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Effects of CTL2 down-regulation on tension wood formation in GM poplars

Marie-Claude Lesage Descauses, Veronique Laine-Prade, Françoise F. Laurans, Jean-Charles Leplé, Vincent Segura, Eric Badel, Bruno Clair, Gilles G. Pilate, Annabelle Dejardin

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XIV Cell Wall Meeting

Programme and Book of Abstracts

Chania, Greece
12 - 17 June, 2016

ORGANIZERS

Dr. Panagiotis Kalaitzis, Dr. Georgia Drakakaki

Chania 2016

The organization of the meeting is supported by:
Conference Centre Bureau of Mediterranean Agronomic Institute of Chania-MAICH
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Scientific Sessions Committees

1. Plant Cell wall structure and Evolution

Paul Dupree, Zoe Popper, Alison Roberts, Marie Christine Ralet

2. Biosynthesis of cell wall components

Vincent Boulone, Monika Doblin, Henrick Sheller, Olga Zabolina

3. Cell biology and dynamics of plant cell wall

Frederica Brandizzi, Erik Nielsen, Staffan Persson, Ariel Orelana

4. Functions of plant cell walls: growth, morphogenesis & development

Alan Showalter, Paul Knox, Daku Demura, Charles Anderson

5. Uses of plant cell walls

John Ralph, Maureen Mccann, Simon McQueen, Shawn Mansfield

6. Biomechanics of plants

Anjia Getman, Sioban Braybrook, Ingo Burget

7. Emerging approaches in cell wall biology and Computational modeling of plant cell wall

Michael Hahn, Silvia Coimbra, Jerome Pelloux

8. Cell wall interactions with microorganisms and the environment / Signaling and defense

Azeddine Driouich, Georg Seifert, Antonio Molina, Bruce Kohorn

Programme

SUNDAY 12th June 2016

- 18:00** **Registration**
- 20:00-23:00** **Welcome Reception - Minoa Palace Hotel**

MONDAY 13th June 2016

- 7:30** **Attendee Registration**
- 8:00-8:30** **Welcome Addresses (Imperial Main Hall)**
Prof. Ch. Kasimis, Secretary General of Agricultural Policy & Management of European Funds, Ministry of Rural Development and Food
I. Malandrakis, Mayor of Platania
- 8.30-10:10** **ORAL SESSION – 2 Biosynthesis of cell wall components**
Moderator: **Dan Cosgrove**, Pennsylvania State University, USA
- 8:30 S2-01 **The structure of Arabidopsis Xyloglucan Xylosyltransferase I and enzymatic activity of Xyloglucan Xylosyltransferase 5**
Zabotina Olga, Iowa State University, USA
- 8:50 S2-02 **Purification, crystallisation and structure of AtFUT1, a xyloglucan α -1,2-fucosyltransferase from Arabidopsis**
Lerouxel Olivier, Univ. Grenoble Alpes, CERMAV, France
- 9:10 S2-03 **Secondary Cell Wall Cellulose Deposition - Simple Polymer, Complicated Biosynthesis**
Mansfield Shawn, University of British Columbia, Canada
- 9:30 S2-04 **Extensive S-acylation of the cellulose synthase complex drives its plasma membrane integration**
Kumar Manoj, University of Manchester, UK
- 9:50 S2-05 **Golgi-localized STELLO proteins regulate the assembly and trafficking of cellulose synthase complexes in Arabidopsis**
Dupree Paul, University of Cambridge, UK
- 10:10-10:40** **Morning Tea/Coffee Break**
- 10:40-12:20** **ORAL SESSION – 3 Cell biology and dynamics of plant cell wall**
Moderator: **Anja Geitmann**, McGill University, Canada
- 10:40 S3-01 **Hetero-trans- β -glucanase, a new wall remodelling enzyme that covalently attaches cellulose or mixed-linkage glucan to xyloglucan**
Frankova Lenka, The University of Edinburgh, UK
- 11:00 S3-02 **A Principle for how Cortical Microtubules Withstand Forces Generated by Motile Cellulose Synthase**
Persson Staffan, University of Melbourne, Australia

- 11:20 S3-03 **Regulation of secondary cell wall formation/patterning during differentiation of xylem vessel elements**
Demura Taku, Nara Institute of Science and Technology, Japan
- 11:40 S3-04 **Functional Analysis of the roles of CSLD proteins during plant cell wall deposition in Arabidopsis**
Nielsen Erik, University of Michigan, USA
- 12:00 S3-05 **The role of pectin metabolism, cell wall pH, mechano- and cell wall integrity sensing in growth contro**
Hofte Herman, Institut Jean-Pierre Bourgin, Université Paris-Saclay, France

12:20-14:00 Lunch Break

14:00-15:40 ORAL SESSION – 5 Uses of plant cell walls

Moderator: **Stephen Fry**, The University of Edinburgh, UK

- 14:00 S5-01 **Stacking of traits for improved biofuel production**
Scheller Henrik, Lawrence Berkeley National Laboratory, USA
- 14:20 S5-02 **A new generation of chromogenic substrates for high-throughput screening of carbohydrate active enzymes and proteases**
Schückel Julia, University of Copenhagen, Denmark
- 14:40 S5-03 **Molecular, nanoscale and mesoscale determinants of biomass recalcitrance**
McCann Maureen, Purdue University, USA
- 15:00 S5-04 **Light-weight load-bearing aerogels from plant-derived mannans**
Tenkanen Maija, University of Helsinki, Finland
- 15:20 S5-05 **Engineering Crops for Whole-Plant-Usage concepts through Modification of the Cell Wall Polymer Callose**
Hanak Tobias, University of Hamburg, Germany

15:40-17:00 Poster Session and Coffee (Imperial 1,2,3,4 Halls)

17:00-18:40 ORAL SESSION – 5 Uses of plant cell walls

Moderator: **Harholt Jesper**, Carlsberg Research Laboratory, Denmark

- 17:00 S5-06 **CESA9 Conserved-site Mutation Affects CESA-Complex Integrity for Low-DP Cellulose Biosynthesis in Rice**
Peng Liangcai, Huazhong Agricultural University, China
- 17:20 S5-07 **Time lapse, multiscale and microfluidic approach using multimodal multispectral autofluorescence and infrared imaging to follow enzyme localization and cell wall changes during biomass hydrolysis**
Guillon Fabienne, INRA, Nantes, France
- 17:40 S5-08 **Cell wall polysaccharides from cereal grains as functional ingredients in formulated food products: structure – function relations**
Costas G. Biliaderis, Laboratory of Food Chemistry and Biochemistry, Aristotle University, Greece
- 18:00 S5-09 **The complexity of the Ruminococcus flavefaciens cellulosome reflects an expansion in glycan recognition**
Venditto Immacolata, Newcastle University, UK
- 18:20 S5-10 **Genetics of plant cell walls: forage maize as a model and a crop**
Trindade Luisa, Wageningen University, Netherlands

TUESDAY 14th June 2016

8.30-10.10

ORAL SESSION – 8

Cell wall interactions with microorganisms and the environment/Signaling and defense

Moderator: **Georg Seifert**, University of Natural Resources and Life Science, Vienna, Austria

- 8:30 S8-01 **Xyloglucan is released by plant roots and has the capacity to increase soil particle aggregation**
Galloway Andrew, University of Leeds, UK
- 8:50 S8-02 **Cell Wall Sensing By Wall Associated Kinases**
Kohorn Bruce, Bowdoin College, USA
- 9:10 S8-03 **PMEI10, PMEI11 and PMEI12 are novel regulators of pectin remodeling in plant immunity**
Lionetti Vincenzo, Sapienza University of Rome, Italy
- 9:30 S8-04 **Modulation of cell wall synthetic machinery in barley papillae induced during infection with *Blumeria graminis* f. sp. *hordei* alters papillae cell wall composition and susceptibility**
Little Alan, University of Adelaide , Australia
- 9:50 S8-05 **Root defense, role of the root extracellular matrix**
Driouch Azeddine, Normandie University at Rouen, France

10:10-10:40

Morning Tea/Coffee Break

10:40-12:20

ORAL SESSION – 2 Biosynthesis of cell wall components

Moderator: **Markus Pauly**, University of Duesseldorf, Germany

- 10:40 S2-06 **Elucidation of the catalytic mechanisms of monolignol biosynthetic enzymes to enable protein engineering-based cell wall modification**
Vermerris Wilfred, University of Florida, USA
- 11:00 S2-07 **Progress Toward Structural Understanding of Cellulose Synthesis by Plants**
Nixon B. Tracy, Pennsylvania State University, USA
- 11:20 S2-08 **Pectin Biosynthetic Activity of Arabidopsis GAUTs Heterologously Expressed in HEK293 Cells**
Engle Kristen, University of Georgia, USA
- 11:40 S2-09 **Hemicelluloses Produced by MUCILAGE-RELATED Proteins Determine the Organization of Polysaccharides in the Arabidopsis Seed Coat Epidermis**
Voiniciuc Catalin, Heinrich-Heine-Universität, Germany
- 12:00 S2-10 **Accumulation of new cell wall in plant without secondary cell wall**
Mitsuda Nobutaka

12:20-14:00

Lunch Break

14:00-15:40 ORAL SESSION – 3 Cell biology and dynamics of plant cell wallModerator: **Mary Tierney**, University of Vermont, USA

- 14:00 S3-06 **Mechano-chemical polarization of cell walls drives shape coordination**
Majda Mateusz, UMEÅ, Sweden
- 14:20 S3-07 **XTH-mediated covalent-linking between cellulose and cellulose**
Nishitani Kazuhiko, Tohoku University, Japan
- 14:40 S3-08 **Using Live-Cell Imaging to Compare Cellulose Biosynthesis in Primary Cell Walls and Induced Secondary Cell Walls**
Li Shundai, Pennsylvania State University, USA
- 15:00 S3-09 **Identification of a sphingolipid mannosyltransferase that is required for normal cellulose deposition in Arabidopsis**
Mortimer Jenny, Joint BioEnergy Institute, USA
- 15:20 S3-10 **RUBY PARTICLES IN MUCILAGE (RUBY) is a putative glyoxal oxidase required for cell wall strengthening**
Sola Kresimir, The University of British Columbia, Canada

15:40-16:10 Afternoon Coffee Break**16:10-17:10 ORAL SESSION – 3 Cell biology and dynamics of plant cell wall**Moderator: **Christoph Ringli**, University of Zurich, Switzerland

- 16:10 S3-11 **Actin and myosins XI are involved in trafficking of cellulose synthase complexes in Arabidopsis**
Staiger Christopher J., Purdue University, USA
- 16:30 S3-12 **Secretion of pectin and cell wall proteins in seed coat epidermal cells of Arabidopsis**
Lee Yi-Chen, University of British Columbia, Canada
- 17:00 S3-13 **Turning on the Lights: Using Click Chemistry to Probe Polysaccharide Delivery, Assembly, and Dynamics in Plant Cell Walls**
Anderson Charles, The Pennsylvania State University, USA

17:10-19:00 Poster Session (Imperial 1,2,3,4 Halls)

WEDNESDAY 15th June 2016

8:30-10:30 ORAL SESSION – 2 Biosynthesis of cell wall componentsModerator: **Antony Bacic**, University of Melbourne, Australia

- 8:30 S2-11 **Recovery of the cse and ccr1 mutant phenotype via vessel-specific complementation**
Vanholme Ruben, University of Gent, Belgium
- 8:50 S2-12 **Molecular Structure of a Cellulose Synthase Plant-Conserved Region by X-ray Crystallography and Small Angle X-ray Scattering and Possible Function in the Catalytic Domain**
Carpita Nicholas C., Purdue University, USA
- 9:10 S2-13 **Designer Lignins: Inspirations from Nature**
Ralph John, DOE Great Lakes Bioenergy Research Center, USA
- 9:30 S2-14 **Cell wall polysaccharide biosynthesis in oomycete pathogens**
Bulone Vincent, University of Adelaide, Australia
- 9:50 S2-15 **Role of Arabidopsis thaliana KNOTTED-LIKE (KNOX) transcription factors in the regulation of cell wall biosynthesis**
Douglas Carl, University of British Columbia, Canada
- 10:10 S2-16 **Understanding the mechanism of (1,3; 1,4)- β -D-Glycan Synthesis in cereals**
Doblin Monika, Australian Research Council Centre of Excellence in Plant Cell Walls, Australia

10:30-11:00 Morning Tea/Coffee Break**11:00-12:20 ORAL SESSION – 4****Functions of plant cell walls: growth morphogenesis & development**Moderator: **Paul Knox**, University of Leeds, UK

- 11:00 S4-01 **Genetic and chemical genomic dissection of the cell adhesion mechanisms in plants**
Mouille Gregory, INRA, Versailles, Finland
- 11:20 s4-02 **Pectin dynamics regulated by endogenous pectate lyases, leading to proper control of cell proliferation in Arabidopsis**
Ohtani Misato, Nara Institute of Science and Technology (NAIST), Japan
- 11:40 S4-03 **Hydroxyproline O-arabinosyltransferase mutants oppositely alter tip growth in Arabidopsis thaliana and Physcomitrella patens**
MacAlister Cora, University of Michigan, USA
- 12:00 S4-04 **How the walls are made in the stem cell niche of the plant shoot**
Wightman Raymond, University of Cambridge, UK

12:20-12:50 Noon Coffee Break

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- 12:50-14:10** **ORAL SESSION – 4**
Functions of plant cell walls: growth morphogenesis & development
Moderator: **Helen North**, INRA
- 12:50 S4-05 **The effect of cell wall polymer interactions on seed mucilage architecture**
Harpaz-Saad Smadar, Hebrew University of Jerusalem, Israel
- 13:10 S4-06 **Establishment of polarity in subsidiary cell mother cells of Zea mays stomatal complexes begins with the differentiation of the matrix cell wall materials**
Giannoutsou Eleni, University of Athens, Greece
- 13:30 S4-07 **Two small multigene hydroxyproline-O-galactosyltransferase families function in arabinogalactan-protein glycosylation, growth and development in Arabidopsis**
Showalter Allan, Ohio University, United States
- 13:50 S4-08 **The Role of xylem morphology on freezing tolerance as indicated by the Arabidopsis Xylan O-acetyltransferase mutant *tbl29/ esk1* and its suppressor *ess1***
Pauly Markus, University of Duesseldorf, Germany
- 14:10-15:30** **Lunch**
- 16.00** **Technical Tour**

THURSDAY 16th June 2016

- 8:30-9:50** **ORAL SESSION – 1 Plant Cell wall structure and Evolution**
Moderator: **Breeanna Urbanowicz**, University of Georgia, USA
- 8:30 S1-01 **Biosynthesis of a novel mixed-linkage arabinoglucan cell wall polysaccharide in *Physcomitrella patens***
Alison W. Roberts, University of Rhode Island, USA
- 8:50 S1-02 **Biochemical Evidence of Fucosylated Xyloglucan in Charophycean Green Algae**
Mikkelsen Maria Dalgaard, Technical University of Denmark, Denmark
- 9:10 S1-03 **A new monoclonal antibody to pectic type I arabinogalactan**
Ralet Marie-Christine, INRA, Nantes, France
- 9:30 **Best Poster Award and Presentation of candidatures for the organization of the next Cell Wall Meeting**
- 9:50-10:20** **Morning Tea/Coffee Break**
- 10:20-11:40** **ORAL SESSION – 1 Plant Cell wall structure and Evolution**
Moderator: **Zoë Popper**, National University of Ireland, Galway, Ireland
- 10:20 S1-04 **Cell-wall assembly during growth and cell elongation in brown algae**
Siméon Amandine, Marine Glycobiology group, Roscoff, France
- 10:40 S1-05 **Supramolecular 3D Nano-Architecture of Arabidopsis Plant Cell Walls by Cryo-Electron Tomography of Vitreous Sections**
Auer Manfred, Lawrence Berkeley Nat'l Lab, USA
- 11:00 S1-06 **Variation in xylan structure: implications for the evolution and biosynthesis of monocot cell walls**
Peña María J., University of Georgia, USA
- 11:20 S1-07 **Algal xylan synthase proves functional orthology between algal and plant cell walls**
Harholt Jesper, Carlsberg Research Laboratory, Denmark
- 11:40-13:00** **Poster Session (Imperial 1,2,3,4 Halls)/ Open table discussion: Increase Participation and Diversity (Imperial Main Hall) Coffee Break**
- 13:00-14:40** **Lunch Break**

14:40-16:20 ORAL SESSION – 4
Functions of plant cell walls: growth morphogenesis & development

Moderator: **Alison Roberts**, University of Rhode Island, USA

- 14:40 S4-09 **Pollen tubes and pathogens: who's got the moves like JAGGER?**
Coimbra Sílvia, University of Porto, Portugal
- 15:00 S4-10 **Mechanics of lobe formation in interlocking plant cells**
Anja Geitmann, University of Montreal, Canada
- 15:20 S4-11 **Integration of cell wall feedback signalling with intracellular growth regulation**
Wolf Sebastian, COS Heidelberg, Germany
- 15:40 S4-12 **A tension-microtubule feedback controls plant shapes through cellulose synthase guidance**
Verger Stéphane, INRA, CNRS, ENS, UCB Lyon 1, France
- 16:00 S4-13 **While reaching for the sky, what controls hypocotyl growth?**
Bou Daher Firas, University of Cambridge, UK

16:20-16:50 Coffee Break

16:50-18:10 ORAL SESSION – 2 Biosynthesis of cell wall components

Moderator: **Rachel Burton**, University of Adelaide, Australia

- 16:50 S2-17 **The identification of Golgi UDP-Aarabinofuranose transporters in Aarabidopsis**
Ebert Berit, The University of Melbourne, Australia
- 17:10 S2-18 **UDP-uronic acid transporters are important providing galacturonic acid and arabinose, but not xylose, inot the cell wall**
Ariel Orellanaa, Universidad Andrés Bello, Chile
- 17:30 S2-19 **Identification of genes that regulate mixed-linkage glucan biosynthesis in Brachypodium distachyon**
Wilkerson Curtis, Michigan State University, USA
- 17:50 S2-20 **Post-translational control of cellulose biosynthesis: comparing the function of CESA5 and CESA6 in seed coat mucilage biosynthesis**
Griffiths Jonathan, Institute Jean-Pierre Bourgin , France
- 18:10 S2-21 **The BIN2 protein kinase directly phosphorylates Arabidopsis CesA1 and negatively regulates cellulose biosynthesis**
Wallace Ian, University of Nevada, USA

FRIDAY 17th June 2016

8:30-9:50

ORAL SESSION – 6 Biomechanics of plants

Moderator: **Laigeng Li**, Chinese Academy of Sciences, China

- 8:30 S6-01 **Distinctive Microfibril Motions Visualized by AFM during Mechanical Extension and Cell Wall Loosening**
Zhang Tian, The Pennsylvania State University, USA
- 8:50 S6-02 **Pollen Tube: From Cell Wall Composition and Ultrastructure to Cell Mechanics and Growth**
Ndinyanka Fabrice Tohnyui, University of Zurich, Switzerland
- 9:10 S6-03 **Effects of CTL2 down-regulation on tension wood formation in GM poplars**
Šećerović Amra, INRA, France
- 9:30 S6-04 **Stomatal Cell Wall Crystallinity: Distinctive structural patterns in diverse phylogenetic groups**
Shtein Ilana, The Hebrew University of Jerusalem, Israel

9:50-10:20

Morning Tea/Coffee Break

10:20-11:40

ORAL SESSION – 7

Emerging approaches in cell wall biology and Computational modeling of plant cell wall

Moderator: **Hahn Michael**, University of Georgia, USA

- 10:20 S7-01 **An integrated computational and experimental approach to discover systems-level controls of morphogenesis**
Szymanski Dan, Purdue University, USA
- 10:40 S7-02 **Combined experimental and computational approaches reveal distinct pH-controlled inhibiting capacities of Arabidopsis Pectin Methylesterase Inhibitors (PMEIs)**
Lefebvre Valérie, Université de Picardie, France
- 11:00 S7-03 **From Octamer to Rosette: Structural rearrangements determine activity of the (1,3)- β -glucan synthase complex**
Voigt Christian, University of Hamburg, Germany
- 11:20 S7-04 **An updated collection of Arabidopsis Glycosyltransferase (GT) clones and an enzymatic characterisation platform for plant cell wall research**
Zeng Wei, The University of Melbourne, Australia

11:40-12:10

Noon Coffee Break

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- 12:10-13:30 ORAL SESSION – 7**
Emerging approaches in cell wall biology and Computational modeling of plant cell wall
Moderator: **Kim Johnson**, University of Melbourne, Parkville, Australia
- 12:10 S7-05 **Synthetic plant carbohydrates as a toolbox for cell wall biology**
Pfrengle Fabian, Max-Planck-Institute of Colloids and Interfaces, Germany
- 12:30 S7-06 **In vivo tagging of non-cellulosic plant cell wall glycans using tagged CBM and scFv probes**
Hahn Michael, University of Georgia, USA
- 12:50 S7-07 **Raman microscopy combined with multivariate data analysis to reveal plant cell wall structure and the deposition of hydrophobising substances on the micro- and nanoscale**
Gierlinger Notburga, University of Natural Resources and Life Sciences, Austria, Hochschule Zurich, Switzerland, EMPA-Swiss Federal Laboratories for Material Testing and Research, Switzerland
- 13:10 S7-08 **Modelling Plant Cell Walls: linking specific wall structures with plant response to stress and fitness**
Eva Miedes, Universidad Politécnica Madrid., Spain
- 13:20-15:20 Light Lunch**

S6-03

EFFECTS OF CTL2 DOWN-REGULATION ON TENSION WOOD FORMATION IN GM POPLARS

Šećerović Amra¹, Lesage-Descauses Marie-Claude¹, Lainé-Prade Véronique¹, Laurans Françoise¹, Leplé Jean-Charles¹, Segura Vincent¹, Badel Eric², Clair Bruno³, Pilate Gilles¹, Déjardin Annabelle¹

¹INRA, UR0588, Unité Amélioration, Génétique et Physiologie Forestières, Orléans, France, ²INRA, UMR Physique et Physiologie Intégratives de l'Arbre Fruitier et Forestier, Clermont-Ferrand, France, ³CNRS, UMR Ecologie des Forêts de Guyane, Kourou, French Guiana,

Angiosperm trees are able to reorient their axes thanks to their capacities to differentiate tension wood on the upper side of stems and branches. In poplar, tension wood fibres develop an extra cell wall layer, named G-layer, responsible for the peculiar mechanical properties of tension wood. G-layer is composed of highly crystalline cellulose microfibrils embedded in a polysaccharide/glycoprotein matrix devoid of lignin. During the G-layer deposition, cellulose microfibrils get oriented parallel to the fibre axis and placed under the state of high tensile stress. Chitinase-like proteins (CTL) have been proposed to play different roles in plant growth and development. Genes encoding CTL have been associated to cellulose synthesis and their mutation causes ectopic deposition of lignin. Transcripts of CTL2 gene were shown to be highly abundant in differentiating tension wood (Déjardin et al., 2004). Its homologue in Arabidopsis is specifically expressed in stems and co-expressed with the CesA genes involved in cellulose synthesis in secondary cell walls (Persson et al., 2005). In our study, we investigated potential function of CTL2 in the formation and mechanical properties of tension wood. Expression of CTL2 was quantified in different tissues and the effects of CTL2 down-regulation have been characterized in GM poplar trees. CTL2 gene appeared highly expressed in xylem with no difference in expression between tension and opposite wood. Downregulation of CTL2 did not seem to impact growth and development of trees in greenhouse conditions. However, stems appeared to be highly breakable in the transverse direction. Anatomical observations of xylem showed altered formation of G-layers in vessel-surrounding fibres in transgenic poplars. Further analyses indicated a substantial increase in wood lignin content. Cellulose crystallinity, microfibril angle and stem mechanical properties are currently assessed. Results will be presented and discussed in the light of present hypothesis regarding CTL2 function in plant development.

S6-04

STOMATAL CELL WALL CRYSTALLINITY: DISTINCTIVE STRUCTURAL PATTERNS IN DIVERSE PHYLOGENETIC GROUPS

Shtein Ilana¹, Shelef Yaniv², Marom Ziv², Bar-On Benny², Popper Zoë A.³, Zelinger Einat⁴, Schwartz Amnon¹, Harpaz Smadar¹

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Stomata evolved ~400 million years ago - and have remained a key feature of plant anatomy and physiology. Stomata offer a unique research system, where the function has remained largely the same, even though various cell wall features have evolved and changed. We attempted a renewed look at stomatal cell wall structure utilizing digitalized polar microscopy and confocal microscopy. We investigated the distribution patterns of cellulose, including microfibril orientation and crystallinity, lignin and phenolic compounds in the stomata of vascular plants from different phylogenetic groups. In addition, we applied a numerical mechanical Finite-Element simulation to understand the mechanical anisotropy of the stomatal cell wall. Stomata of the six species chosen for study cover a broad structural, ecophysiological and evolutionary spectrum: two ferns and two angiosperm species with kidney-shaped stomata, and two grass species with dumbbell-shaped stomata. Surprisingly, we observed three distinct patterns of cellulose crystallinity in stomatal cell walls: the ferns exhibited pattern Type I, angiosperm kidney-shaped stomata exhibited pattern Type II and the grasses presented Type III. Our data demonstrates for the first time the existence of distinct spatial patterns of varying cellulose crystallinity in guard cell walls. Guard cell walls undergo reversible deformations during opening/closing of the pore and thus must be both extremely strong and flexible. Different cellulose crystallinity patterns could influence those properties. Such spacial patterns could imply different biomechanical function, which in its turn could be a consequence of different environmental