Mechanical stimuli and vascular tissue differentiation

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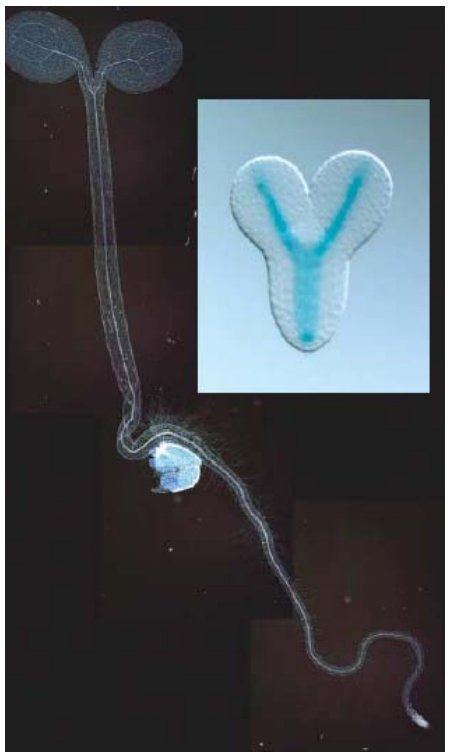
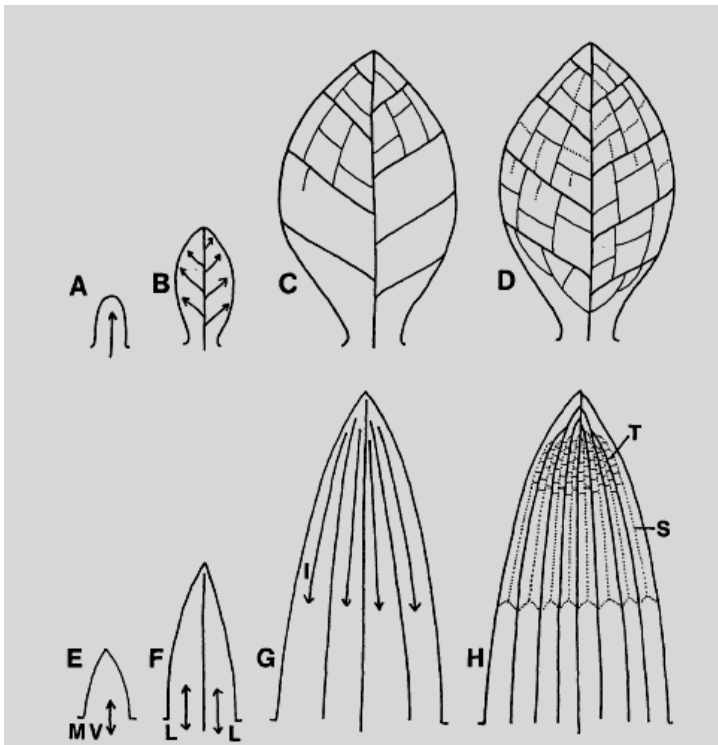
University of Neuchâtel
Switzerland

VASCULAR TISSUES
CONNECTORS OF PLANT ORGANS



Fukuda (2004) Mol. Cell. Biol. 5

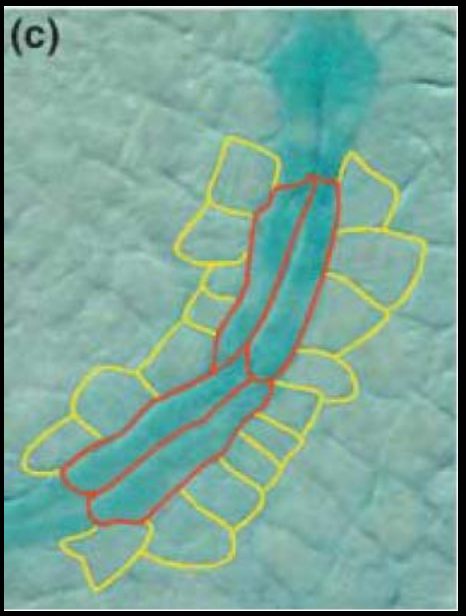


Nelson and Dengler (1997) Plant Cell 9

DEVELOPMENT

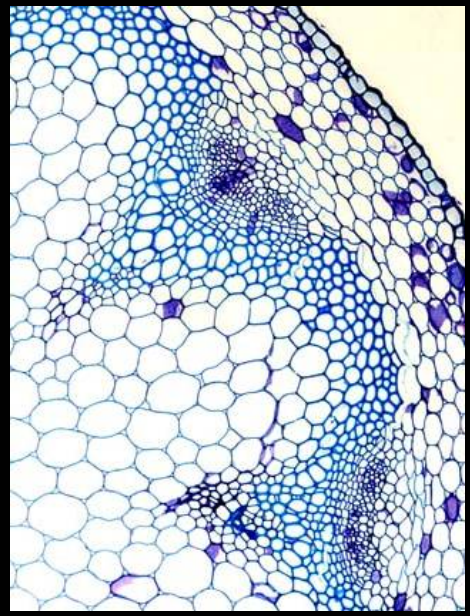
I. Patterning

Recruitment of cambium cells



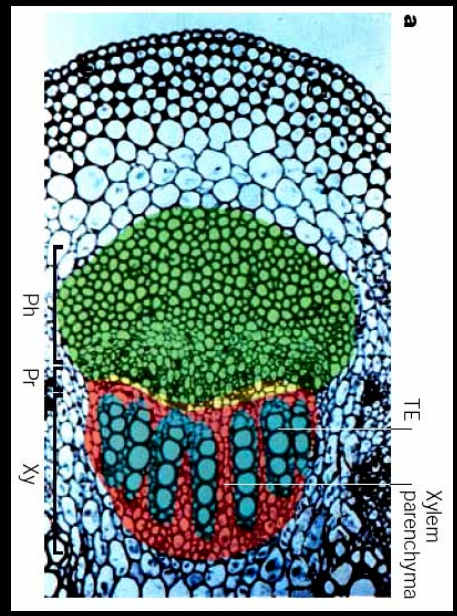
Scarpella and Meijer (2004) New Phytol

Arrangement of xylem and phloem



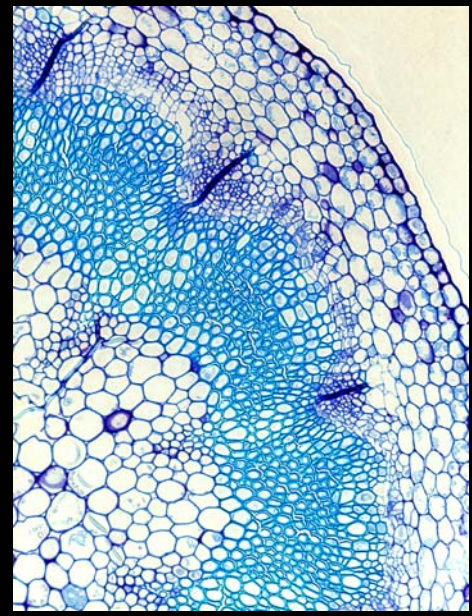
II. Differentiation

Formation of xylem and phloem

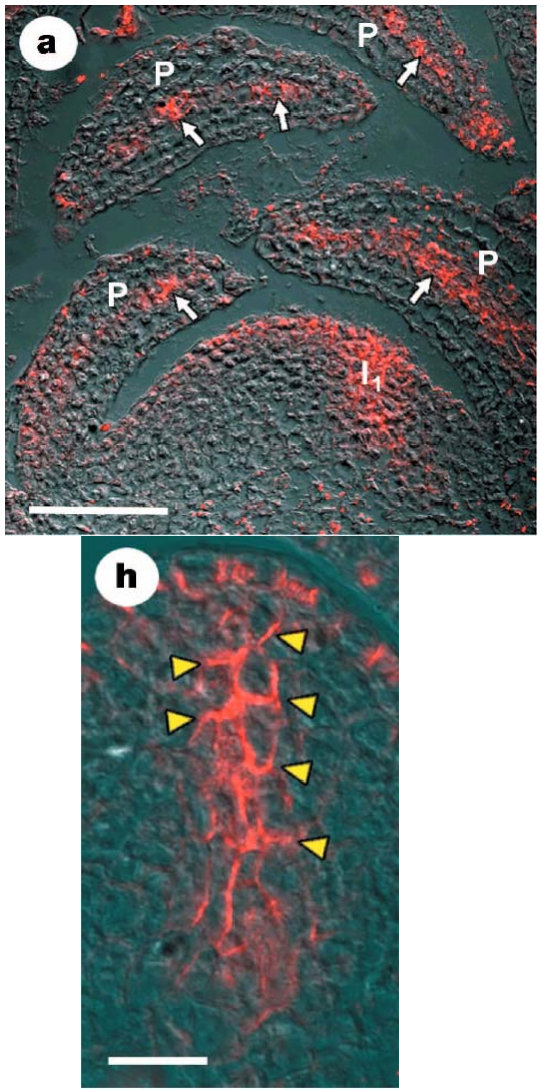


Fukuda (2004) Mol. Cell. Biol. 5

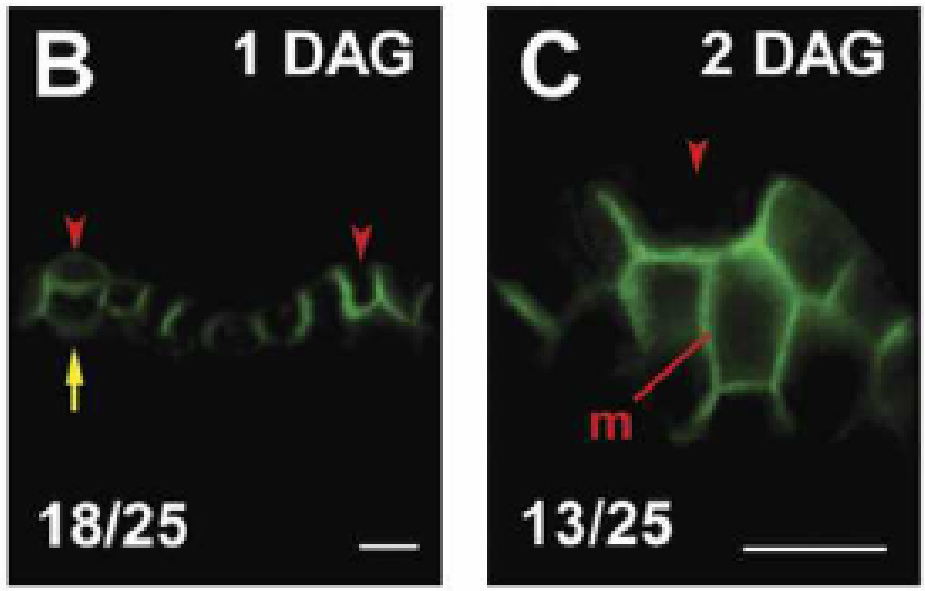
Secondary growth

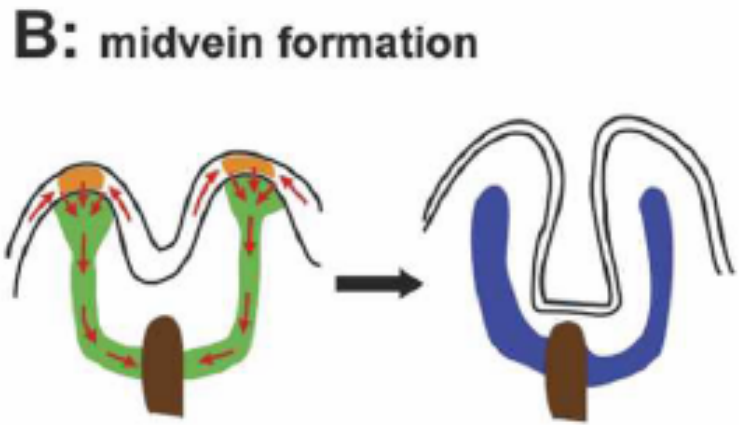


PATTERNING-AUXIN



Reinhardt et al. (2003) Nature

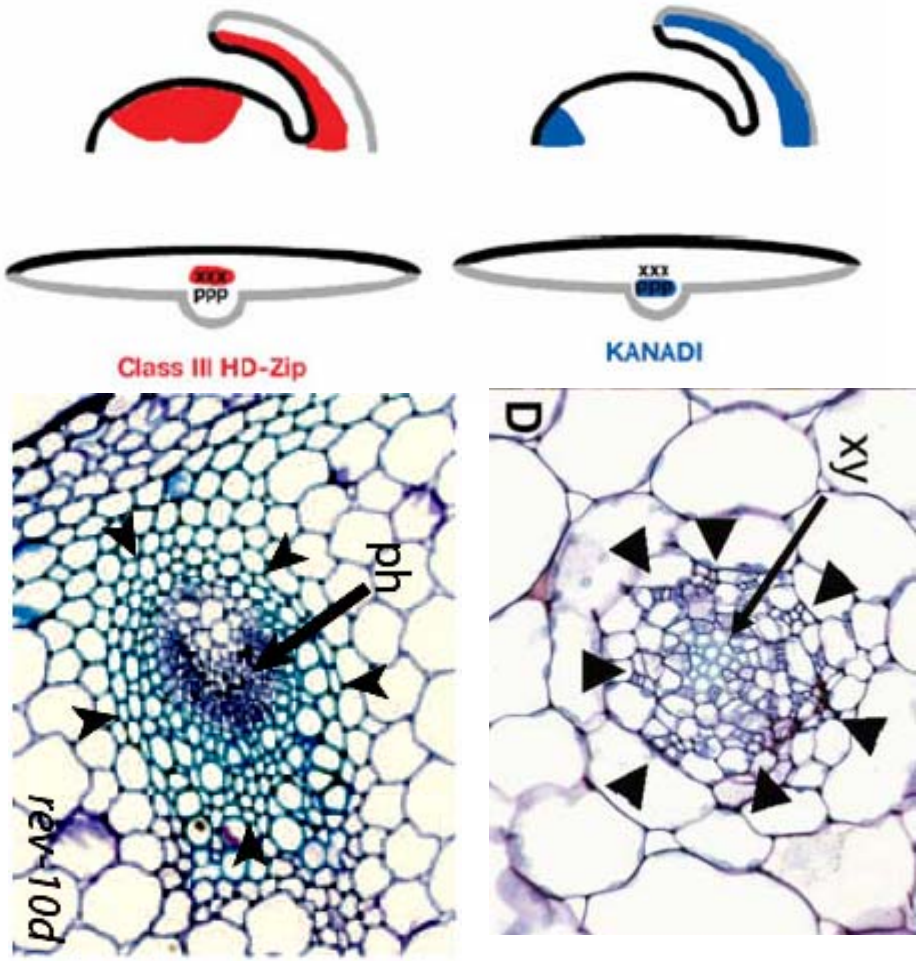




Scarpella et al. (2006) Genes&Development

PATTERNING

AD-& ABAXIAL TRANSCRIPTION FACTORS



Emery et al. (2003) Curr.Biol.

DIFFERENTIATION

Sieve elements,
companion cells, parenchyma

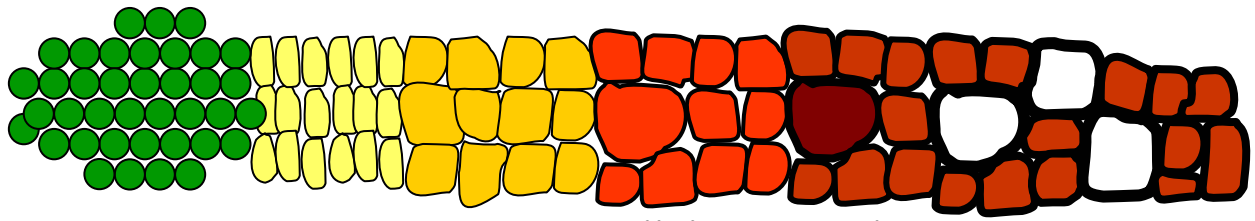
Tracheary elements, fibers, parenchyma

division

elongation

secondary cell wall formation

programmed cell death

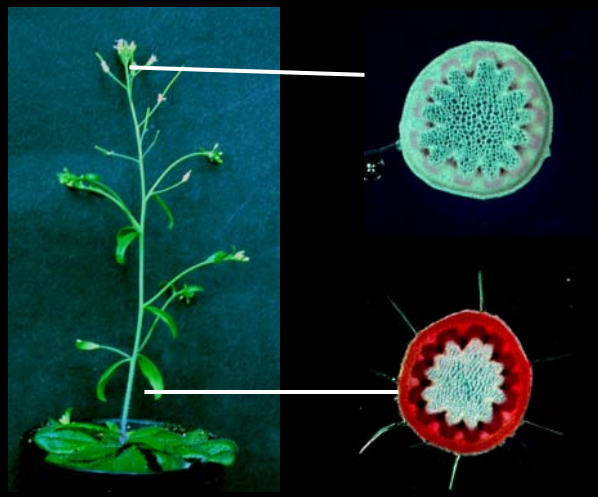


- transcription factors
- cell cycle control
- primary cell wall synth.

- cellulose synth.
- lignin synth.

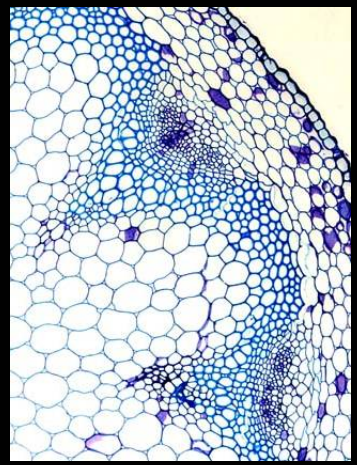
- wall degrading enzymes
- lignin synthesis
- PCD-genes

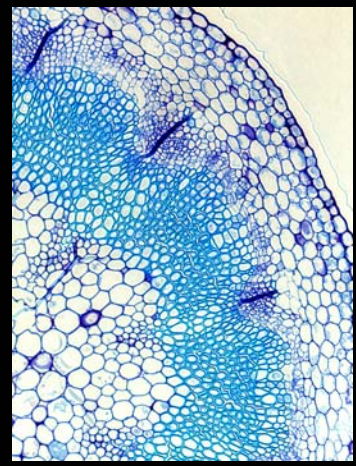
SECONDARY GROWTH & WOOD FORMATION

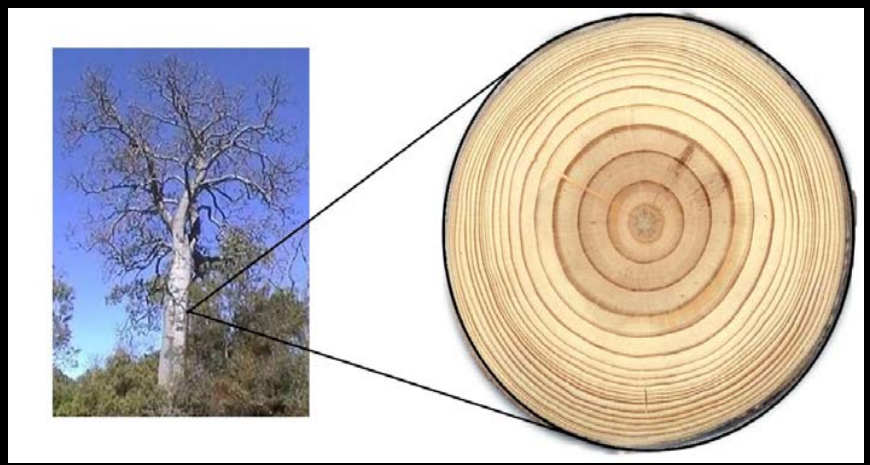


annuals

Arabidopsis

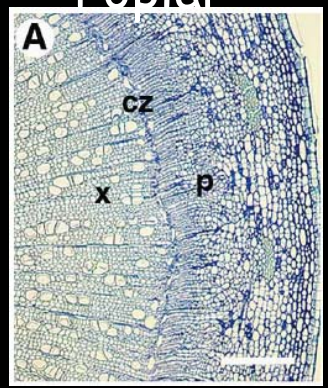






perennials

Poplar



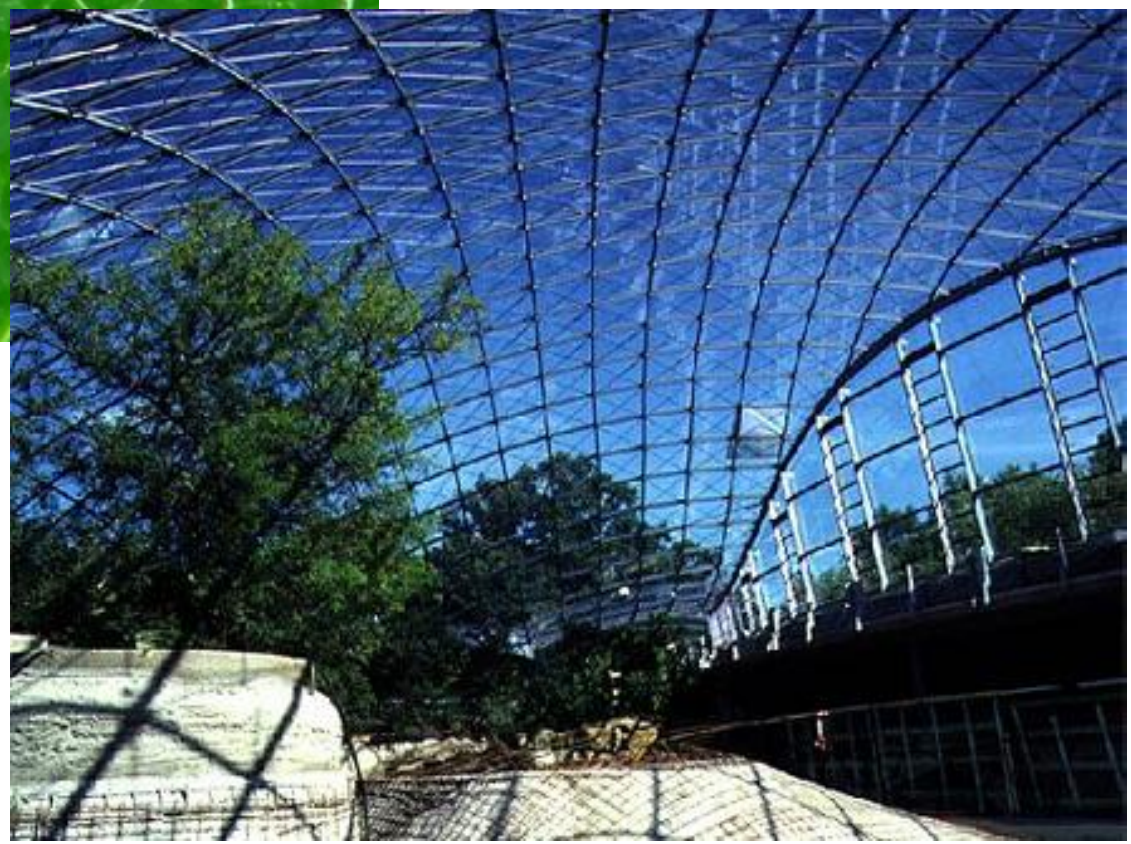
Chaffey et al. (2002)

RESEARCH FOCUS

INTERPLAY OF AUXIN, KANADI AND HD-ZIPIII IN VASCULAR DEVELOPMENT

MECHANICAL SIGNALS IN VASCULAR DEVELOPMENT

MECHANICAL SIGNALS



MECHANICAL CONTROL OF DIVISION PLANE

Compressive forces in a cell culture induce spatial ordering of division and cambium-like growth

Lintilhac et al. (1984) Nature

Cambium formation from callus in grafts depends on mechanical pressure

Barnett et al (2000) Cell and molecular biology of wood formation

Cell differentiation in Zinnia depends on cell culture density

McCann et al.(2001) Plant Physiol

PLANT GROWTH IN MICRO- AND HYPERGRAVITY

Microgravity:

Increase of
- hypocotyl growth
- cell wall extensibility
- xyloclucan degrading enzymes

Decrease of
Cell wall polysaccharides

Soga et al. (2002) Planta

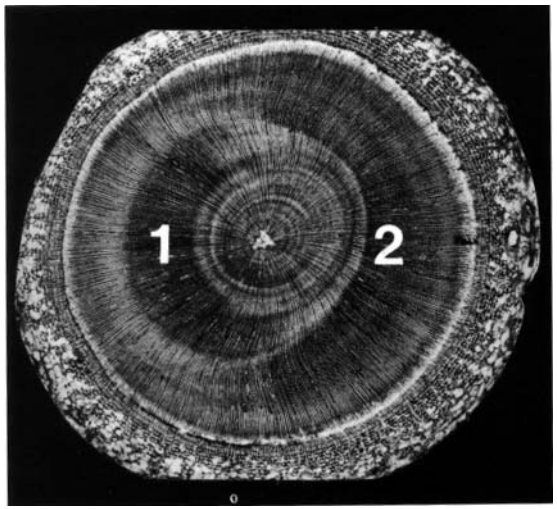
Hypergravity:

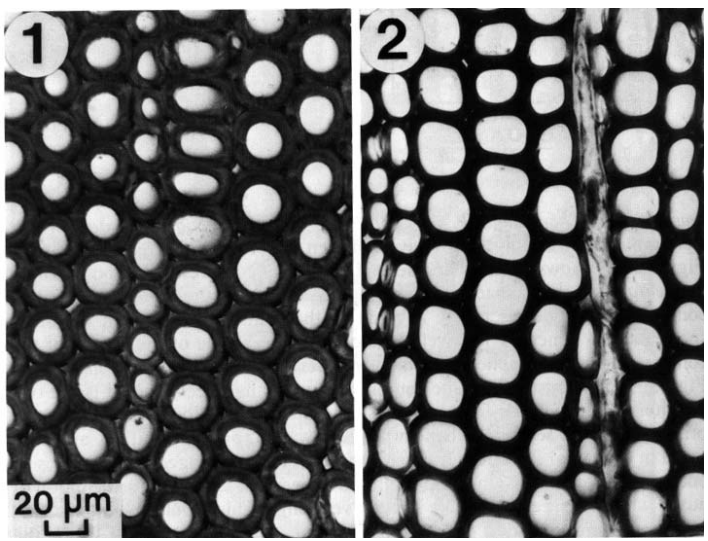
Increase of
- cell wall thickening
- lignins
- cell wall polysaccharides

Decrease of
- hypocotyl growth
- cell wall extensibility
- xyloclucan breakdown

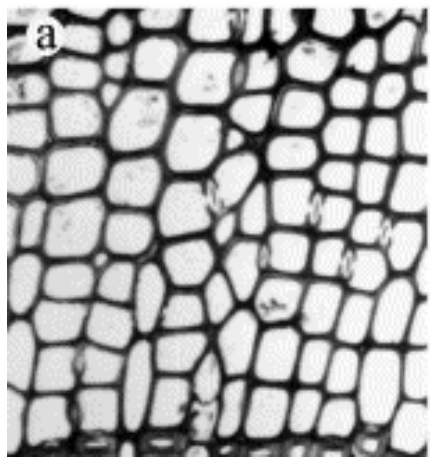
Soga et al. (2004) Planta
Hoson et al. (1996) J Exp. Bot

REACTION WOOD



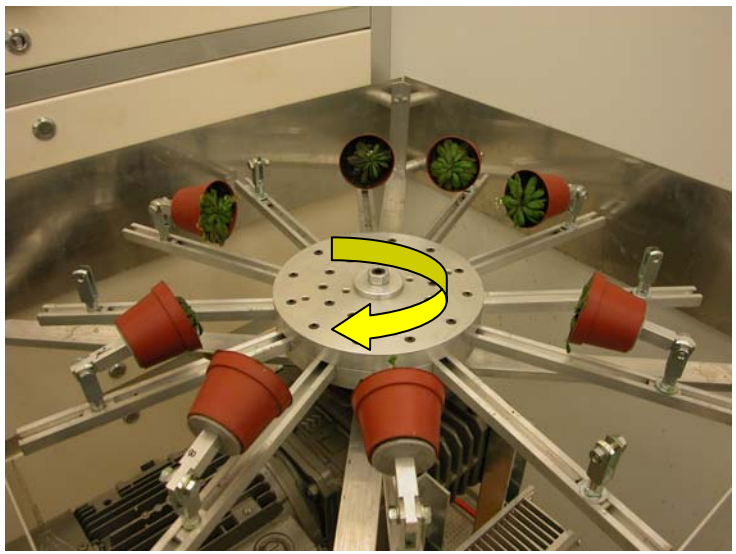


Timell (1984)



Kwon et al.(2001) Phytochemistry

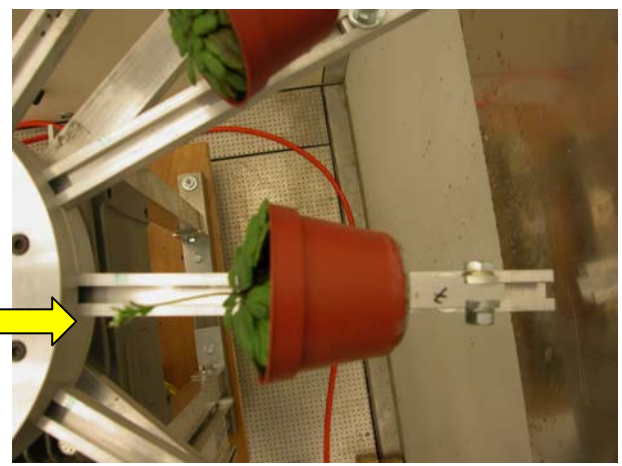
THE EXPERIMENTAL SYSTEM



$11\ ms^{-2} = 1.123g$

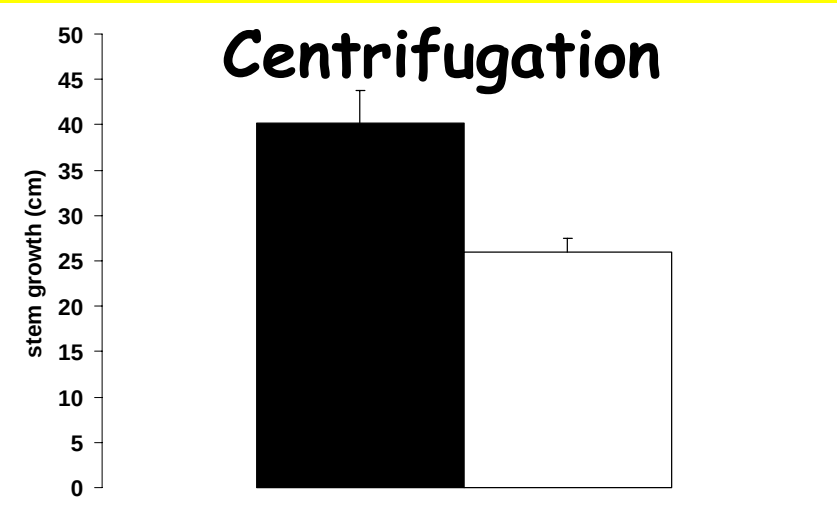
Centrifugal force

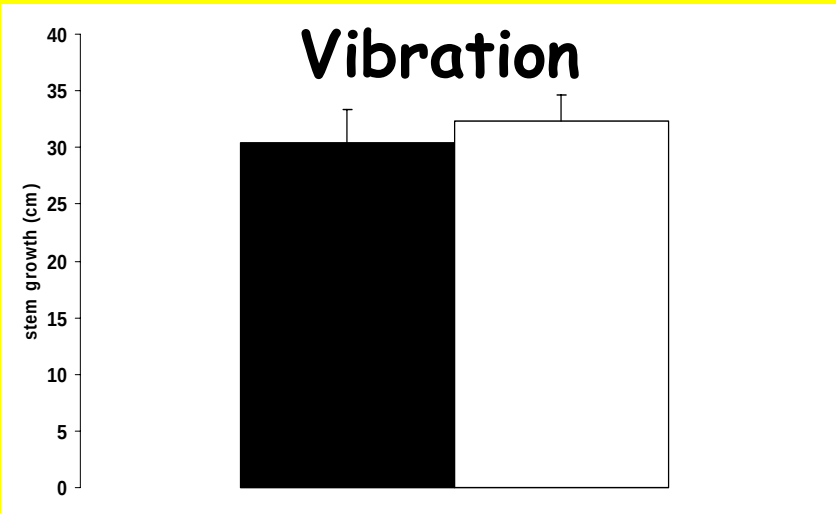
$az = r\ (\ 2\Pi\ f)^2$



Effects of mechanostimulation on stem growth

Stem growth 14d

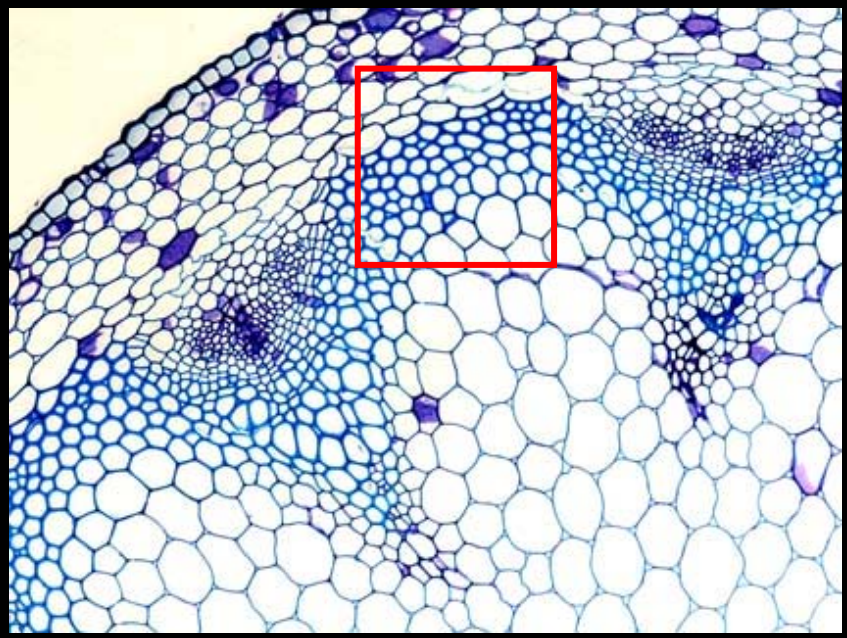


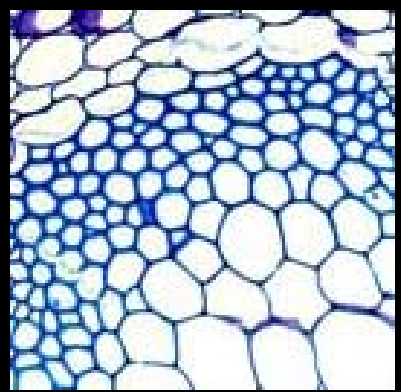


■ Control □ Centrifugation/vibration

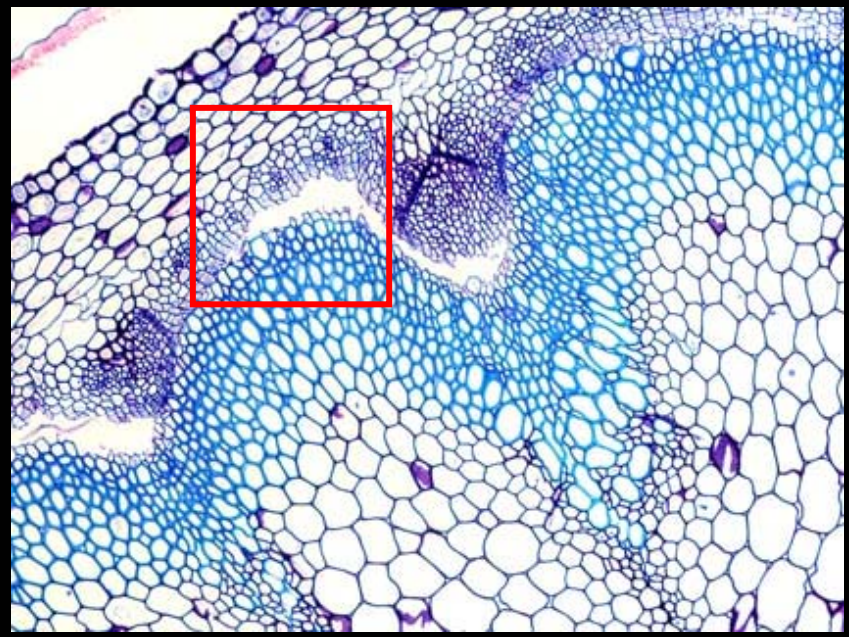
STEM DIFFERENTIATION

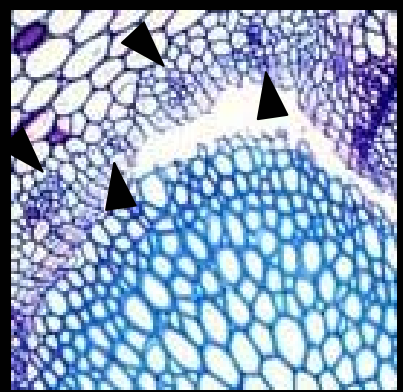
Control 14d



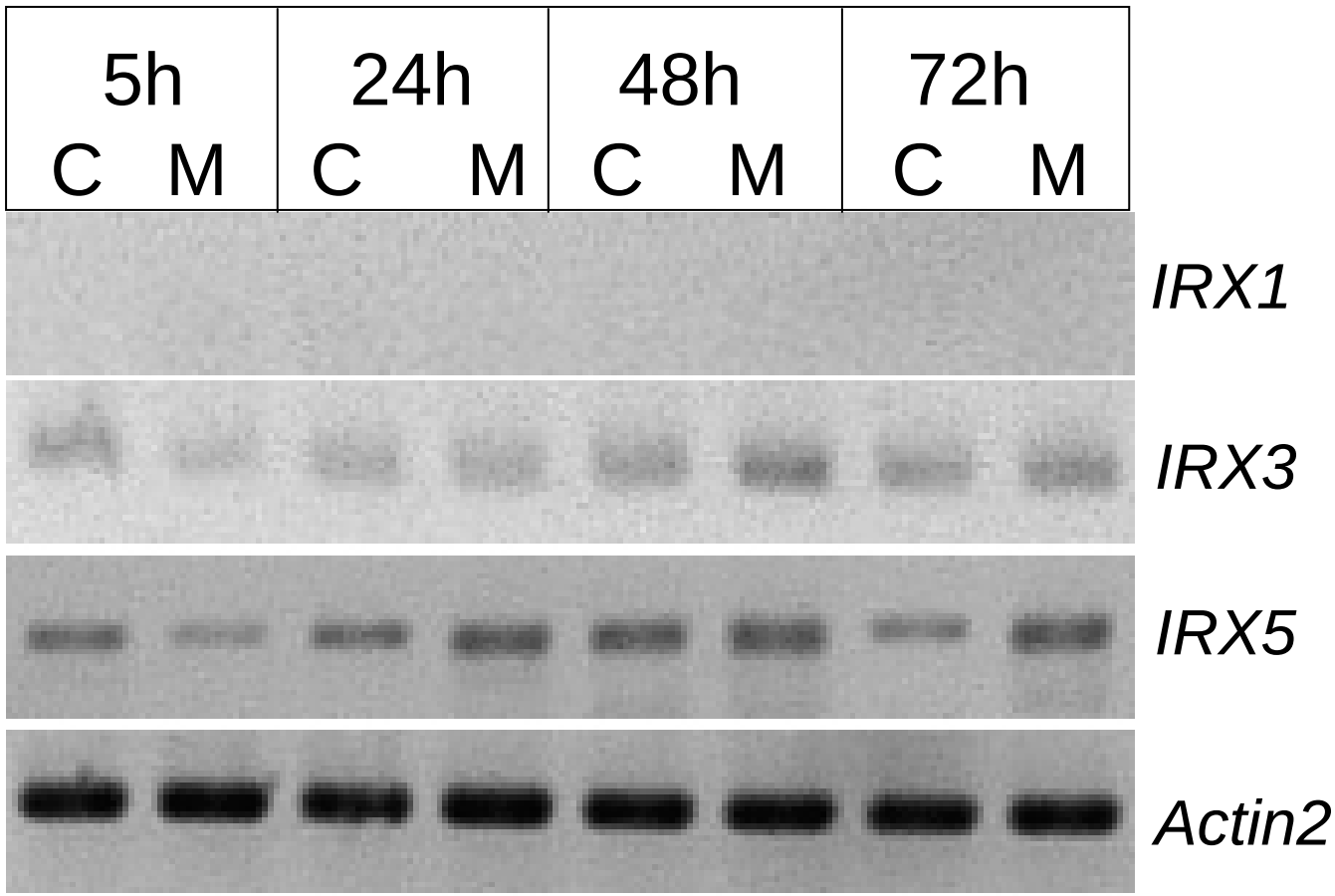


Centrifugation 14d

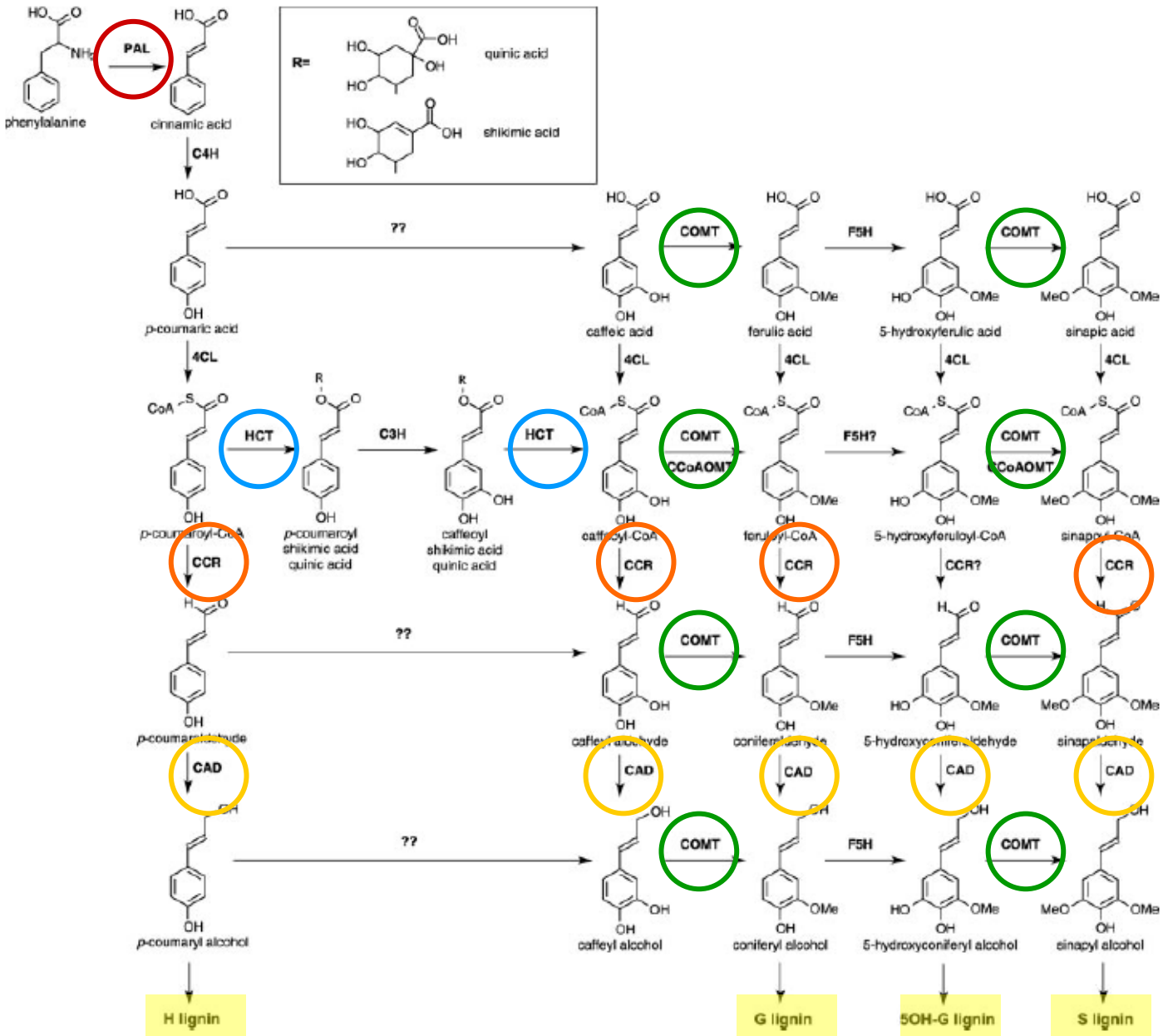




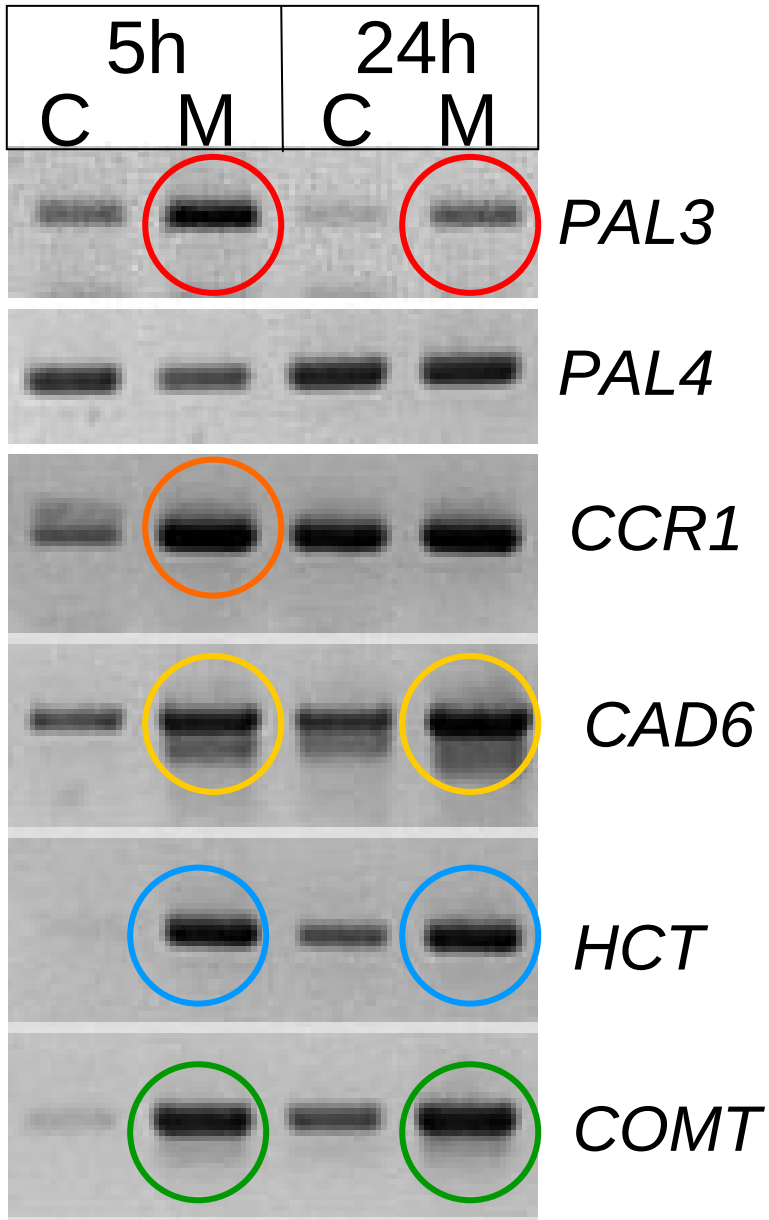
CELLULOSE SYNTHESIS GENES



LIGNIN BIOSYNTHESIS



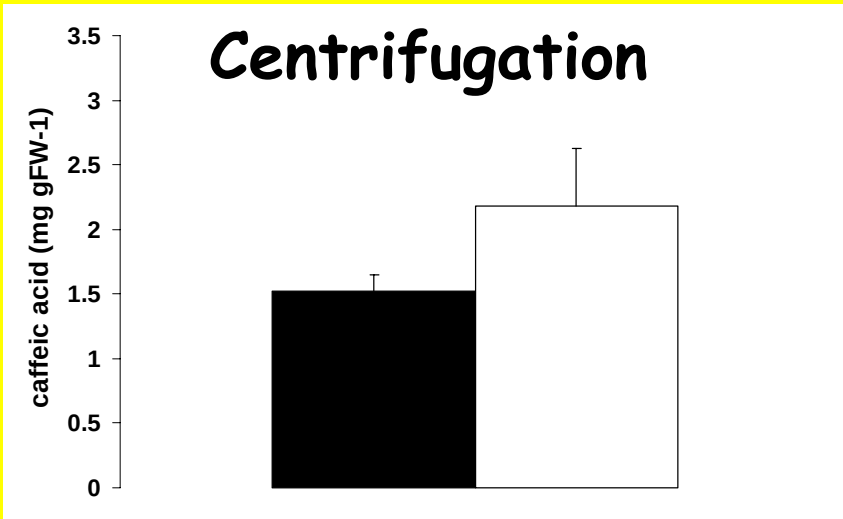
LIGNIN BIOSYNTHESIS GENES

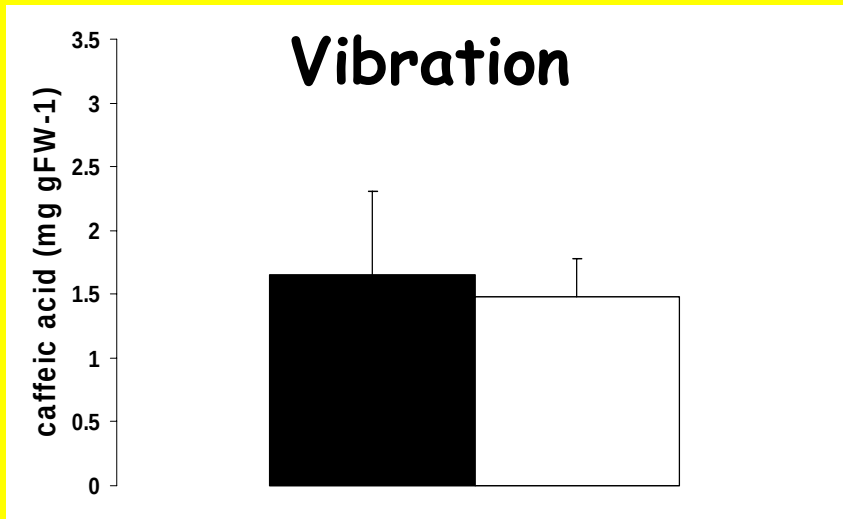


Effects of mechanostimulation on free phenols

Free phenol content after 10d

(methanol extraction, Ciocalteu reaction)



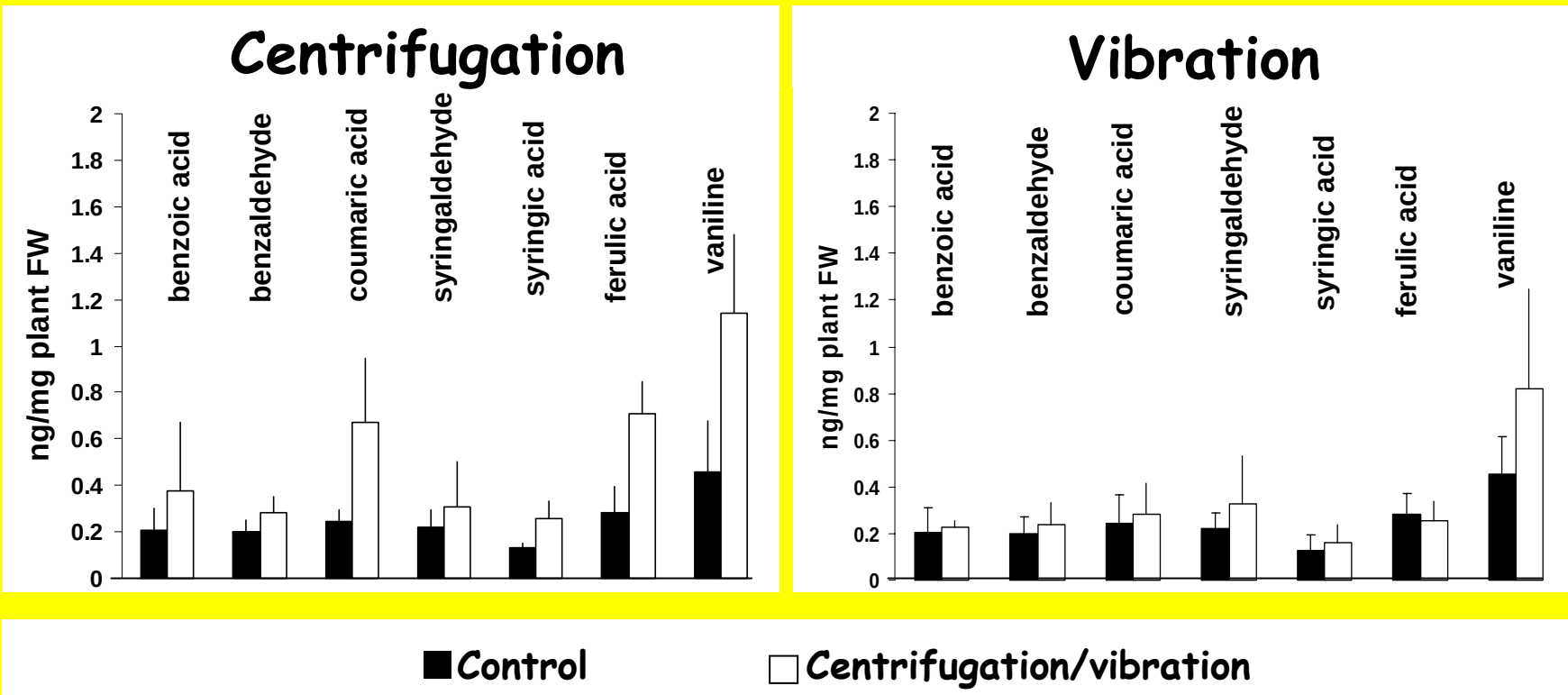


■ Control □ Centrifugation/vibration

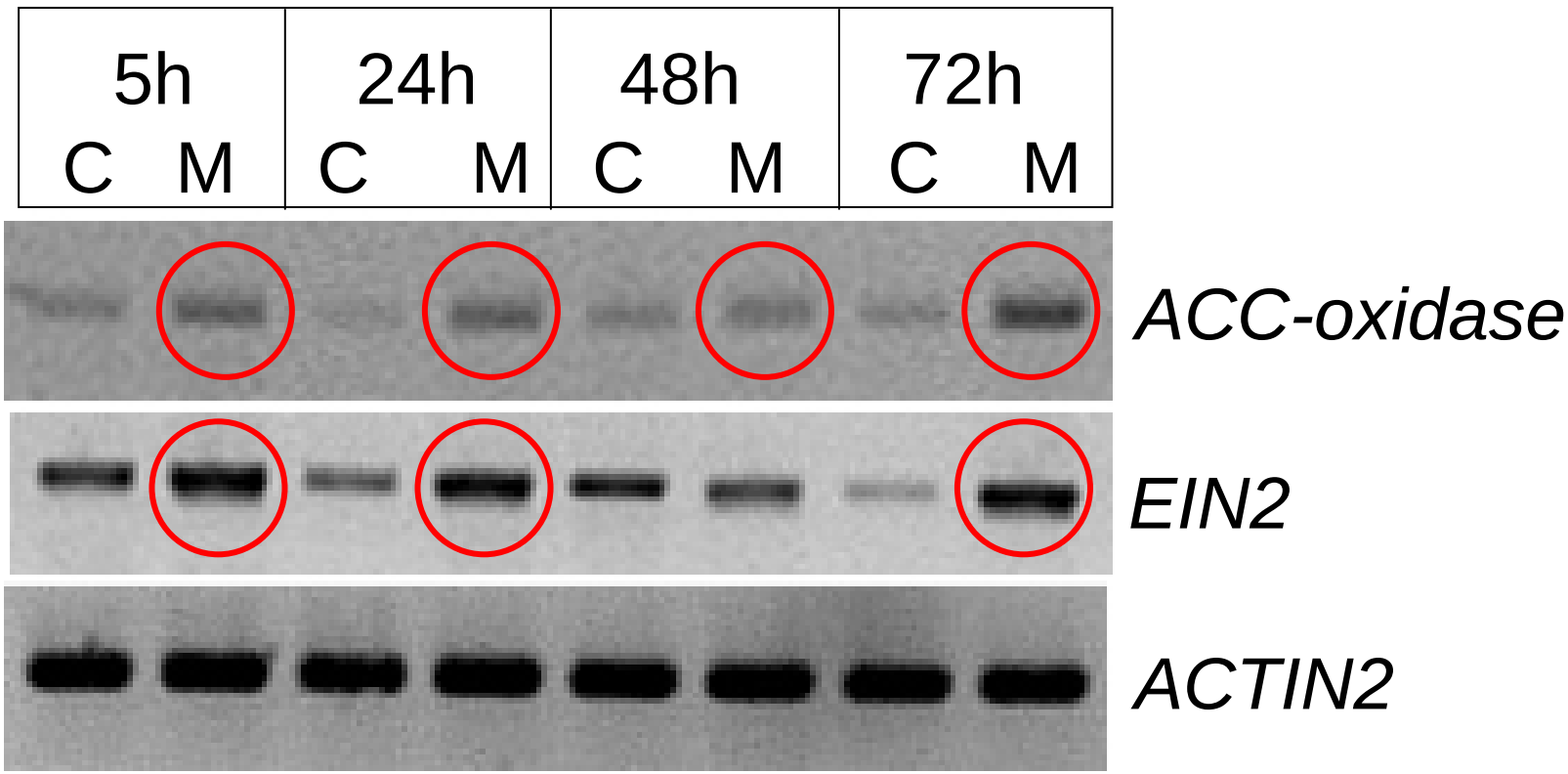
Effects of mechanostimulation on monolignols

Monolignol content after 10d

(saponification, HPLC)

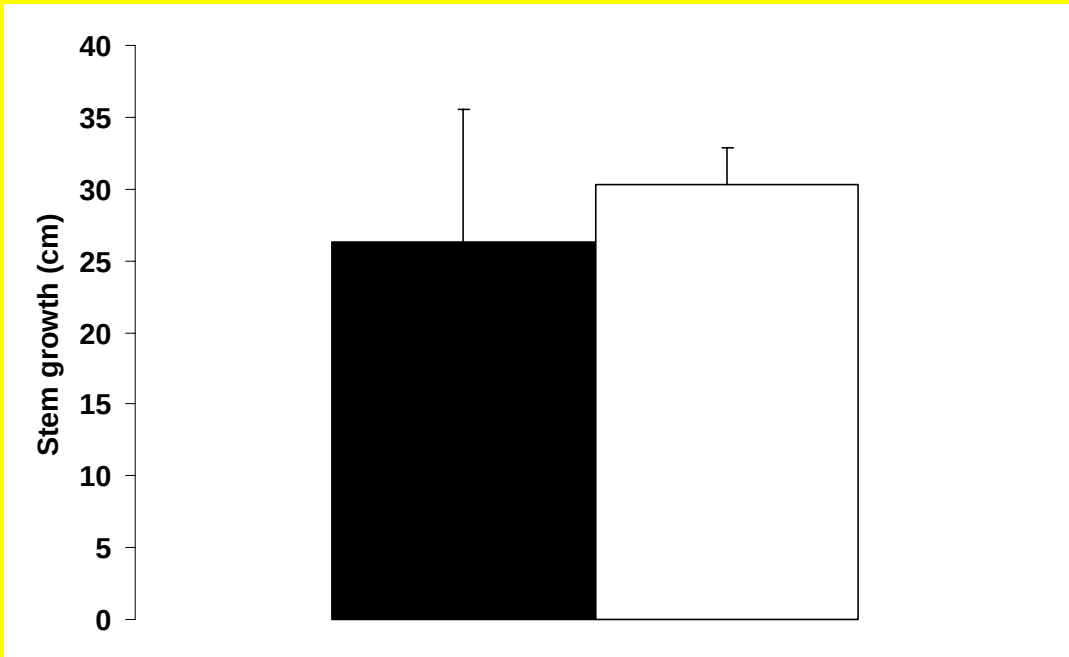


ETHYLENE-RELATED GENE EXPRESSION



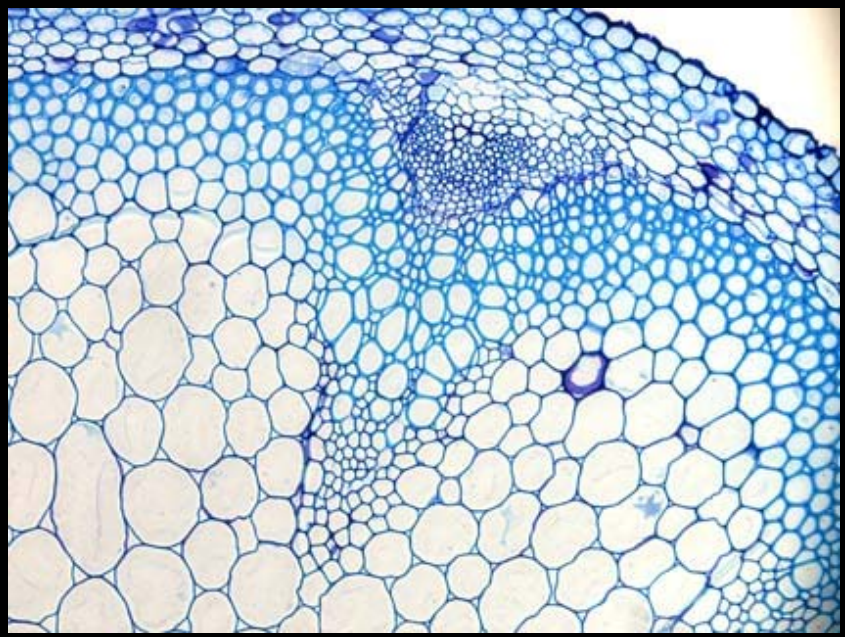
Effects of mechanostimulation on stem growth in ein2 mutants

Stem growth 14d

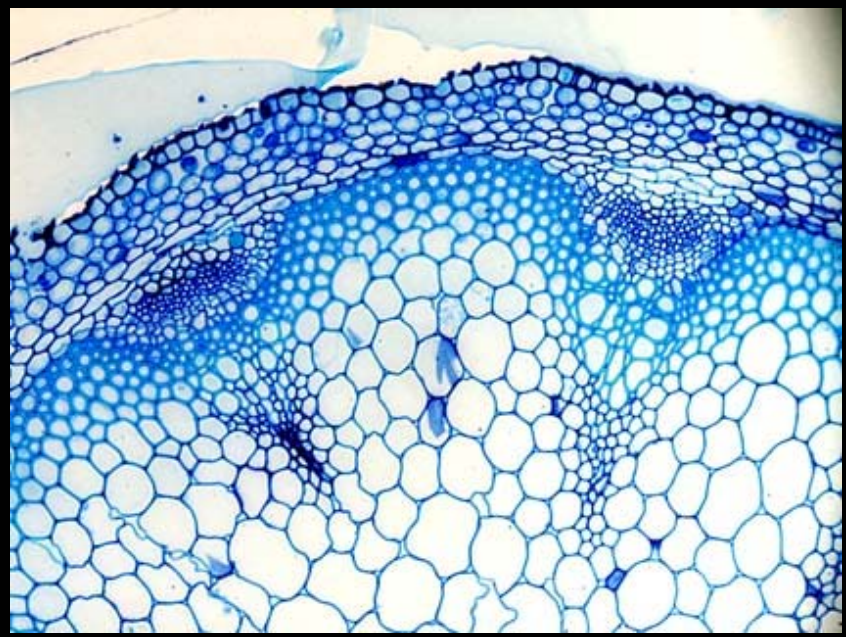


STEM DIFFERENTIATION IN ein2

Control 10d



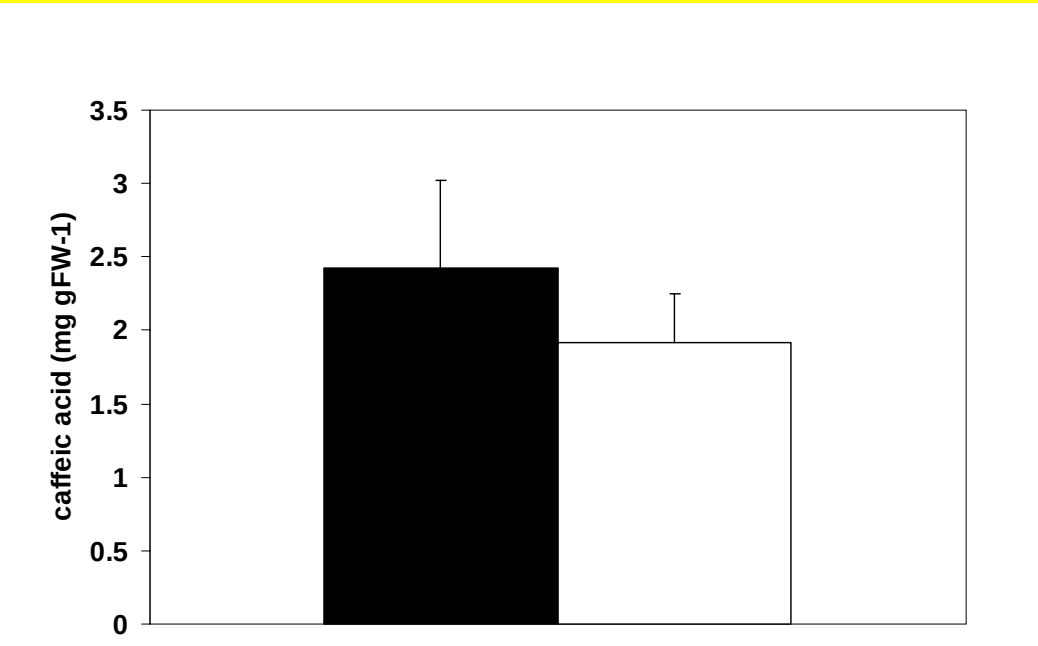
Centrifugation 10d



Effects of mechanostimulation on free phenols in ein2 mutants

Free phenol content after 10d of centrifugation

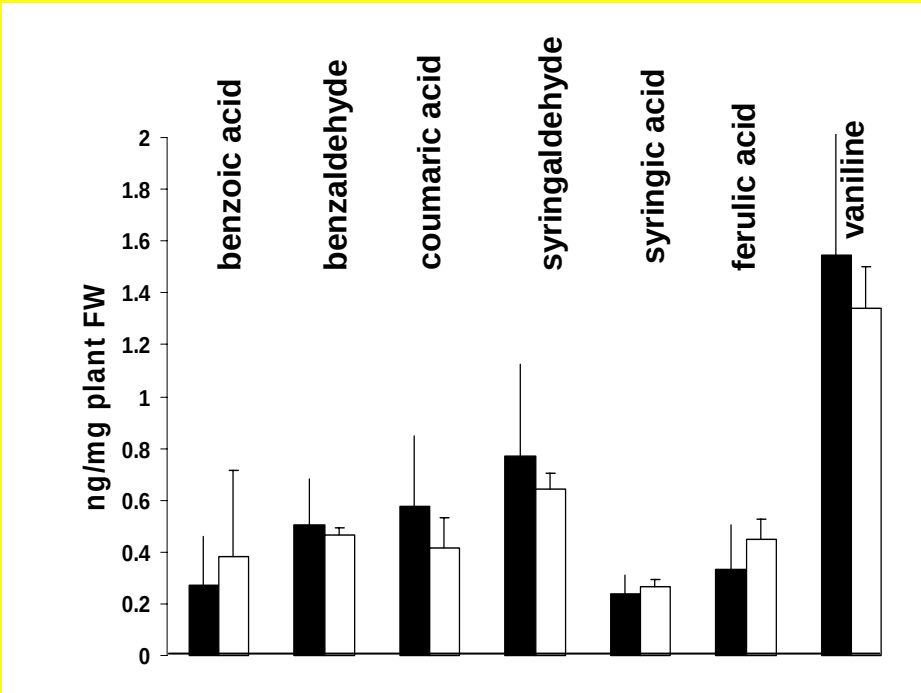
(methanol extraction, Ciocalteu reaction)



Effects of mechanostimulation on monolignols in ein2 mutants

Monolignol content after 10d of centrifugation

(saponification)



SUMMARY and CONCLUSIONS

- Mechanical stimulation decreased stem growth
- Secondary growth was induced, when plants were mechanically stimulated.
- Mechanical stimulation induced new phloem poles.
- Lignin biosynthesis genes were induced by mechanical stimulation, as well as contents of free phenols and monolignols
- Decreased stem growth, secondary growth and enhanced lignin production did not occur in the ethylene insensitive mutant ein2 after mechanical stimulation.

Ethylene involved in the signal transduction from mechanical stimulation to secondary growth?

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Institute of Chemistry
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COST E50 CEMARE
Pro Techno Foundation