Lignin biosynthesis: Old roads revisited and new roads explored

Background

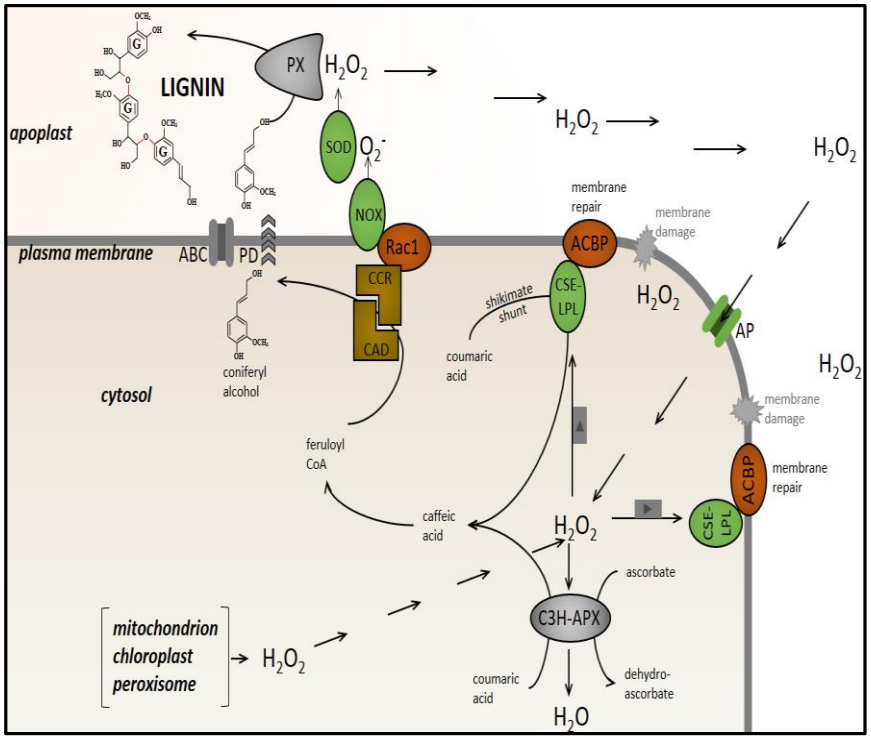
- Modifying the amount or composition of lignin in plant cell walls can improve forage digestibility, facilitate bioprocessing of lignocellulose to liquid biofuels, or tailor the polymer itself for conversion to materials and/or bioproducts.

Conclusions

- The operation of parallel pathways to caffeic acid occurring at the level of shikimate esters or free acids may help provide robustness to the lignin biosynthesis pathway under different physiological conditions.
- Several features of the pathway appear to link monolignol biosynthesis to both generation and detoxification of hydrogen peroxide.
- Monolignol transport to the apoplast may involve passive diffusion, although this may be targeted to sites of lignin initiation/polymerization by ordered complexes of both biosynthetic enzymes on the cytosolic side of the plasma membrane and structural anchoring of proteins for monolignol oxidation and polymerization on the apoplastic side.

Significance

- Critical for such applications is a thorough understanding of how plants make this complex polymer. This review article summarizes recent findings that have overturned some of the conventional thinking on how plants assemble and polymerize lignin, and presents hypothetical models to suggest new research directions.



A model showing two parallel pathways to caffeic acid and linking monolignol biosynthesis to generation and detoxification of hydrogen peroxide. Abbreviations: NADPH oxidase (NOX), cinnamoyl CoA reductase (CCR), RAC1 membrane-associated GTPase, cinnamyl alcohol dehydrogenase (CAD), passive diffusion (PD), ABC, family of active transporters, superoxide dismutase (SOD), caffeoyl shikimate esterase/lysophospholipase 2 (CSE/LPL2), acyl CoA-binding protein (ACBP), aquaporins (AP), coumarate 3-hydroxylase/ascorbate peroxidase (C3H/APX), peroxidase (PX).

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†Invited perspective to mark the election of the author to the fellowship of the Royal Society in 2018

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