Lecture in line with the course

„Biotechnology of trees and fungi“

Lignin

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Characteristics

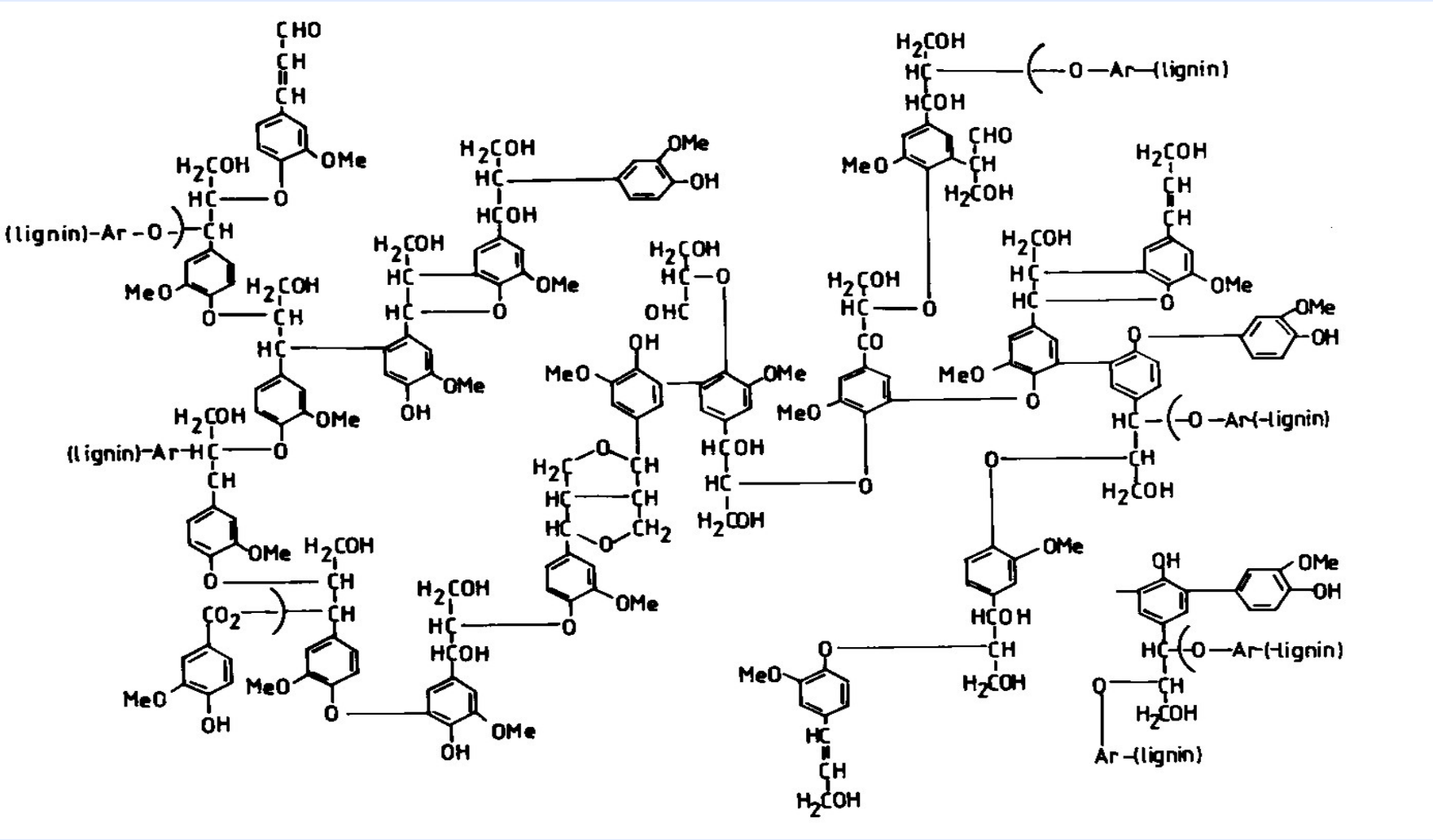
⇒ Lignin consists of aromatic rings with OH-groups

⇒ Lignin belongs to the group of phenols

⇒ Lignin is build up by cross-linked macromolecules and therefore a complex heteropolymer

⇒ Lignin is present in any type of plant

Spruce lignin



Functions

⇒ It acts as a skeleton in all parts of a plant and is responsible for *mechanical support*, *water transport* and *defence* in vascular plants

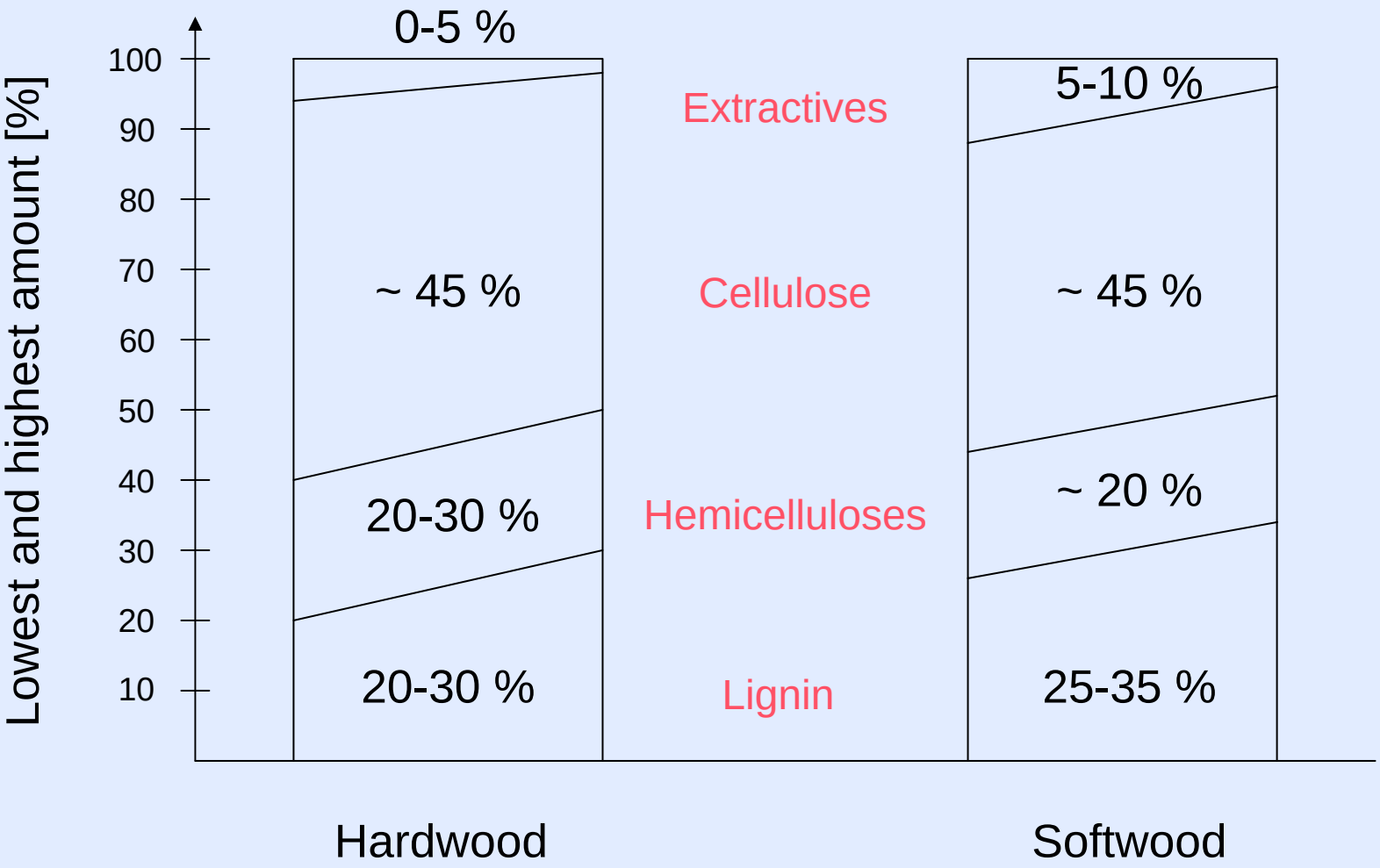
⇒ The insolubility and complexity of the lignin polymers offer plants a resistance against degradation of most microorganisms

Lignification

⇒ The process of lignification was a necessary precondition for the evolution of “land plants” from “water plants”

⇒ Lignification is mainly important in stem wood but also in branches, leaves and roots especially of woody plants

Chemical composition of trees



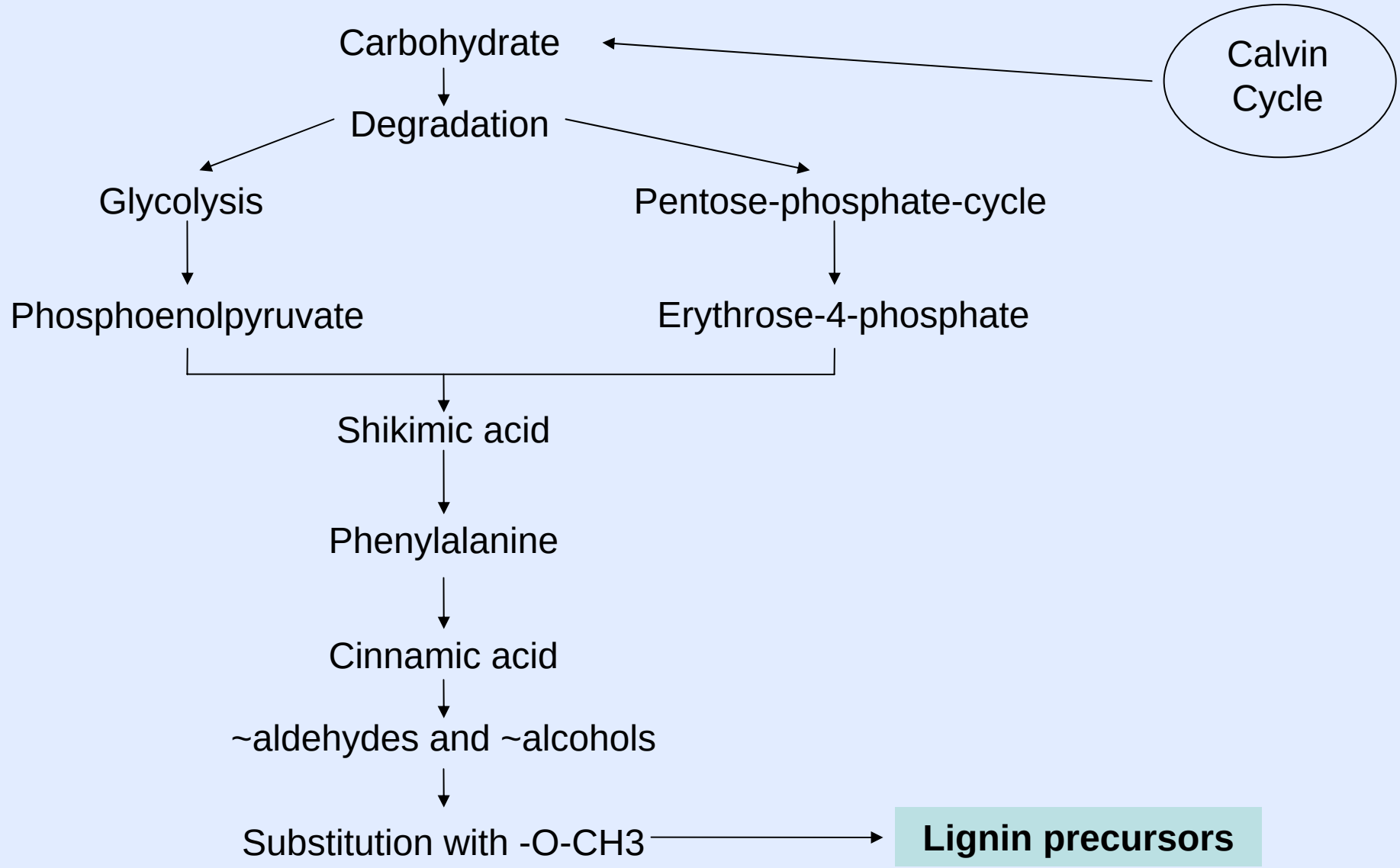
Composition of beech wood (*fagus sylvatica*)

⇒ Cellulose	42 %	
⇒ Lignin	28 %	
⇒ Mannan	18 % (pentosane)	} Hemicelluloses
⇒ Xylane	11 % (hexosane)	} Hemicelluloses
⇒ Others	1 %	

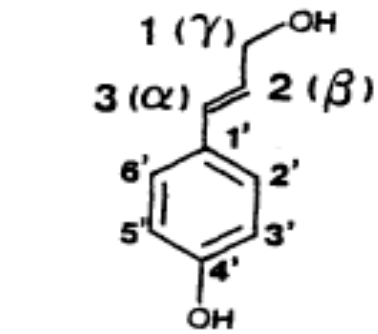
Parameters that influence the lignin amount

- ⇒ Type of tree
  - ⇒ Softwood - Hardwood
- ⇒ Age of the tree
  - ⇒ The older the tree the higher is the lignin amount
- ⇒ Part of the tree
  - ⇒ Lignin amount differs between stem, branches and leaves
- ⇒ Anatomic structure of wood
  - ⇒ “Regular” or “Irregular”
- ⇒ Climatic growing conditions
  - ⇒ Soil, humidity, rain, sunshine

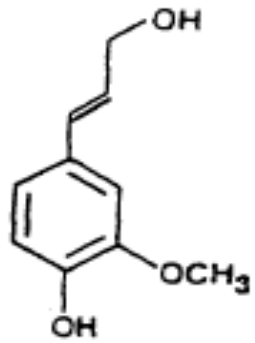
Lignin accumulation in plants



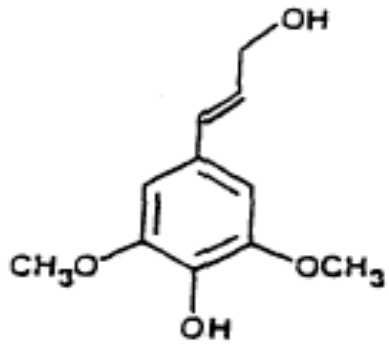
Lignin precursors



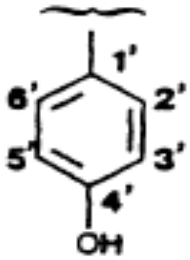
p-coumaryl



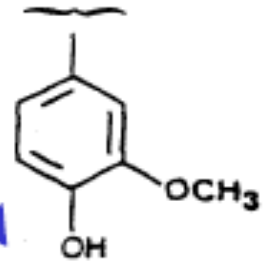
coniferyl



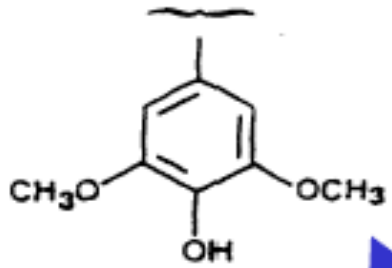
sinapyl



p-hydroxyphenyl (H)



guaiacyl (G)



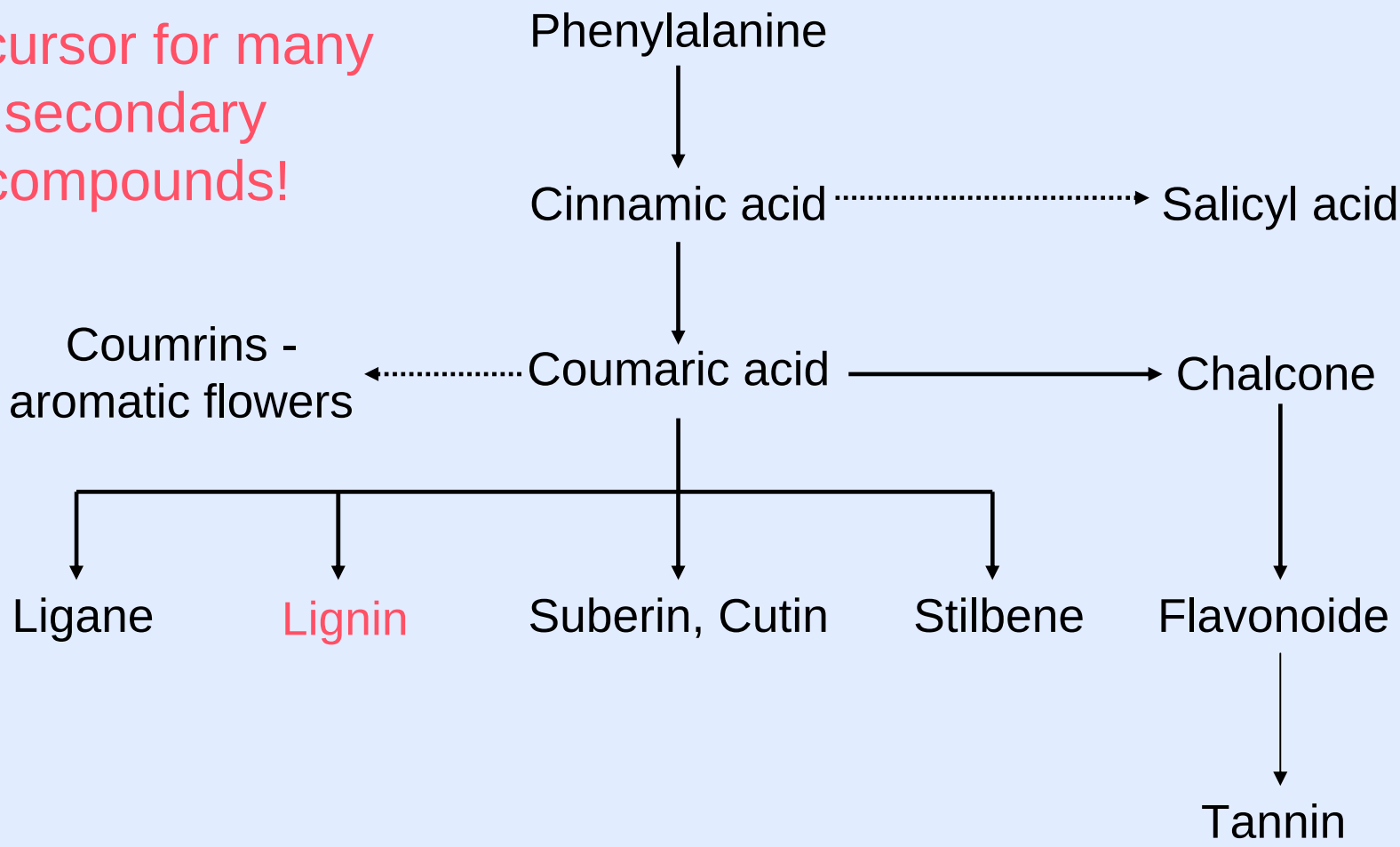
syringyl (S)

Coniferlignin

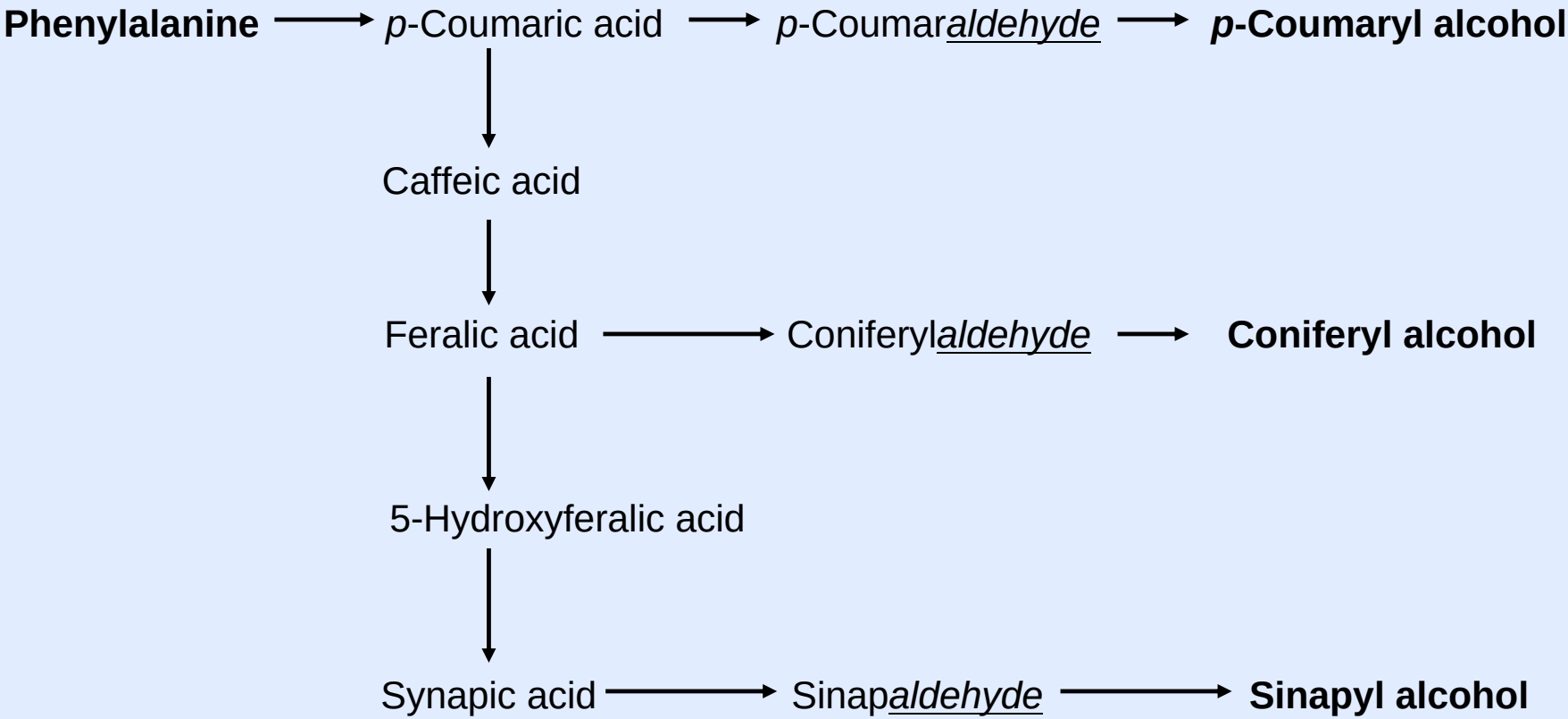
Angiospermlignin

Phenylalanine

Phenylalanine is the central precursor for many secondary compounds!



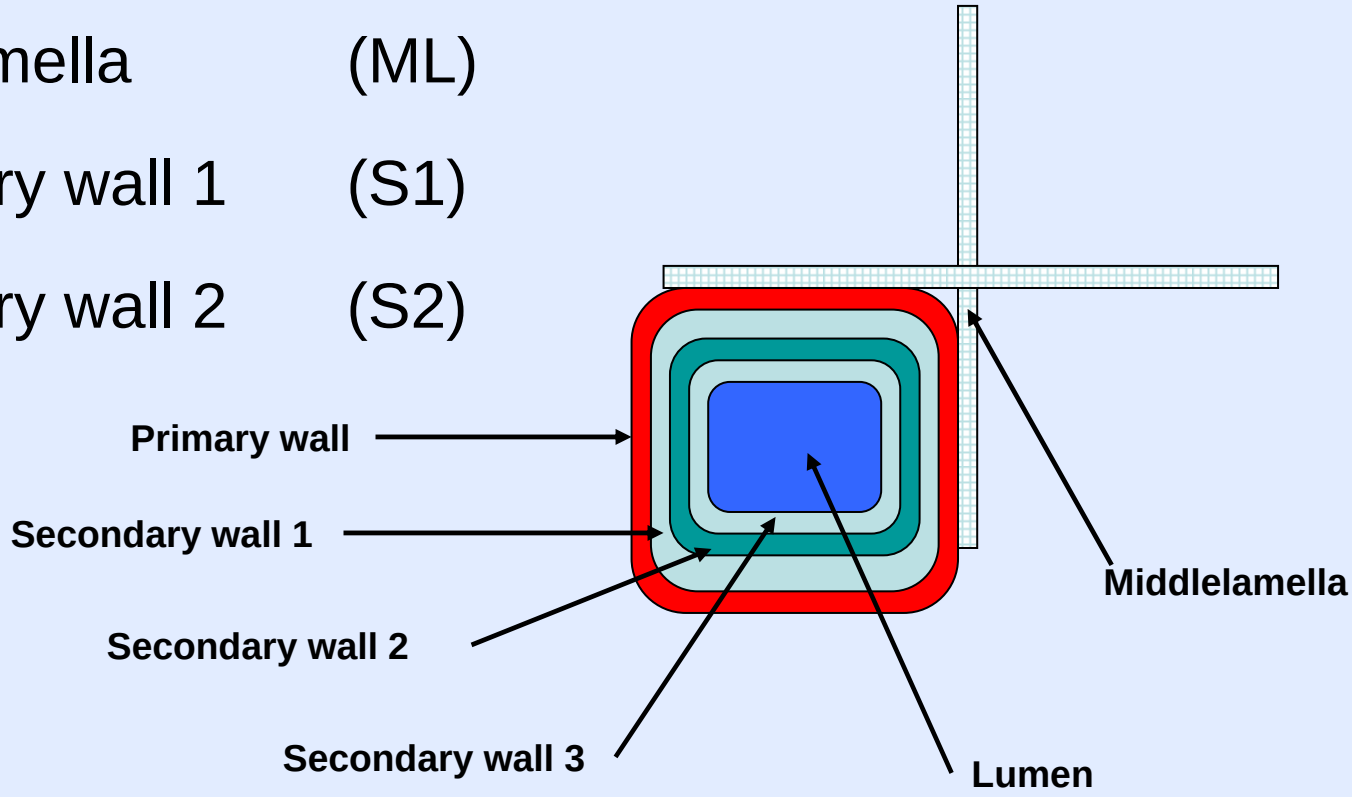
Phenylalanine - precursors - pathways



Location of lignin in plants

Lignin occurs mainly in

- ⇒ Middlelamella (ML)
- ⇒ Secondary wall 1 (S1)
- ⇒ Secondary wall 2 (S2)



Methods to determine lignin

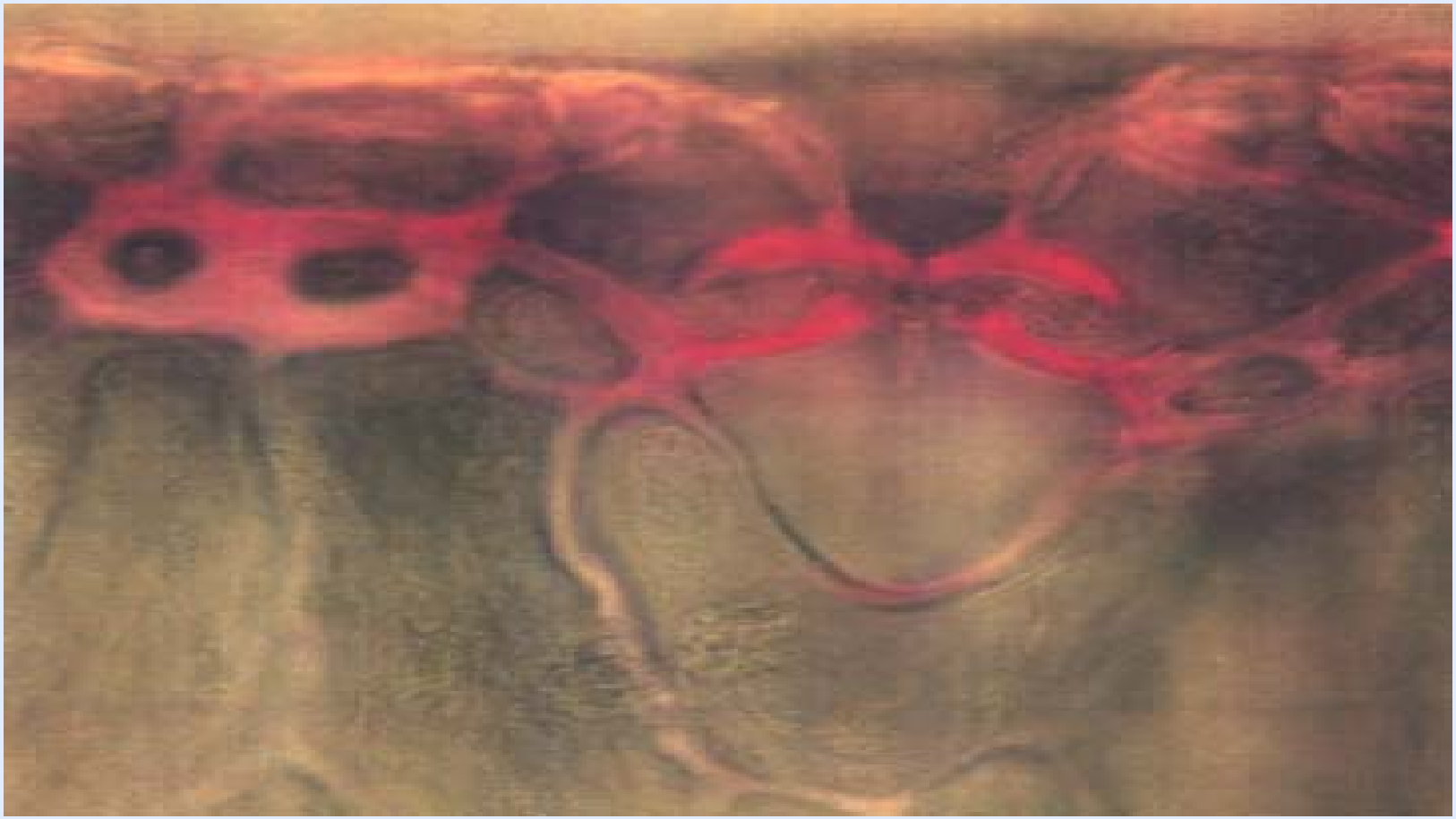
Non-destructive methods

- Staining
  - Wiesner method
  - Mäule method

Destructive methods

- Chemical disintegration
  - Acetylbromide method
  - Halse method

Lignin in young spruce needles



Phloroglucinol staining

Lignin in industrial applications

⇒ Lignin amount influences the use of wood in different industrial applications

⇒ Lignin affects mainly negative properties in industrial products

⇒ Different methods are required to use wood as raw material for industrial applications

Paper industry

- ⇒ Mainly softwood is used for pulp/paper production
  - ⇒ Pine, spruce
- ⇒ Lignin influences the later properties of paper
  - ⇒ Colour, strength, etc.
- ⇒ Different methods are required for pulp production
  - ⇒ Sulphite method, sulphate method
- ⇒ During pulp production a high amount of chemicals and lignin occur as waste-products
  - ⇒ Waste-products are used for energetic applications

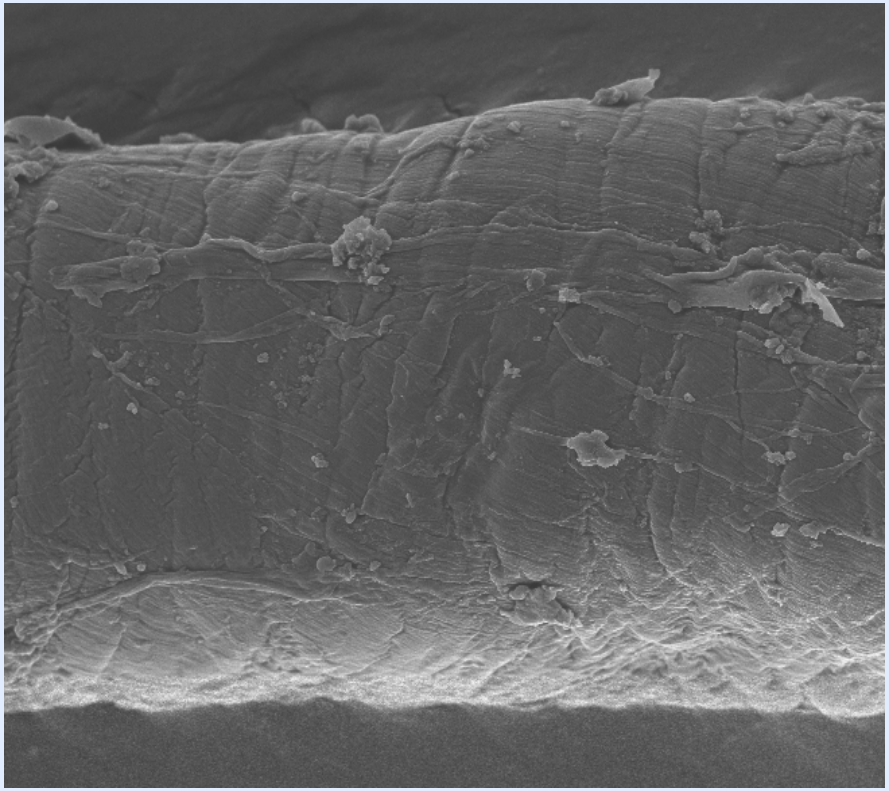
Charcoal production

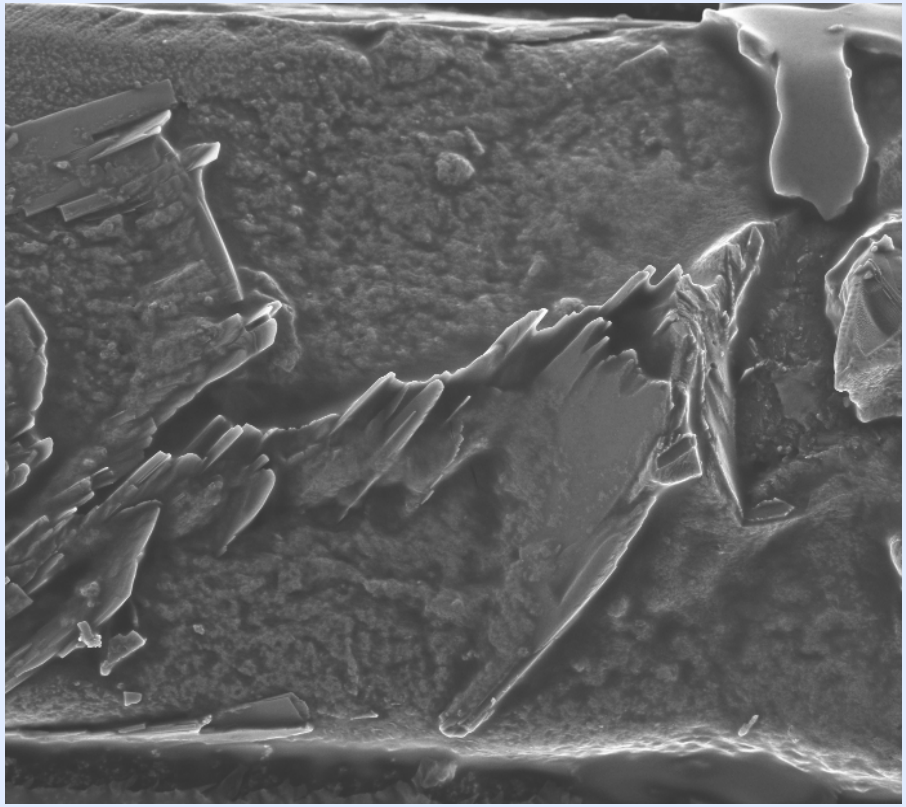
- ⇒ Only beech wood is used for charcoal production
- ⇒ The outcome of 1 ton beech wood is 333 - 350 kg charcoal
- ⇒ Different methods are used for charcoal production
  - ⇒ Degussa method, SIFIC method
- ⇒ The outcome is equal to the lignin content and some remaining celluloses and hemicelluloses
- ⇒ Lignin consists mainly of carbon - carbon is responsible for later generated heat

Wood based panel industry

- ⇒ Lignin can react with materials that are used for the production of wood based panels
  - ⇒ Binder systems (urea-formaldehyde-, phenol-formaldehyde-, melamine-urea-formaldehyde resins), hardeners, fungicides, etc.
- ⇒ Lignin amount depends on the type of material (fibres, particles) that is used
  - ⇒ Particle production is a mechanical process - no loss of lignin
  - ⇒ Fibre production is thermo-mechanical process (plastification) - loss of lignin
- ⇒ Lignin can be used as binder system
  - ⇒ Enzymatic treatment with laccase

Lignin on fibre material





Lignin as binder system

- ⇒ Lignin can be treated with enzymes such as laccase to abrade the surface
- ⇒ Laccase is an enzyme that is used for wood degradation in nature by white-rot-fungi
- ⇒ Polymerization and depolymerization processes
- ⇒ The abraded surfaces allows a wood-to-wood bonding effect without the use of other conventional resins

Literature

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