

Preface

With today's ever growing economic and environmental problems, wood as a raw material takes on increasing significance as the most important renewable source of energy and as industrial feedstock of numerous products. Its chemical and anatomical structure and the resultant excellent properties allow wood to be processed into the most widely differing products: from logs to furniture and veneers and from wood chippings to pulp and paper. The aim of this book is to review research progress on the cellular aspects of cambial growth and wood formation in trees over the last decades. The book is divided into two major parts. The first part covers basic processes of wood biosynthesis, focusing mainly on five major steps that are involved in this process:

1. Cell division: The cambium is a secondary meristem responsible for wood increment. It is required for the regular renewing of xylem and phloem in trees and consists of dividing meristematic cells and their phloem and xylem derivatives. The latter give rise to various wood cells such as tracheids, vessels, fibres and parenchyma cells.
2. Cell expansion: During the formation of the primary wall, derivative cells expand in longitudinal, radial and tangential directions. This process is determined by various enzymes such as expansins, xyloglucan endotransglycosylases and pectinases as well as the availability of osmotically active ions (e.g. K^+). Hence, mineral nutrients play decisive physiological roles in xylogenesis. For example, during potassium starvation, cambial activity and wood increment and vessel size are significantly reduced. Molecular and electrophysiological studies indicate a strong involvement of specific K^+ channels in the regulation of wood formation.
3. Secondary cell wall formation: Formation of the secondary cell wall starts already before completion of cell expansion. In a coordinated manner cellulose, hemicellulose and lignin are synthesized by various enzymes to generate the different layers (S1, S2, S3) of the secondary wall which is mainly responsible for the outstanding mechanical properties of wood.

4. Programmed cell death: Water-conducting cells such as vessels and tracheids as well as most of the stabilizing cells like fibres die in a regulated manner before they take over their functions. After the collapse of the vacuole, specific enzymes that degrade the cytoplasm but not the cell wall are released.
5. Heartwood formation: Older annual rings no longer transport water or store nutrients but instead often store phenolic compounds as well as resins which provide long-term resistance to pathogens and thus increase natural durability.

The second part of the book deals with the regulation of wood formation by endogenous and exogenous factors. On the endogenous level, the emphasis is placed on two aspects:

- Control of wood formation by phytohormones: Auxins, gibberellins, cytokinins and ethylene have been shown to be involved in wood formation in a synergetic manner.
- Control of wood formation by molecular mechanisms: Wood formation is driven by the concerted expression of numerous genes. The use of molecular techniques in wood biology has enabled the identification of various transcription factors that are part of a network regulating secondary cell wall deposition.

Apart from endogenous factors, various exogenous effects are involved in wood formation:

- Climate factors: Environmental conditions such as temperature, precipitation, light intensity and duration have important effects on wood formation. While rising temperature is of significance for cambial reactivation in spring, a reduction in day length plays a major role in the early- to latewood transition as well as in cambial deactivation in trees growing in temperate zones. It is expected that with ongoing global warming, present-day tree species will not be optimally adapted hydraulically and mechanically to rising CO₂ levels and temperature. Apart from a shift of latitudinal and altitudinal ranges, these changing conditions also affect the structure of wood cells.
- Abiotic stress factors such as drought stress and salinity are becoming increasingly important and cause changes in wood structure and increment.
- Mechanical stress: Reaction wood is a mechanism by which trees respond to stem displacement. It is formed in response to prevailing winds, snow or slope and has the function to reorient a leaning stem or branch. Characteristic chemical and ultrastructural changes occur in tension wood of hardwood species as well as in compression wood of softwood species.

Due to modern microscopic as well as molecular techniques, the understanding of wood formation has progressed significantly in the last decade. By emphasizing the cellular aspects, this book gives first an overview of the basic processes of wood formation, before it focuses on factors involved in the regulation of this process.



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