Structure of wood in relation to decay.

Chemical

**Cellulose** - b 1-4 Glucose polymer, organized into microfibrils, crystalline & non-crystalline - Broken down via enzymatic digestion at repeating bond structure

Endo-cellulase cleave in the middle

Exo-cellulases, cellobiohydrolases (CBH), work from the ends of long strands cleaving 2-4 units from the end

beta-glucosidases cleave di and tri-saccharides into monomers (i.e., glucose).

![Cellulose Structure](image)

**Hemicellulose** - short chain polymers: xylans (polymerized pentose sugars), glucomannans (hexose sugars). Primarily: xylose, mannose, galactose, rhamnose, and arabinose, Cross-linked to cellulose and pectins. Broken down enzymatically by hemicellulases, but also soluble in alkali and hydrolyzes readily in dilute acid to form sugar acids;

**Lignin** - phenyl propane skeleton: complex non-repeating structure

![Lignin Structure](image)

Broken down via free radical reaction. (i.e., the Fenton reaction):

\[
\text{Fe}^{+2} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{+3} + \text{OH}^- + \text{OH}^-
\]

Enzyme systems used: Lacases, Manganese Peroxidases, Lignin peroxidases? - expressed in culture only if fungi are starved for lignin.
Relationship to cellular structure

Wood structure

Pectic material - in middle lamella (area between cell walls)

"Extractives"

N,P,- mostly in living cells as proteins, amino acids, nucleic acids etc.

Distribution of water - free water with negative pressure, matrix water

Who causes decay? - mostly basidiomycetes (agarics, polypores and resupinates), a few ascomycetes especially members of the Xylariales (e.g. Hypoxylon).

Types of Rot (or ways to describe them)
  by chemistry of rot: brown vs white
  - color misleading - cellulose and hemicellulose only, versus lignin, cellulose and hemicellulose

  - Strangly brown rots efficiently remove the cellulose without cellulases (evidence from recent genome sequence of *Postia*)

  - different ecological consequences, brown rot residues and soil

  by position in tree: root, butt, top (trunk)

  by type of wood: heart rot, Sapwood rot (saprot in book)

  by looks: pocket, stringy, cubical, etc

Pathogens (heartrots and sapwood roots) vs. Saprobes (slash rots, or simply saprobes)

Pathogenic wood decay (that occurring in living trees) - restricted to specialize subset of decay fungi.

How is wood defended from decay?

Sapwood vs Heartwood
  living with dead cells versus dead
  High water content vs lower water content
  low in extractives (preservatives) vs high in extractives

Importance of water in sapwood
shape of decay pockets is determined by physical characteristics of wood and distribution of water: or why the CODIT (containment of decay in trees) theory is all wet: Hydration protects sapwood, while heartwood is protected by extractives
Frequency of decay in Sapwood vs Heartwood reversed upon death of tree. Trees get heartrots while they are living, but the sapwood decays fastest once the tree dies.

Infection courts - or how do decay organisms get in?

Wounds - wind, fire, branch stubs, insects

Endophytic colonization - colonize and wait (e.g. Hypoxylon, Echinodontium tinctorium)

Growth from adjacent infected trees (root rots primarily, but also in Hymenochaete corrugata - (Alan Rayner refers to it as the bondage fungus because it ties up hazel's limbs)

Heartrots - decaying the primarily the dead wood of living trees, but considered to be pathogens

often some host specificity (particularly conifer vs hardwoods)
Some die out when tree dies - example: Oligoporus amarus, O. sequoiae

Echinodontium tinctorium - indian paint fungus - common white stringy heart rot of conifers. Typically high in trees, endophytic colonization

Phellinus/Inonotus species - all white roots, found on both conifers and hardwoods (although particular species are usually one or the other). Commonly pathogenic heartrots and sapwood rots. Examples: Phellinus pini (species complex)- common heart rot of conifers - causing a white pocket rot, Phellinus gilvus - common on oak and other hardwoods in our area. Phellinus weirii - root rot of conifers in pacific northwest

Ganoderma species all white roots, found on both conifers and hardwoods (although particular species are usually one or the other). Brown spores Example species G. applanatum- (the artists conk), Ganoderma lucida complex (Chinese medicine).

Saprobic wood decay - a highly competitive environment - zone lines show border of war zone

Wood endophytes get first dibs (e.g. Hypoxylon thouarsianum / SOD interaction); maybe Stereum

Early pioneers - prolific sporulators (e.g. Trametes versicolor, Trichaptum, Fomitopsis pinicola, Crytoporus volvatus)

Mycoparasitism (one fungus parasitizing another) as a way to capture the resource (Lenzites betulina: and Trametes versicolor), Tremella and Sterum

Importance of decay for ecosystem

C (N) recycling
Soil structure
Wildlife habitats
A pictorial summary of some common decay fungi in our area. Common species are listed and arrows point to their common habitats within trees. Those that point to the standing tree are found in living trees, those that point to the logs are found in dead material. Dotted arrows indicate a lower frequency or importance in that habitat. Trunk or top rots, butt rots, and root rots are indicated by position in the living tree. The dark area within the tree and logs indicates the heartwood. Host ranges are not listed for the root rots because we will discuss those later in greater depth.

Root Disease

Effects of root disease
change in composition because of specificity - succession? (primary hosts and secondary hosts)
predisposition - especially to bark beetles
Growth loss greatest, (height first)
Loss of accumulated volume - also premature death & decay
Delays in restocking - decades in gaps
hazards - in populated areas

General symptoms of root disease
tree mortality spread out over many years and usually present in only some species; in new centers young suppressed trees are often the first to go lions tailing due to slow growth (in contrast to needle loss caused by pollution) reduced production of needles, Chlorosis (yellow needles) premature pruning of lower branches Bark beetle attack esp. *Dendroctonus* spp. in pine and Doug-fir, *Scolytus* in fir. *Resinosus* (*Pinus, Picea, Pseudotsuga, Larix only*) discoloration in wood, lesions on roots

**References:**
In the text see pages 348-358. In your text the coverage of the basic terminology is good and it has a nice table of some common decay fungi. The section of CODIT should be ignored as it is probably incorrect.

Rayner, A. D. M. and Boddy, L. 1988. *Fungal decomposition of Wood. Its Biology and Ecology*. This is a great book, unfortunately it costs $165! and is housed off campus. The information on the Fenton reaction and the role of water in limiting decay and defining the shape of the decay column comes from this book. see Chapters 2, 8, 10 (332-360), 11 (410-419). I’ll put in on reserve in case any of you have a strong interest

Wikipedia has very good writeups on cellulose, lignin, and hemicellulose. Several of the images used in the powerpoint come from there.