

Cell wall structure

Wood Technology

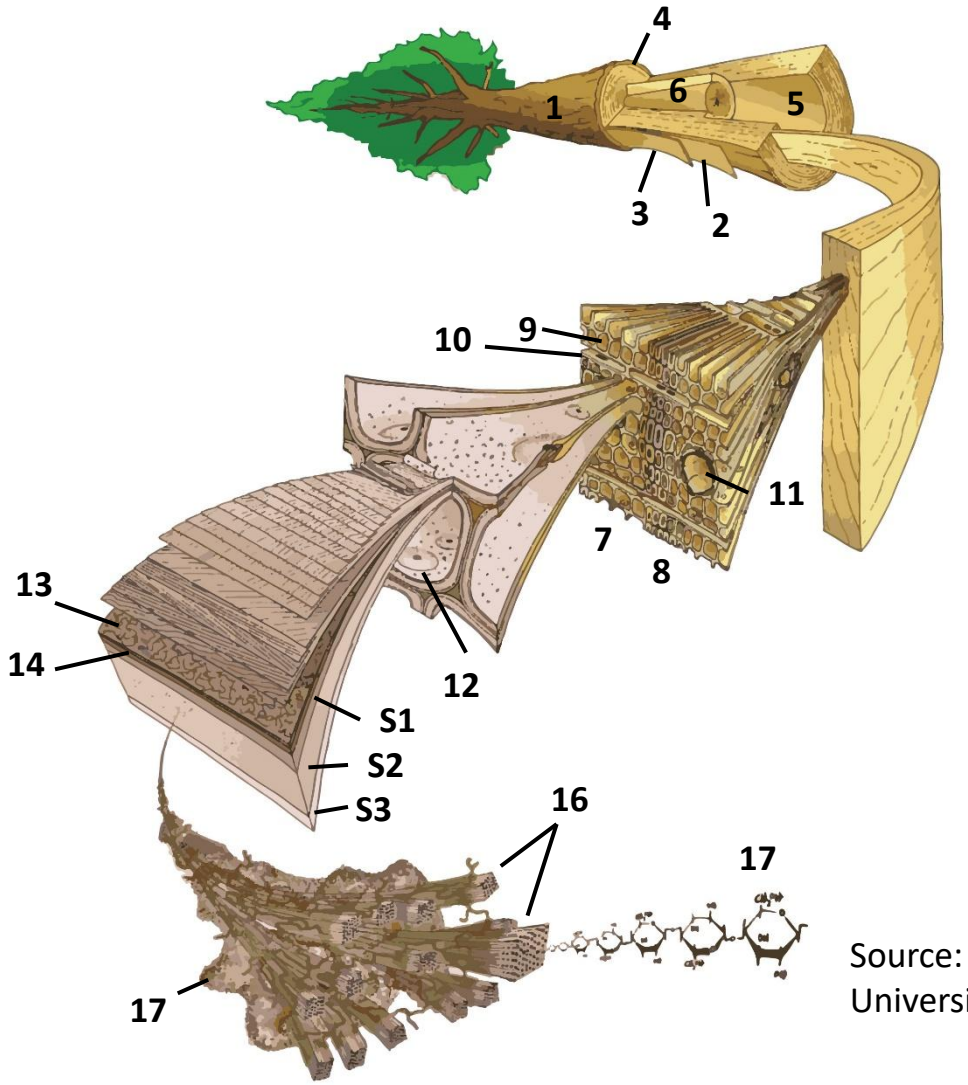
Matthew Schwarzkopf

Cell wall structure

- Learning objectives
  - Identify the different layers of the wood cell wall
  - Understand the composition and function of the different parts

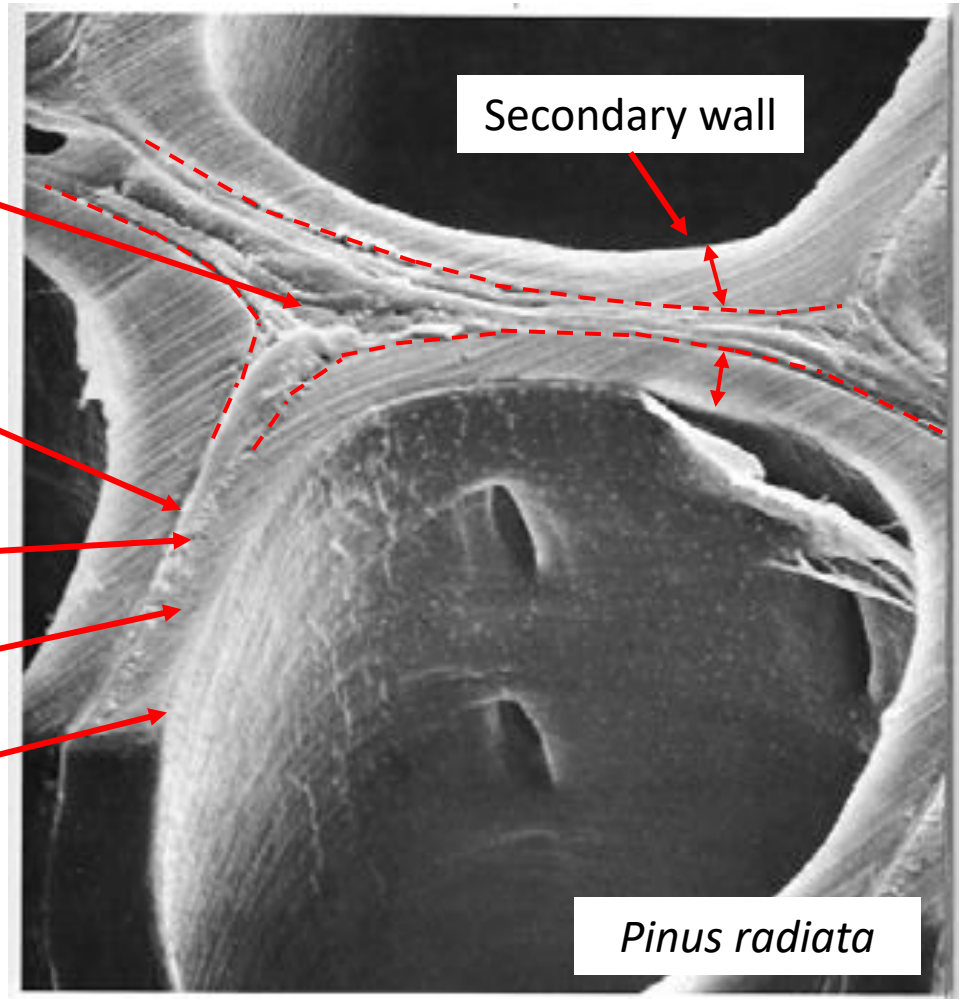
Hierarchy of wood structure

1. Tree stem
2. Cambium (living cells)
3. Inner bark (active phloem)
4. Outer bark
5. Sapwood (water conducting, mostly dead cells)
6. Heartwood (non-conducting, dead cells)
7. Earlywood
8. Latewood
9. Tracheid
10. Ray
11. Resin canal
12. Bordered pits
13. **Middle lamella**
14. **Primary wall**
15. **Secondary wall, S1, S2, S3**
16. **Microfibrils**
17. Cellulose chain
18. Amorphous matrix



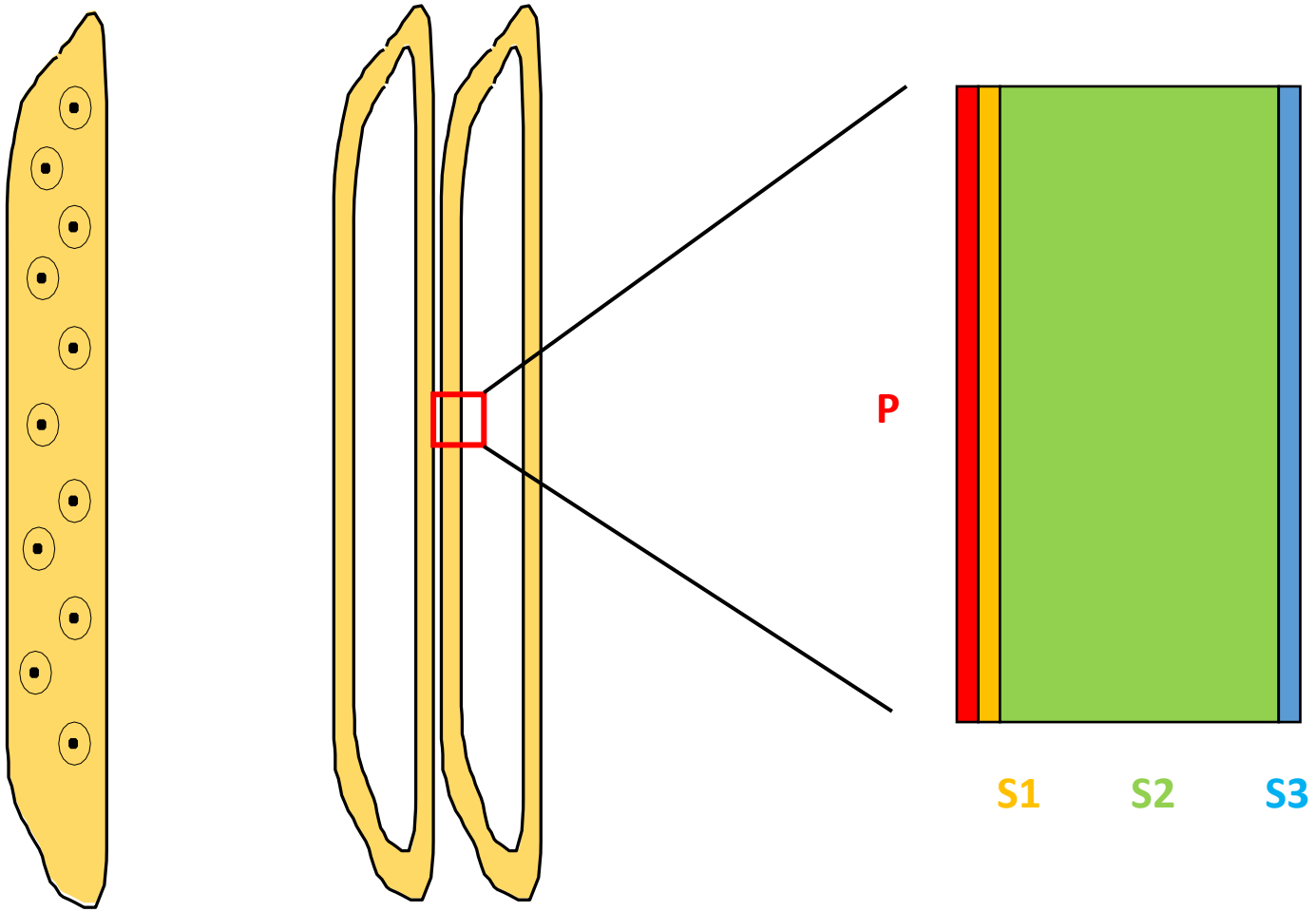
Source: Adapted from Mark Harrington, University of Canterbury, 1996

Cell wall layers



Source: Meylan and Butterfield

Layered cell wall



P = Primary cell wall
S1, **S2**, **S3** = Secondary cell wall layers

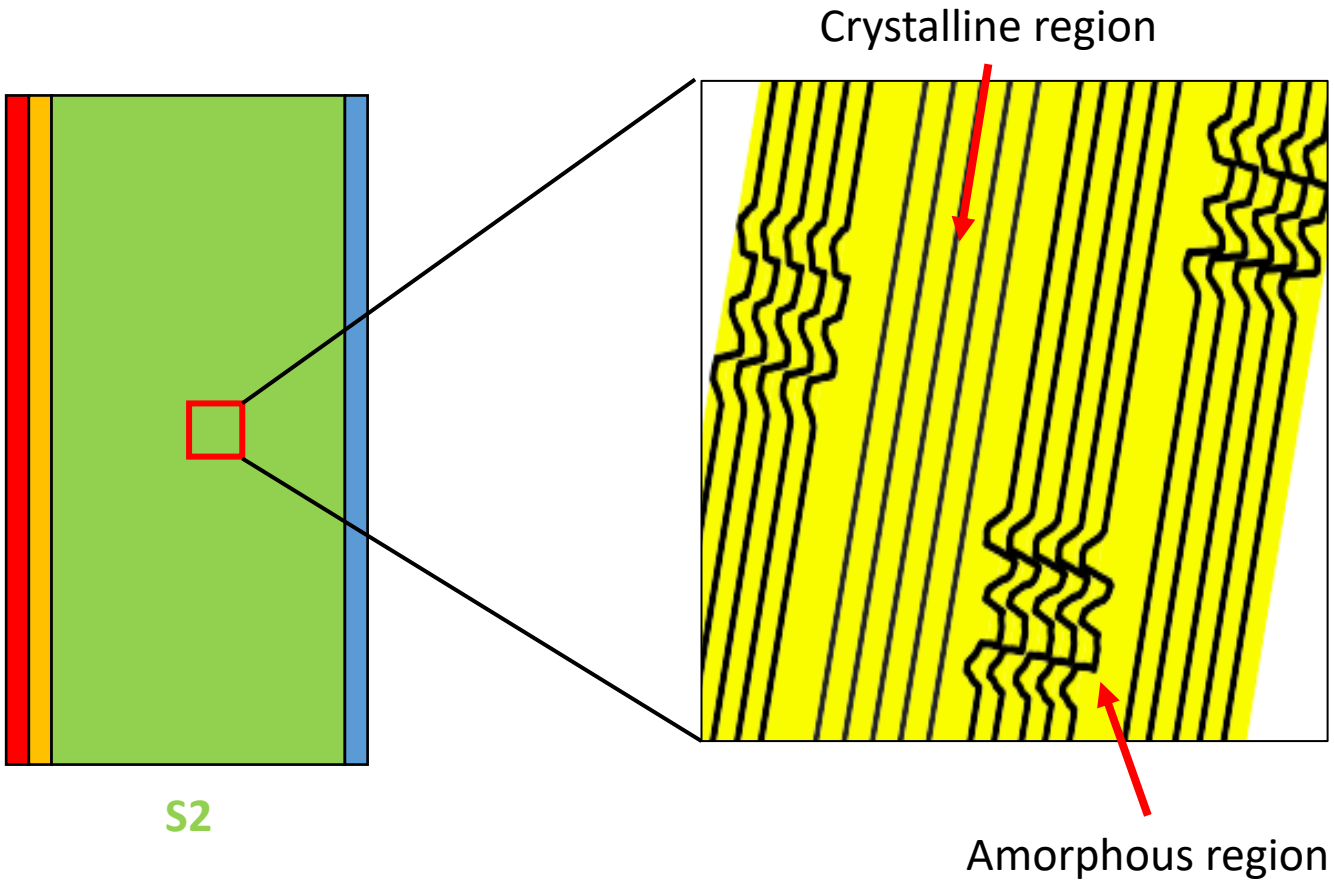
The cell wall is composed primarily of three polymers:

Cellulose
Hemicellulose
Lignin

These polymers have defined orientations and layers.

Source: Adapted from Milota

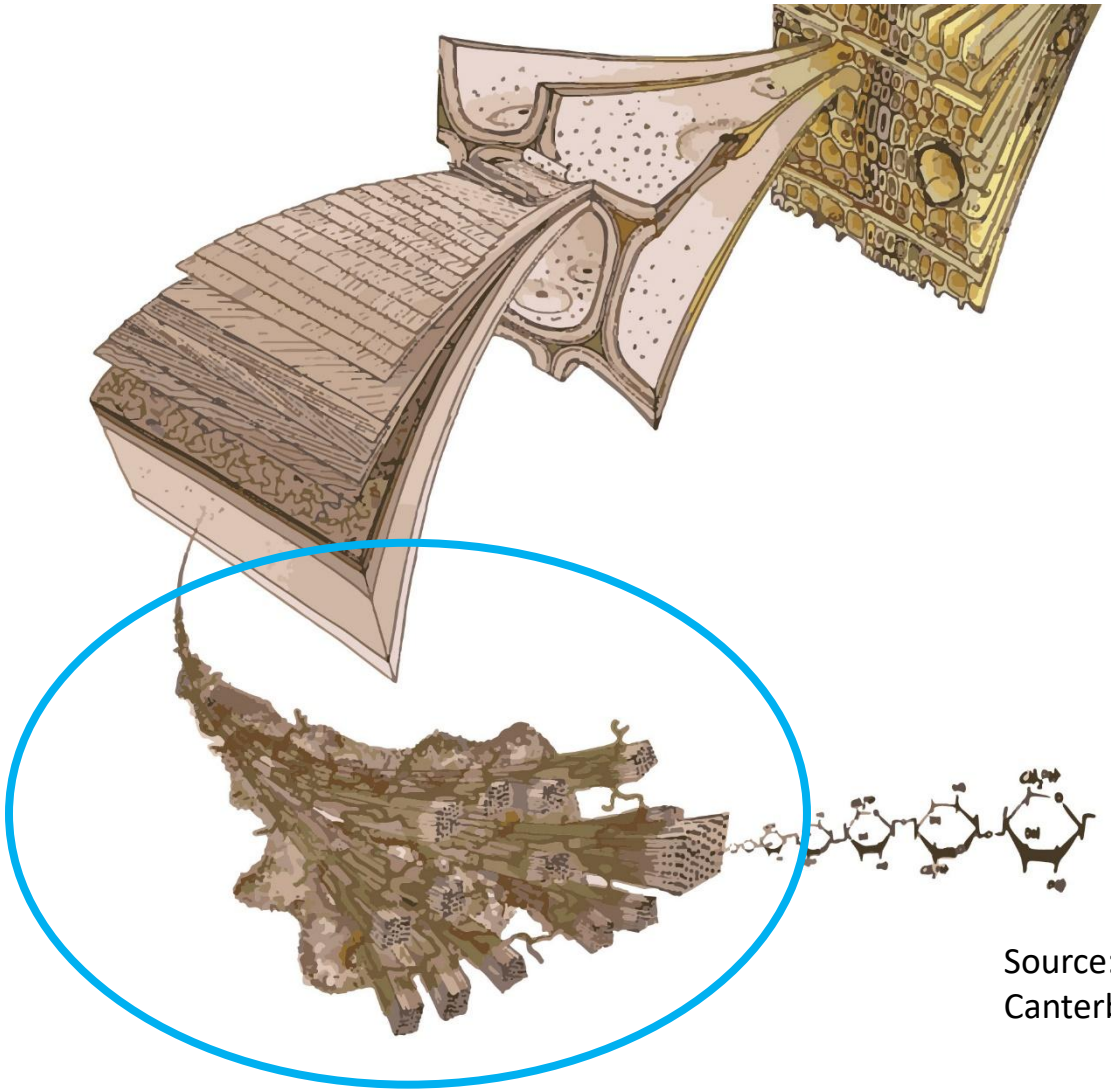
Layered cell wall - microfibrils



Microfibrils are bundles of cellulose molecules in a helix form and are approximately 10 to 20 nm in diameter

Source: Adapted from Milota

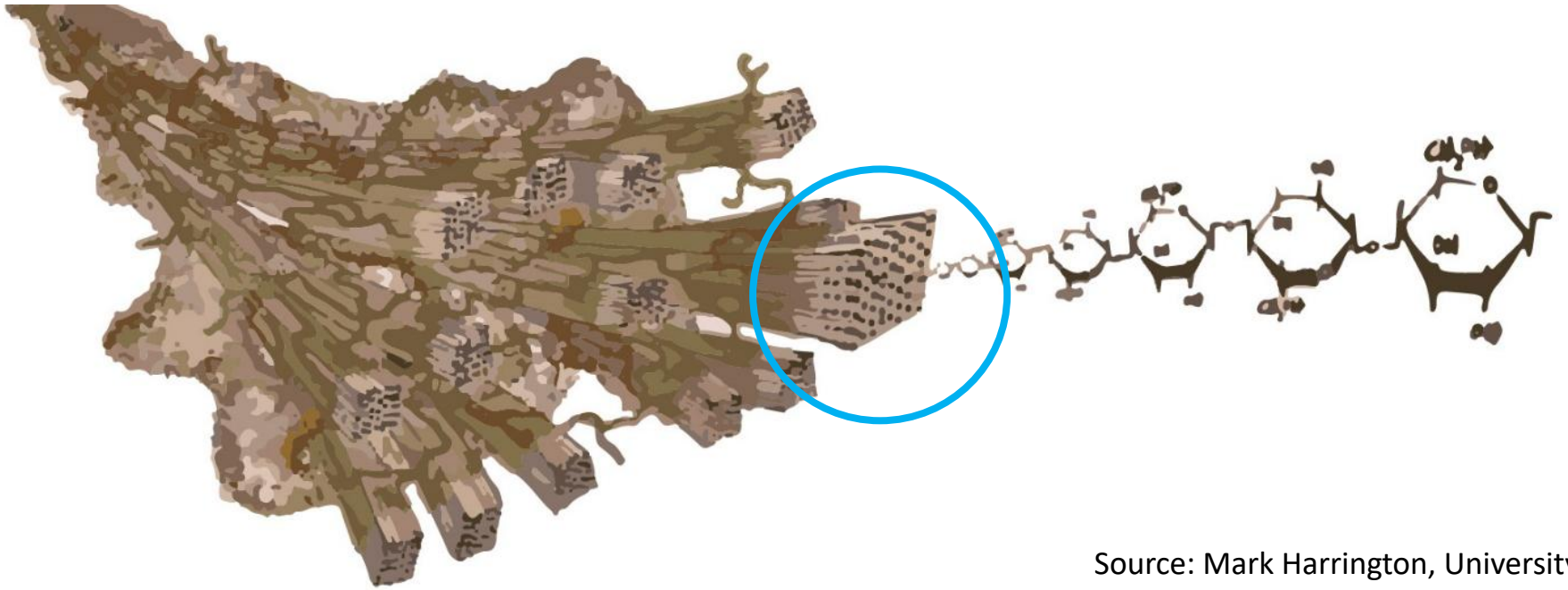
Layered cell wall - microfibrils



Source: Mark Harrington, University of Canterbury, 1996

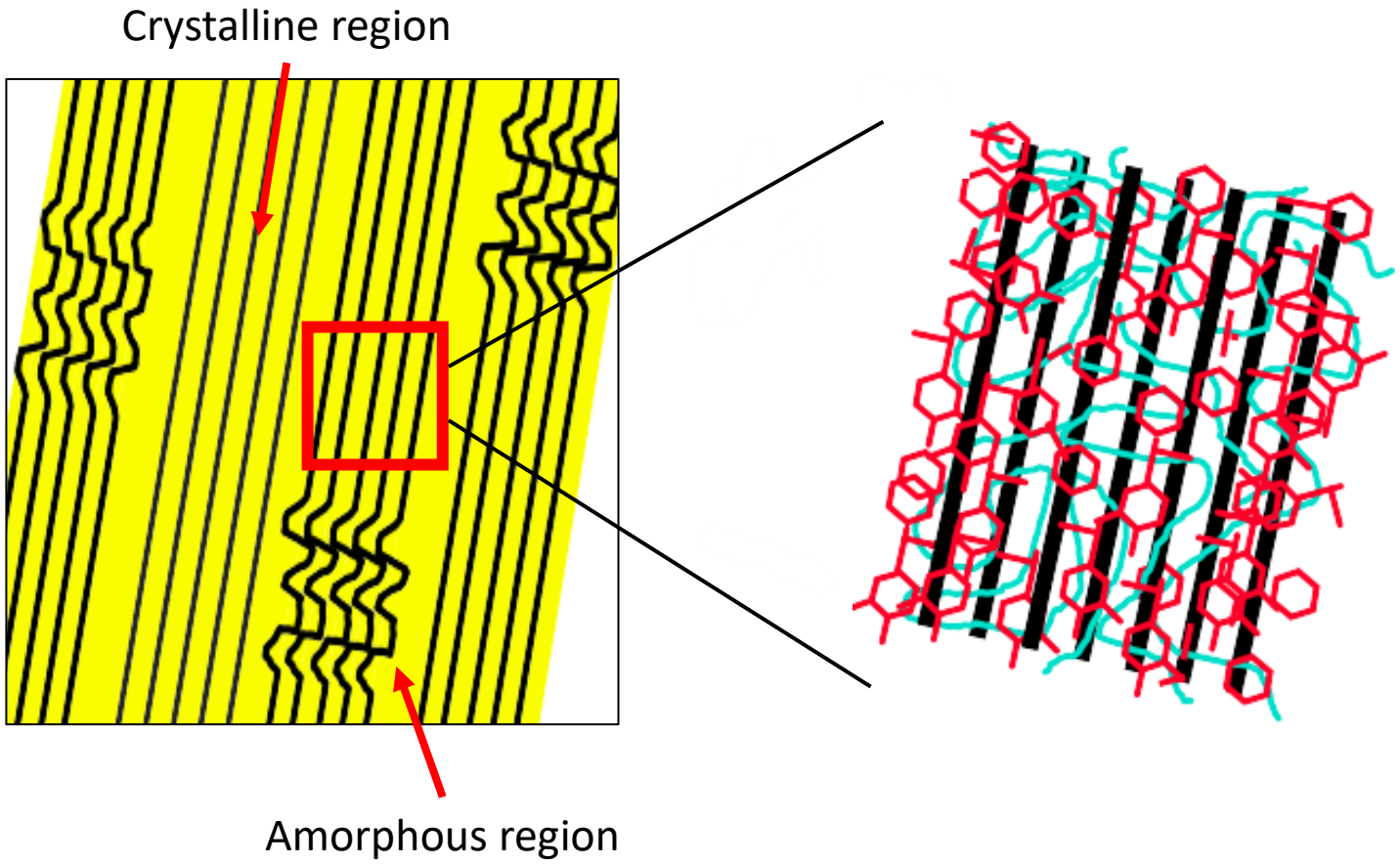
Layered cell wall - microfibrils

Microfibril cluster – 10 to 20 nm **Molecule < 1 nm**



Source: Mark Harrington, University of Canterbury, 1996

Layered cell wall - microfibrils

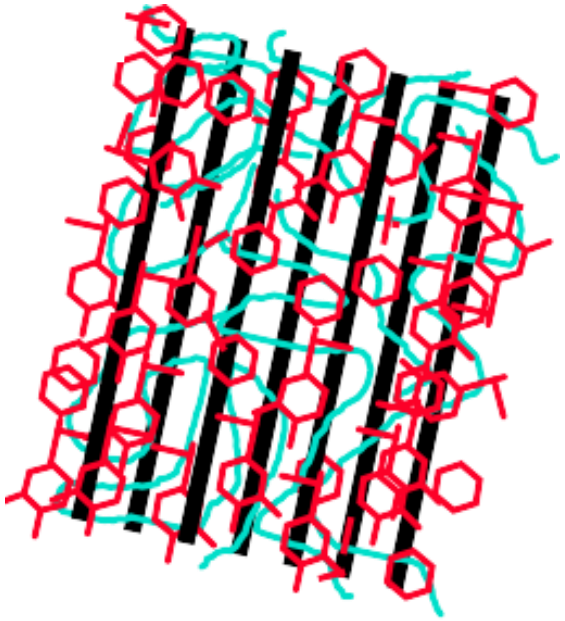


Microfibrils are encased in hemicellulose with a matrix of lignin, binding the fibrils in place.

Black lines are representing microfibrils, red are hemicelluloses, blue is lignin.

Source: Adapted from Milota

Basic components



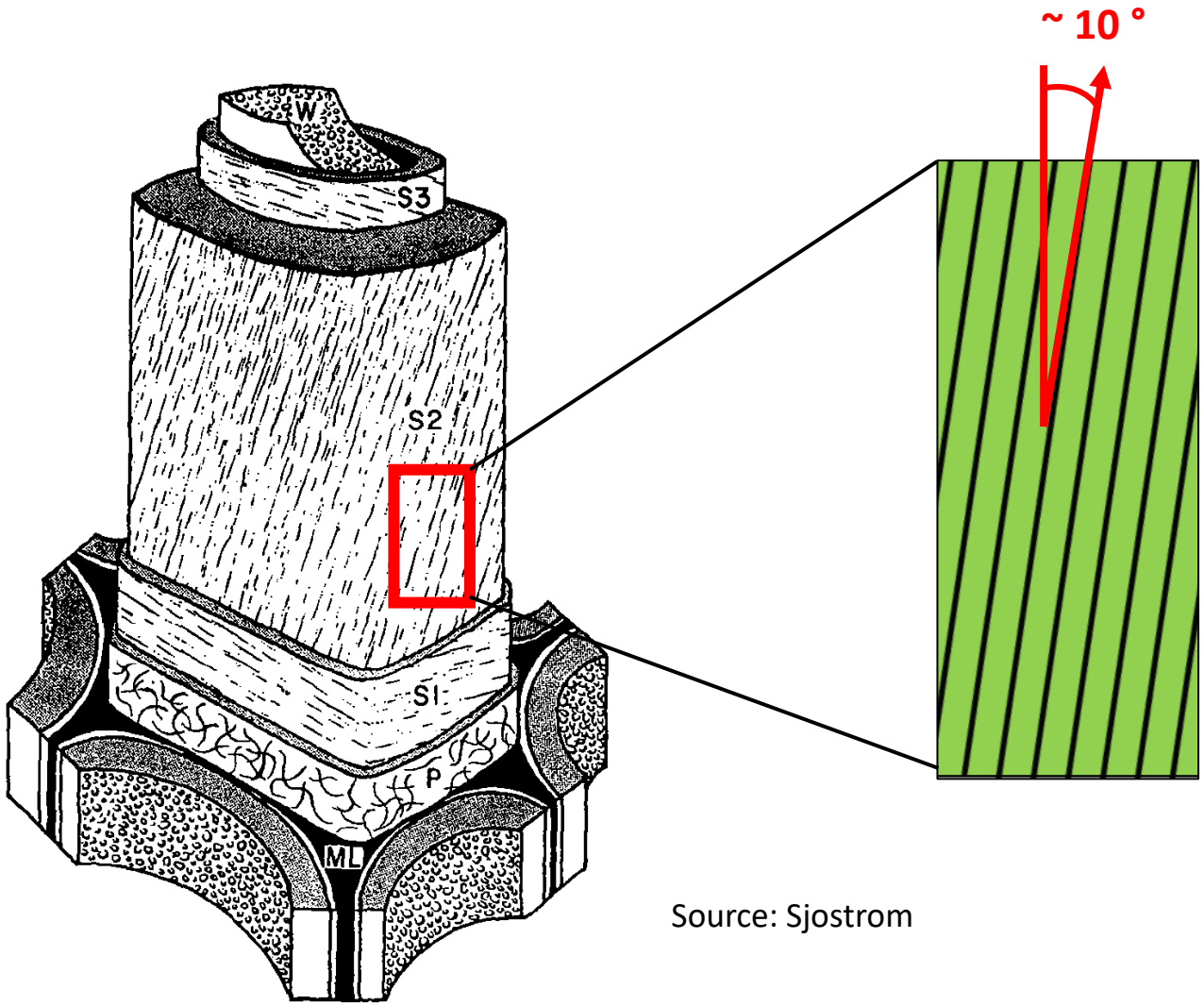
Cellulose: Long-chain linear polymer of glucose that forms crystalline structures (reinforcing rod).

Hemicellulose: Collective term used for a group of low molecular weight, simple sugars (mannose, xylose, galactose, etc.) that form an amorphous polymer. Serves as the link between cellulose and lignin.

Lignin: Large and highly branched polymer that is composed of phenylpropane units (thermoplastic matrix).

Source: Adapted from Milota

Cell wall structure - formation



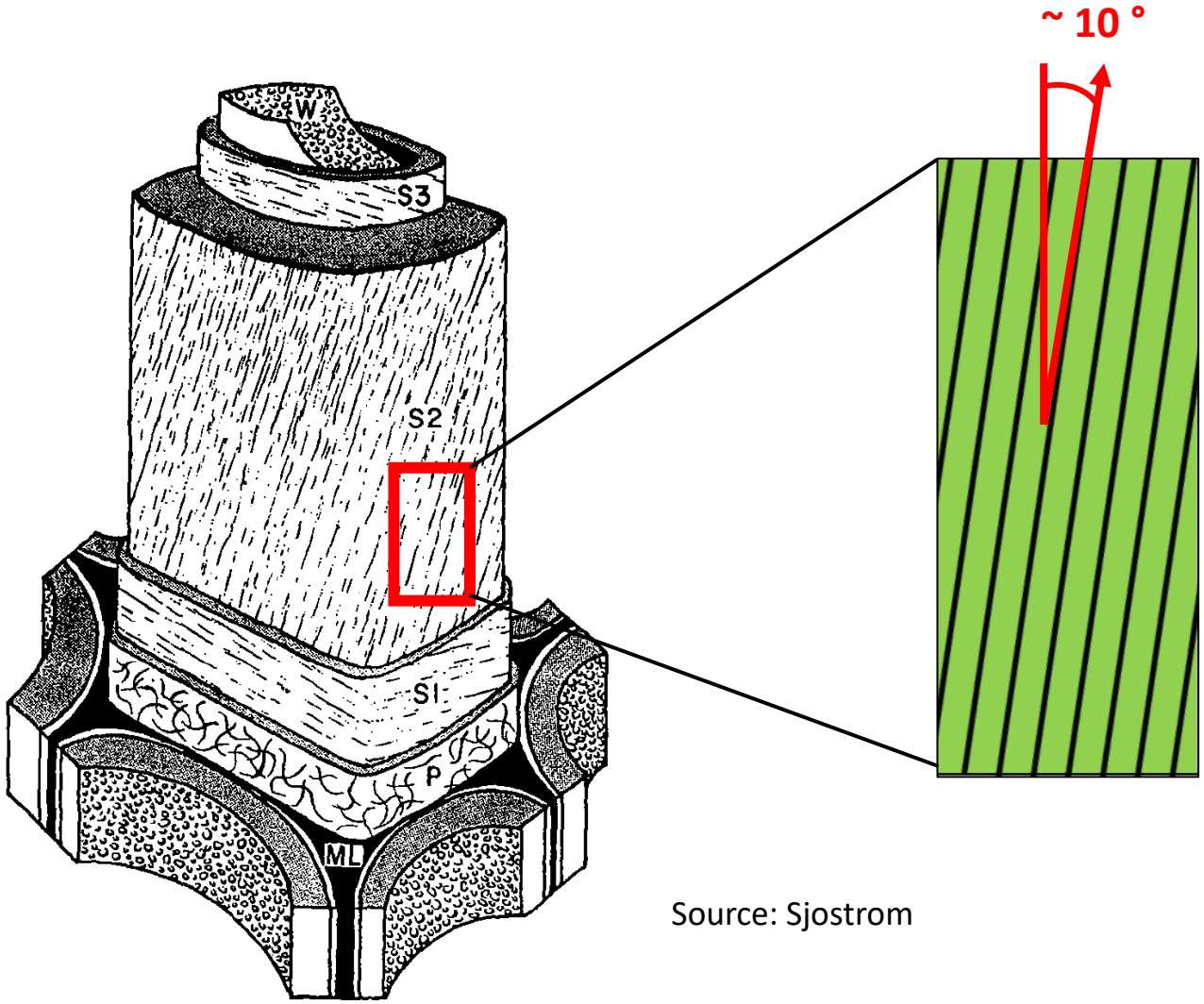
Source: Sjostrom

- Primary wall
  - Formed after cell division
- Secondary wall
  - Forms after primary wall is done growing
- Middle lamella
  - Material between cells

- Wood properties are due to the secondary wall, and to a much greater extent the S2 layer

Source: Adapted from Milota

Cell wall structure - Orientation



Source: Sjostrom

- Primary wall
  - Pectin-like substances
  - Some cellulose (~9 %)
- Secondary wall
  - S1: 50-70 °, 4-6 layers, ~ 0.1 µm
  - S2: 10-30 °
    - EW – 30-40 layers, ~ 0.6 µm
    - LW – up to 150 layers
  - S1: 60-90 °, 4-6 layers, ~ 0.1 µm

Source: Adapted from Milota

References

- Milota, M. 2010. Oregon State University. Wood Science and Engineering, WSE 521, Wood Science 1, Class Lectures.
- Meylan, B.A. and B.G. Butterfield. Three-dimensional structure of wood. Syracuse Press. Syracuse, NY. 80 pp.
- Sjostrom, E. 1990. *Wood Chemistry: Fundamentals and applications.* San Diego.