. Paraformaldehyde was added to the hole in the left section, but not to the control section on the right. This shows how chemicals may reduce a tree's ability to compartmentalize, so that decay develops rapidly.

67. Holes have helped researchers select individuals within a species that compartmentalize rapidly and effectively. All trees in Populus species, clone 42, were

strong compartmentalizers, while all trees in clone 49 were not. It appears that the capacity to compartmentalize is under strong genetic control.

68. CODIT is also applicable to root rots. A tree either rapidly stops the spread of infection, as shown in this pine infected by Fomes annosus, or it does not, letting the infection girdle and kill the root or butt. A cross-section was cut near the top of the dead area....

69. to show how the fungus was walled off in the wood after being stopped in the bark.

70. The same patterns occur with Armillaria mellea. This aspen compartmentalized decay associated with Armillaria mellea after infection in the bark was stopped.

71. In this spruce sample, the pencil indicates the limits of the dead bark. Fungi did not spread into new wood that formed after the infected wood was contained.

72. Decay associated with Armillaria mellea in this red spruce did not spread to the center, because it was already altered. The pencil shows where wall 4 separated decayed wood from sound wood that formed after the dead area stopped developing.

73. In this beech root, decay associated with Armillaria mellea was strongly restricted by wall 3 at the red arrows. Again, fungi do not grow at will in a tree.

74. The bottoms of roots usually decay first and then connect with the wood between them at the tree butt. Decay will then be most advanced between the roots, as in this balsam fir. Trees with decay at this juncture often split above the roots.

75. Fomes pini associated with rot produced a wedge of tissue in the bark as indicated by the red arrows. It does not infect healthy sapwood or heartwood, but only wound-altered, resin-soaked, old sapwood and young heartwood, shown by the red dot and letter W, creating a ring pattern.

76. Sound heartwood separates many rings of decayed wood in this pine. The center was probably infected when it was still producing resin. Fomes pini does not grow at will in heartwood. As the ring patterns show, heartwood must be altered to accommodate the fungus before it can spread.

77. A variant of Fomes pini that occurs in fir on the west coast produces large wedges of infection in the bark. When these wedges coalesce, they will girdle the tree.

78. Many fungi produce wedges in bark. Trees usually respond by producing a blocking tissue in the bark. A wedge, like this formed by Poria obliqua in paper birch, allows the fungus to spread to the outer side of wall 4, thus enlarging the wound and starting seesaw action between tree and fungus. The result is a perennial canker.

79. The seesaw action between this red oak and Strumella coryneoidea went on for many years. The green arrows show where the tree kept the fungus from spreading by producing a wood barrier. At the red arrows a new fungus wedge broke out and began to advance, thus enlarging the canker.

80. Trees are highly ordered supersystems, composed of many compartments. They build up in an orderly way, and when microorganisms invade they break down in an orderly way, as well. CODIT gives us an opportunity to understand these highly ordered processes, and to begin to regulate them.