Wood Matters

A celebration of the work of John Barnett

Thursday 29th and Friday 30th May 2008

Programme and Abstracts

Programme - Day 1

9.30 Welcomes by **David Cutler**, President of the Linnean Society of London, **Xavier Deglise**, President of IWAS and **Regis Miller**, Executive Secretary of IAWA

SESSION I: INVITED PAPERS ON WOOD PROPERTIES AND WOOD IDENTIFICATION

9.45 **Xavier Deglise** - *Relationships between wood microstructure, adhesion, finishes and their durability*

10.10 **George Jeronimidis** - *Reaction woods: inspiration for smart materials and structures*

10.35 **Frank Beall** - *Some published and unpublished ultrasonic research on wood*

11.00 **Robert Evans** - *Effects of climate change on wood microstructure and properties using SliviScan*

11.25 Coffee

11.55 **Peter Gasson** - *Anatomy and identification of CITES woods*

12.20 **Regis Miller** - *Non-anatomical features in wood identification*

12.45 Lunch & poster session

SESSION II: CONTRIBUTED PAPERS ON WOOD STRUCTURAL DIVERSITY

14.00 **Frederic Lens** - *A search for phylogenetically informative wood characters in the subfamily Rauvolfioideae (Apocynaceae)*

14.15 **Pieter Baas** - *Alstonia spatulata: Pith helmets adrift and rootwood from the swamps*

14.30 **Jennifer Evans** - *The wood anatomy of the Mimosoideae (Leguminosae)*

14.45 **David Rabaey** - *The ultrastructure and development of pseudotori*

15.00 **Lydia White** - *Mahogany*

15.15 **Jianxiong Lu** - *Anisotropic characteristics of wood dynamic viscoelastic properties*

15.30 **Robert Franich** - *Properties of cell walls prepared using supercritical fluids*

15.45 Tea

SESSION III: IAWS ACADEMY LECTURE

16.30 **John Barnett,** introduced by **Xavier Deglise** - *Understanding cambial behaviour: the key to wood quality*

17.30 Reception and poster session

19.30 Celebratory dinner at Galileo's Restaurant, Haymarket

Abstracts - Day 1

Relationships between wood microstructure, adhesion, finishes and their durability

Xavier Deglise, *LERMaB, Université Henri Poincaré*
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It has been known for a long time that wood exposed to solar radiation is subjected to surface degradation – primarily colour changes, surface checking developed at the margins of rays, propagated at the interface between adjacent tracheids, close to the middle lamella. Despite this behaviour and increasing pressures from competitor materials, because of the sustainable development, wood regains market shares in construction and decorative purpose such as furniture, parquetry, joinery, cladding and decking. To ensure its long term durability wood is usually coated with various decorative and protective finishes such as opaque paints and semi-transparent stains as well as penetrating finishes or film forming clear varnishes. Studies of the weathering or accelerated ageing of coated wood systems have shown that protection depends not only on the topcoat performance, but also on the substrate and particularly on the wood/coating interface. Nowadays new strategies such as wood chemical modification are under development.

Reaction woods: inspiration for smart materials and structures

George Jeronimidis, *University of Reading*
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Smart materials and structures can adapt, passively or actively, in response to external stimuli. One of the most interesting and useful type of response involves the beneficial shape changes of load-bearing structures. This is indeed what trees do as a result of their gravitropic response. The mechanisms which trees put in place to create the internal stress system responsible for inducing curvature in leaning trunks, for example, stem from the production of "reaction woods". Tension wood in angiosperms and compression wood in gymnosperms are amazing examples of modulation of physical and mechanical properties at the microscale (cell wall, cells) resulting from changes in the architecture of cellulose microfibrils and the in the physical interaction between sub-structures. Understanding the mechanism associated with reaction wood, from the stimulus to the response, via signalling and regulation, provides a biomimetic blueprint for the design of man-made fibrous composites systems with smart characteristics.

Some published and unpublished ultrasonic research on wood

Frank Beall, *University of California, Berkeley*
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Ultrasonic techniques are very well suited to composite materials such as wood. In this presentation, applications of a specialized type of ultrasonics, acoustic emission (AE) will be shown for a variety of investigations. Four published examples will be given, including measurement of springback from particleboard, detection of decay through radial compression, measurement of fissuring during combustion, and control of lumber drying. The unpublished examples are measurement of density in machining of hardboard and detection of water stress in trees. These studies were chosen to provide a overview of the potential of AE covering a wide range of materials and techniques.

Effects of climate change on wood microstructure and properties using SilviScan

Robert Evans, *CSIRO Fellow*
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Trees are relatively long-lived organisms that compensate for their lack of mobility in changing environmental conditions by continuously adjusting their incremental structure (and therefore wood quality). Although there are strong genetic controls over wood structure, large environmental responses are possible. Temperature and rainfall patterns may change significantly over the next few decades. There may even be insufficient water in some areas to maintain species that are now in production. Studies of the effects of climate on wood properties will help guide selection and management of appropriate trees for future plantations, and will lead to better management of commercial risk. SilviScan is finding application in this area, as relatively large numbers of measurements of several properties can be made at high spatial (temporal) resolution. Interpretation is not straightforward, as many factors must be considered, including confounding environmental and genetic variables and instrumental effects.

Anatomy and identification of CITES woods

Peter Gasson, *Royal Botanic Gardens, Kew*
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There are c.23 timber species in 20 genera listed on CITES Appendices I-III. Most can be confused with non-listed taxa, and it is challenging for customs officers to recognise whether an import of timber or manufactured articles is legal or otherwise. This talk concentrates on two examples: (1) Ramin (*Gonystylus* spp.), which is similar to many other light-coloured woods from Asia including

Anthocephalus sp. (kadam, Rubiaceae) and *Dyera* sp. (jelutong, Apocynaceae). All c.30 species of *Gonystylus* are covered by CITES. (2) Brazilian Rosewood (*Dalbergia nigra*) is the only CITES-listed species out of the 100 or more anatomically alike *Dalbergias*. Fluorescence of water extracts appears to be a reliable method of separating *D. nigra* from *D. spruceana* (Miller & Wiemann) and Geoffrey Kite at Kew is beginning to identify the heartwood phenolics involved using HPLC-MS (High Performance Liquid Chromatography - Mass Spectrometry). Many people consider that DNA fingerprinting may help with some identification problems in the future, assuming that there is extractable DNA in heartwood.

Non-anatomical features in wood identification and systematic wood anatomy
Regis Miller, *USDA Forest Service, Center for Wood Anatomy Research*
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Non-anatomical features are useful in wood identification and may prove to be useful in systematic wood anatomy although they are rather subjective in nature. Non-anatomical features include color, density, fluorescence (surface and extract), color of water and ethanol extracts, and several simple chemical tests (burning splinter, froth, chrome azurol-S, and sodium nitrite). Results on color, density, surface fluorescence, and chrome azurol-S test have been reported for most genera and studies have shown that they are useful in wood identification and systematic wood anatomy. Other non-anatomical features have not been fully studied, but preliminary studies show that they are useful in some taxa. The sodium nitrite test is especially interesting within Fagaceae since the ring and diffuse porous "white oaks", *Castanea*, and some species of *Lithocarpus* test positive but not others. Applied on all woods, may reveal many more positive species/genera and further extend its value.

A search for phylogenetically informative wood characters in the subfamily Rauvolfioideae (Apocynaceae)
Frederic Lens, *Laboratory of Plant Systematics (K.U. Leuven)*
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Wood anatomical studies in the economically important Apocynaceae or dogbane family are fragmentary. This study represents a first attempt to unravel the phylogenetic significance and major evolutionary trends in the wood of the family, using the large subfamily Rauvolfioideae as a case study. Progress in molecular systematics has demonstrated that Rauvolfioideae are paraphyletic, and characters previously used to define tribes appear to be strongly homoplasious. Consequently, our major aim is to contribute to the urgently needed search for meaningful non-DNA characters at the tribal level, using LM and SEM observations of 90 species belonging to all ten tribes. We found that most of the current tribes are characterized by a unique combination of wood characters, such as vessel grouping, vessel element length, fiber type, abundance of uniseriate rays, and fused multiseriate rays, despite the co-occurrence of erect as well as climbing taxa in five tribes. Climbing rauvolfioid taxa can generally be distinguished from erect species by their wider vessels, tendency to form paratracheal axial parenchyma, and the presence of tracheids and laticifers in their rays. With respect to the entire family, there is a general phylogenetic tendency towards shorter vessel elements, more pronounced vessel grouping, higher tracheid abundance, more paratracheal parenchyma and fewer axial parenchyma cells per strand in the more derived Apocynaceae, and most of these evolutionary patterns are likely to be triggered by drier environmental conditions and/or shifts from the erect to the climbing habit.

***Alstonia spatulata*: pith helmets adrift and rootwood from the swamps**

Pieter Baas, *Nationaal Herbarium Nederland*
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Very large and extremely light pieces of driftwood washed ashore on the Marshall Islands in the Pacific were tentatively identified as rootwood of *Alstonia spatulata* (Apocynaceae), a wide-spread swamp forest tree from the Indo-Pacific region. In its native distribution area, the light rootwood is used for manufacturing pith helmets, rafts, rafters for fishery, and as a poor substitute of cork – the latter three uses are also made of the driftwood in the Marshall islands. The rootwood anatomy is very aberrant, with a ground tissue of broad fibres that show no or very little intrusive tip growth and very thin secondary walls, vessels as narrow as the fibres, narrow zonate parenchyma bands, probably marking growth periodicity following the inundation cycles in the swamp forest, and extremely low and narrow rays. The functional anatomy of the roots remains completely enigmatic, but the fact that similar xylem histologies occur in flooded stem parts of a range of woody families in the Neotropical inundation forests (Alex Wiedenhoeft, personal communciation) suggests convergent evolution of functionally adaptive significance. Combined ecophysiological and wood anatomical studies of the rootwood and basal stemwood of tropical swamp forest trees in the field are clearly needed.

The Wood Anatomy of the Mimosoideae

Jennifer A. Evans, *Cardiff University*
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The pantropical subfamily Mimosoideae (Leguminosae) currently comprises 78 genera and 3,270 species. This study provides a detailed account of mimosoid wood anatomy, covering c. 77% of the genera, and the photographic plates act as an identification atlas for the subfamily. We highlight cases in which wood anatomical characters of potential taxonomic significance support or conflict with the current classification of genera, suprageneric groups, and tribes. Mimosoid wood is homogeneous and distinguishable from members of the other subfamilies of Leguminosae, Caesalpinioideae and Papilionoideae. The characters found to be most divergent in Mimosoideae wood are: presence or absence of septate fibres, the presence and extent of confluent or banded axial parenchyma, and ray width. These characters tend to be conserved within genera and also between members of the same generic group, but are not of taxonomic value at the tribal level where there is too much variation within and overlap between tribes.

Ultrastructure and development of pseudo-tori in secondary xylem

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Recent micromorphological observations of angiosperm pit membranes have extended the number of taxa with pseudo-tori in tracheary elements. The development of pseudo-tori in *Malus yunnanensis*, *Ligustrum vulgare*, *Pittosporum tenuifolium*, and *Vaccinium myrtillus* was studied in order to determine the homologous nature of these plasmodesmata associated thickenings across flowering plants. Early ontogenetic stages based on transmission electron microscopy illustrate the formation of a primary thickening as a result of swelling of the pit membrane in fibre-tracheids and vessel elements. At a very late stage during cell differentiation, a secondary thickening is deposited on the primary thickening. Plasmodesmata are always associated with pseudo-tori at these final developmental stages. After autolysis, the secondary thickening becomes electron-dense and persistent, while the primary thickening becomes very transparent and partially or entirely dissolves. The developmental patterns observed in the species studied are similar and agree with earlier ontogenetic studies in Rosaceae, suggesting that pseudo-tori are homologous features across angiosperms.

Mahogany

Lydia White, *Royal Botanic Gardens, Kew*
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The identification of the CITES Appendix II listed true mahogany *Swietenia* is notoriously difficult. It is easily confused with other so-called 'mahogany' timbers, such as the African genera *Khaya* and *Entandrophragma.* Such confusion arises because of the liberal use of the name 'mahogany', along with a long list of other common names. These 'mahogany' timbers look almost identical to *Swietenia*, macroscopically and microscopically, therefore making identification increasingly difficult.

This talk focuses on how *Swietenia* can be identified, through detailed comparison of wood anatomical characteristics, from other traded 'mahogany' timbers. This research is also the subject of a new book, *Mahogany*, by Lydia White and Peter Gasson (Kew Publishing). This book is an essential resource for everyone involved with the regulation of endangered timbers, including wood anatomists, customs officers and timber traders.

Anisotropic characteristics of wood dynamic viscoelastic properties

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The anisotropic characteristics of the dynamic viscoelastic behavior of Chinese fir [Cunninghamia lanceolata (Lamb.) Hook] plantation wood were investigated in this study. Testing was performed at temperature range from -120 to 40°C at 1Hz using the Dynamic Mechanical Analysis (DMA). DMA experiments were carried out with different mechanical modes (tension and flexural). The effects of freezing and heating treatments were also investigated. The results showed that the specimens oriented parallel to the grain presented higher storage modulus and the lower β-loss peak temperature than the ones oriented perpendicular to the grain, which was opposite to synthetic polymer composites where the stiffer direction has a higher loss peak temperature. The rheological properties of wood also showed a dependence upon the mechanical modes used during the measurements, and the tension mode presented higher stiffness than the flexural mode. The dynamic viscoelastic properties of wood were affected by freezing or heating treatment.

Properties of cell walls prepared using supercritical fluids

Robert Franich, *SCION*
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The process of evaporation of water from green wood to produce a dry specimen for study has consequences which can include bulk material, micro- and nano-structural change owing to initial and induced moisture gradients which can result in altered material properties.

We have investigated a process for extraction of water from green wood cells by exploiting the chemical reaction between carbon dioxide and water. This paper will present results from reaction of green sapwood with CO_2, where phase-change is used to drive chemical change, during which, wood material is accurately and uniformly de-watered to closely-approach fibre-saturation point. Wood material produced using this process has proved valuable for investigating dynamic behaviour of hydrated wood cells in which only bound water within cell walls is present.

International Academy of Wood Science

ACADEMY LECTURE

Understanding cambial behaviour - The key to wood quality

John R Barnett
Professor Emeritus
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All wood is produced by the vascular cambium. Variability in wood properties is caused by variability in structure, reflected in differences in wood anatomy and in the structure cell walls, particularly the walls of fibres and tracheids. Although the wood anatomy of a particular species is genetically determined and predictable in a tree growing under benign conditions, this does not prevent variation being imposed to some extent by environmental stress. The structure and composition of fibre and tracheid walls may be similarly altered depending on growing conditions. In hardwoods, anatomical variation reflects such things as a change in the proportions of cell types produced by the cambium and in the amount of growth undergone by the derivatives before their final dimensions are fixed by secondary wall formation. Variation in secondary wall structure is manifested as changes in the pattern of deposition and the composition of cell wall components such as lignin and cellulose.

It is therefore self-evident that understanding the behaviour of the cambium and the development of its derivatives holds the key to understanding at least some of the processes of wood formation and how these affect the structure and quality of wood produced. One approach to this problem, dating back to the seventeenth century but still relevant today, has been the use of microscopy to investigate the fine structure of the vascular cambium and its xylem derivatives. This lecture will consider what microscopy has revealed about the structure of the cambium; the differences between dormant and active cambium and the changes taking place on reactivation at the start of the growing season; the structure of developing xylem elements, and the role of plasmodesmata and the symplasm in differentiation.

The Lecturer

John R. Barnett is Professor Emeritus in Structural Botany in the School of Biological Sciences at the University of Reading. He obtained his BSc in Biological Chemistry at the University of Manchester in 1966, and his PhD in Biophysics under the supervision of R.D.Preston FRS, FLS, FIAWS, at the University of Leeds in 1969. From 1969 to 1977, he was employed as Scientist at the Forest Research Institute of the New Zealand Forest Service. In 1977, he took up the post of Electron Microscopist, then Director of Structural Studies in the Plant Science Laboratories at the University of Reading. In 1996 he was appointed Head of the Department of Botany, and in 2002, Head of the School of Plant Sciences.

His research interests have centred on the application of microscopy to the vascular cambium and developing secondary xylem in softwoods and hardwoods, and to developing graft unions in woody plants. He has supervised 25 PhD students in these topics and others ranging from plant anatomy to fuelwood production. He has published more than a hundred refereed papers and reports, and made more than 50 oral conference presentations.

He was elected fellow of IAWS in 1995 and Vice President in 1999, becoming President in 2002. He is a Fellow of the Linnean Society and was elected a Trustee and Council Member of the Society in 2004. He was awarded an Erskine Fellowship by the University of Canterbury New Zealand in 2005. He has served on the editorial board of the Journal of the International Association of Wood Anatomists, and is presently co-editor of Wood Science and Technology and serves on the editorial boards of Annals of Botany, Holzforschung, Sylva Fennica, and Chinese Forestry Science and Technology. In 1996 he won a major grant from the European Commission to co-ordinate and international project on the vascular cambium. He currently acts as Chair of an EC COST Action entitled Cell Wall Macromolecules and Reaction Wood, which involves coordinating scientists from fifteen European countries.

The International Academy of Wood Science

IAWS was founded in Paris on 2 June 1966. It is a non-profit organization of wood scientists, recognizing all fields of wood science and associated technology, with worldwide representation.
The objectives of the Academy are:

- Recognizing meritorious wood scientists by their election as Fellows
- Honoring distinguished achievements in the science of wood
- Promoting a high standard of research and publication

Executive Officers of IAWS

Xavier Deglise, President
Frank C Beall, Vice President
John R Barnett, Past President
Uwe Schmidt, Secretary
Howard Rosen, Treasurer

IAWS Membership

Members of the Academy belong to one of the two classes: Fellows or Supporting Members. Supporting Members are elected by the Board and include educational, research, industrial, or governmental organizations and individuals that are actively engaged in or promoting research in wood science or the enhanced utilization of wood on the basis of scientific or technological principles and practices. Nominations of candidates as new Fellows can be made only by a Fellow who must provide supporting documentation. There are currently over 307 Fellows and 24 Supporting Members, representing 35 countries.

The Academy Lecture

The Academy Lecture program was established to promote the objectives of IAWS. It honors distinguished achievements in wood science, which in turn encourages high standards of research and publication. Academy Lectures are presented in different parts of the world, in connection with meetings of the IAWS or related professional organizations. The topic chosen for the Academy Lecture is to be of current concern in the field of wood science and associated technology, and relevant to the audience.

IAWS Lecturers

1973	Günther Becker
1976	Erich Adler
1980	Wilfred Côté
1981	Tore E Timell
	Suezone Chow
1982	Josef Gierer
1983	Olof H Samuelson
	Bruce J Zobel
1984	David A I Goring
1985	William E Hillis
1986	Walter Liese
1988	Walter G Kauman
	Ricardo O Foschi
	Takayoshi Higuchi
1989	Karl-Erik Eriksson
	Knut P Kringstad
1990	Dietrich Fengel
	Josef Bauch
1991	Henry I Bolker
1992	Robert H Leicester
1994	John M Dinwoodie
1995	Robert W Kennedy
	Horst H H Nimz
	Noritsugo Terashima
	Hikaru Sasaki
1997	Frank C Beall
	Bjarne R Holmbom
1999	James L Bowyer
2000	Antonio Pizzi
	Gyozuke Meshitsuka
	Tomasz Wodzicki
2001	H-M. Chang
2002	Rajai H. Atalla
	Kunio Hata
2003	Robert Evans
	Gösta Brunow
	Jack Saddler
2004	Norman P. Kutscha
	Daniel Guitard
2005	Helmuth Resch
	Rafael Vicuna
2006	Fred Kamke
	Ted Hillis
2007	Wolfgang Glasser
	Kazumi Fukazawa
	Xavier Deglise

Programme - Day 2

SESSION IV: INVITED PAPERS ON WOOD DEVELOPMENT, DYNAMICS AND FUNCTION

9.00 **Katia Ruel** - *Analysis of genetically modified plants to better understand the macromolecular assembly in lignified cell walls*

9.25 **Anne Mie Emons** - *From cellulose synthase to xylem wall texture in a systems biology approach*

9.50 **Jean-Paul Joseleau** - *Wood fibre's ultrastructural organization influences their pulping behaviour and paper properties*

10.25 **Peter Barlow** - *Unresolved matters in the vascular cambium: where do all the cells come from?*

1050 Coffee

11.20 **Björn Sundberg** - *FuncFiber: a large scale initiative towards understanding gene function in wood formation*

11.45 **Uwe Schmitt** - *High resolution cambium dynamics: a useful approach for the determination of climate effects on wood formation in trees.*

12.10 **Steven Jansen** - *Structure and function of pit membranes*

12.35 **Pekka Saranpää** - *Climate change and wood structure*

13.00 Lunch & poster session

SESSION V: CONTRIBUTED PAPERS ON XYLEM DYNAMICS

14.00 **Hans Beeckman** - *Dendrochronology in the dense tropical rainforest of the Congo Basin: tree ring analysis of Millettia laurentii*

14.15 **Veronica de Micco** - *Quantitative wood anatomy in seedlings and tree rings*

14.30 **Ryo Funada** - *Microtubules and wood formation*

14.45 **Elizabeth Magel** - *Molecular basis of discolourations: Heartwood formation versus defence reactions*

15.00 **Sergio Rossi** - *Age dependant xylogenesis in timberline conifers*

15.15 **Derek Gray** - *Chiral structures in trees*

15.30 Tea

SESSION VI: CONTRIBUTED PAPERS ON WOOD STRUCTURE AND PROPERTIES

16.00 **Rupert Wimmer** - *Better wood for better products: from understanding to application*

16.15 **Joseph Gril** - *Modelling the hygromechanics of wooden panel paintings from the cultural heritage*

16.30 **Janis Gravitis** - *Wood cell walls and nanostructures: challenge for wood science and industry*

16.45 **Peter Niemz** - *Influence of temperature and some other parameters on the shear strength of glued wood joints*

17.00 Closing remarks by programme organiser **Pieter Baas**

Analysis of genetically modified plants to better understand the macromolecular assembly in lignified cell walls

Katia Ruel, *Centre de Recherches sur les Macromolécules végétales (CERMAV-CNRS)*
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Perturbing the biogenesis of plant cell walls by manipulating some genes of lignin or/and polysaccharide biosynthesis is a strategy to understand the role and function of the macromolecules in the formation and assembly of the cell walls. Chemical analysis allows the monitoring of the impact of the genetic modification on the synthesis of wall polymers. However, because the matrix polymers are heterogeneous in their chemical structure and in their distribution within the cell walls, a detailed assessment of the spatio-temporal impact of the genetic transformation must be carried out *in muro* during cell wall development and at the highest resolution of microscopy. In this respect, transmission electron microscopy (TEM) coupled to immunological probes constitutes a performing approach to analyse and characterise the genetic phenotypes.

Through examples of model plants (Arabidopsis, Tobacco, Populus, Eucalyptus) genetically altered in the synthesis of their hemicelluloses and lignins, correlations were tentatively made about the function of these macromolecules in the wall assembly. In many instances it appears that the impact of a gene on the cell wall assembly is not directly visible or affects more than the correlated gene product. In this respect, the example of the transformation on the MYB transcription factors, which have been suggested to take part in the regulation of the spatial and temporal control of lignin, will be discussed.

From cellulose synthase to xylem wall texture in a systems biology approach

Anne Mie Emons, *Laboratory of Plant Cell Biology, Wageningen University*
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Cellulose synthase complexes, ‘particle rosettes’, are nanomachines having glucosyltransferases as main ingredient. After their insertion by Golgi vesicles into the plasma membrane of plant cells, they start producing the cellulose microfibrils, micrometers long and 3 nm wide crystalline structures consisting of 18-36 cellulose polymers. The texture of microfibrils, especially the fibril angle, is species and developmental stage specific and an important determinant for industrial use of plant material as fibre paper, timber, etc. Future use of cellulose as source for biofuel and nanotechnological purposes, combined with new cell biological tools that make the process of its production visible in living cells, stimulates new research, and systems biology approaches allow backward modelling predicting cell modules underlying the cellulose synthesis process, and forward modelling enabling plant (WOOD) design.

Wood fibres ultrastructural organization influences their pulping behaviour and paper properties

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Fundamental understanding of the ultrastructural and macromolecular organization of the wood fibre walls is a prerequisite to the understanding of the behaviour of industrial fibres during their processing in the pulp and paper manufacturing. Based on microscopy studies and on the results of modelling of cellulose/xylan and cellulose/lignin interactions, the complex microfibrillar aggregation in lamellae that constitutes essential elements of the architectural framework of the lignocellulosic fibre walls justifies the patterns of delaminations and microfibrillation caused by the mechanical refining stages applied to chemical pulps.

Some characteristic consequences of paper recycling treatments may also be explained on the basis of the ultrastructural organization of the fibre wall. This is illustrated by the release of fine elements originating from the fibre wall whose re-integration into the fibre network was studied using a specific labelling method specially developed to that end.

The impact of genetic modifications of poplar trees on the fibre walls integrity was examined and correlated to the consequences on the pulping aptitude of the transformed plants.

Unresolved Matters In The Vascular Cambium: Where Do All The Cells Come From?

Peter W. Barlow, *School of Biological Sciences, University of Bristol*
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Using both light and electron microscopy to observe aspects of the growth and development of the vascular cambium and its derivatives in young cuttings of hybrid aspen (*Populus tremula* × *tremuloides*), three main questions emerged: 1) How do the various cell types come to acquire their characteristic spatio-temporal arrangements? 2) Do fusiform cells ‘sculpture’ the radial framework of the ray system? 3) What is the relationship between the distribution of newly forming rays and the onset of vessel formation? In other words, where do all the tissues and their cells come from? The first question has recently been addressed in connection with cellular determination and radial patterning in the secondary phloem (Barlow and Lück, 2006 – and here one case of radial patterning in secondary xylem was also mentioned). However, questions 2 and 3 also call for much more attention to be paid to the basic and remarkable systems of secondary growth and development (see Barlow, 2005). We shall deal briefly with each of these three questions, in so far as time allows.

FuncFiber; a large scale initiative towards understanding gene function in wood formation

Björn Sundberg, *Umeå Plant Science Centre, Department of Forest Genetics and Plant Physiology, Swedish University of Agricultural Sciences*
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A bridging task in tree biotechnology research is to identify and functionally understand genes underlying traits of commercial interest. At Umeå Plant Science Centre, scientists have used cryomicrotome dissectioning/microarray analysis to reveal key genes in wood formation. Information from UPSC wood transcriptomics is used by academics, and by SweeTreeTechnologies (STT) in their large-scale gene knock-down program in poplar. Within FuncFiber Centre of Excellence in Wood Science (www.funcfiber.se), more than 40 transgenic lines with preliminary phenotypes in wood properties emerging from this effort are currently under investigation. FuncFiber is an interdisciplinary program that combines biology, chemistry and chemometrics. Within the network state of the art technology for FT-IR wood imaging and NMR analysis of whole ball milled cell wall samples have been developed for wood phenotyping. The databank of transgenic trees with altered wood properties will provide more insight into our understanding of wood formation, from genes to wood properties.

High-resolution cambium dynamics: a useful approach for the determination of climate effects on wood formation in Scots pine trees

Uwe Schmitt, *Johann Heinrich von Thunen-Institute (vTI)*
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Intra-annual cambium dynamics were determined with high time-resolution for Scots pine trees growing at two sites in the Finnish boreal zone using the pinning technique. With this technique, during the vegetation period a thin needle is inserted weekly or bi-weekly in a stem through the bark and cambium into the xylem. Due to this action, the cambium immediately stops regular wood formation and develops wound tissue, which allows the amount of wood formation to be monitored microscopically. We could record onset, intensity and end of wood formation of individual trees. Two-third of the annual radial growth was produced within four weeks from mid-June to mid-July, just before the warmest period of the year. Dates of onset of cambial activity were compared with corresponding heat sums, calculated in degree-days. It was found that cambial activity started when heat sum accumulated to approximately 12.5% of the long-term site-specific sum of degree days.

The structure and function of pit membranes: new discoveries and impacts on whole plant hydraulic function

Steven Jansen, *Jodrell Laboratory, Royal Botanic Gardens, Kew*
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SEM and TEM observations illustrate that the pit membrane exhibits greater structural variation than previously thought, with a more than 20 fold difference in thickness (from 70 nm to 1892 nm) and maximum pore diameter (10 – 200 nm) across 26 hardwood species studied. Species from predominately wet or riparian habitats had thinner pit membranes while those from arid or saline habitats had thicker, less porous pit membranes. The large variation in pit membrane structure observed has the potential to exert a strong influence over the regulation and efficiency of water transport through the vascular system and the resistance of this system to dysfunction via air entry (cavitation) and xylem bourn pathogens. However, caution must be used when using pit structure to predict functional characteristics, because tissue level properties such as vessel diameter, length and wall overlap, also strongly influence hydraulic traits at the organ and whole plant level.

Does climate change and nutrient optimisation affect the wood structure and chemistry of Norway spruce (*Picea abies* (L). Karst.)?

Pekka Saranpää, *The Finnish Forest Research Institute*
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The effects of elevated CO_2 and fertilisation on growth rate and wood structure (fibre dimensions) and wood chemistry of Norway spruce was studied from a long-term nutrient-optimisation experiment in Flakaliden, northern Sweden and in Asa, southern Sweden. The experiment was established in 1987 in a 28-year-old stand in Flakaliden and in a 14-year-old-stand in Asa. Whole-tree chamber (WTC) experiments were carried out in Flakaliden between 1998-2000 and 2002-2004. The ambient [CO_2] was 365 and elevated 700 ppm.

Elevated CO_2 decreased slightly cell wall thickness in earlywood and increased tracheid diameter in latewood of Norway spruce. Nutrient optimisation had a significant effect on growth and wood properties. The fertilised trees had shorter and thinner-walled fibres than the control trees. Also, latewood proportion was significantly smaller and the concentration of lignin was higher in fertilised trees than in control trees. However, the effects were different between the two experiments.

Dendrochronology in the dense tropical rain forest of the Congo Basin: tree ring analysis of *Millettia laurentii* De Wild

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Management plans aiming at a sustained of production of forest functions and goods need reliable information on tree age and growth. The only way to obtain this key information in the tropics is often the analysis of growth patterns in the secondary xylem.

Stem disks of *Millettia laurentii* from the Shanga region in the Republic of Congo have been analysed. The rings appeared to be anatomically distinct with a border formed by marginal parenchyma, mostly followed by a wide band of fibres with nearly no vessels. This fibre band is followed by a typical alternation of narrower fibre bands and undulating banded parenchyma. In the centre of the tree, rings are often very narrow with unclear borders producing non-measurable rings.

Ring width series have been cross dated. The annual nature of the rings has been confirmed by radiocarbon analysis. High resolution analysis of stable carbon revealed a peak of the $\delta^{13}C$ concentration near the ring border. Lower $\delta^{13}C$ concentrations have been found in the parenchyma bands.

Quantitative Wood Anatomy in seedlings and tree rings

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In the second workshop on Quantitative Wood Anatomy held at the Swiss Federal Research Institute WSL in Birmensdorf (Switzerland) in May 2007, Quantitative Wood Anatomy (QWA) has been defined as a methodological approach based on the measurement of wood cell anatomical characteristics, analyzed through time and used to characterize the relationships between tree growth and various environmental factors. This approach can be applied at different scales, from the early deposition of cellulose microfibrils in cell walls, up to the analysis of different xylem cell-types in dendrochronological studies for ecological and technological purposes.

QWA can be considered a tool for a looking-back analysis to reconstruct developmental processes including cambial activity. Thus, it can be useful in Mediterranean woody species to detect the frequent anomalies in wood structure, such as the so-called false rings. In this framework, wood anatomy of the young structures is investigated together with the observation of plant architecture, to help understanding of cambial activity in such environments, also improving the functional interpretation of tree rings.

Microtubules and wood formation

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Cambial cells differentiate into secondary xylem cells through a process of cell expansion or elongation, cell wall thickening, cell wall sculpturing (formation of modified structure such as pits), lignification, and cell death. Considerable evidence in a wide variety of woody plant cells has revealed that dynamics of cortical microtubules are closely related to the orientation and localization of newly deposited cellulose microfibrils in the differentiating secondary xylem cells. Cortical microtubules play an important role in the morphogenesis of secondary xylem cells, thereby controlling the formation of wood. Therefore, cortical microtubules might provide a target for biotechnological applications to change the quality of wood.

Molecular basis of discoloration processes in broad-leaved trees – Gene expression analyses of key enzymes of flavonoid biosynthesis in *Robinia pseudoacacia* L.

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Discoloration processes in the wood of standing trees occur as constitutive heartwood formation or as a defence reaction to wood pathogens. In both cases these discolorations are characterized by the biosynthesis of flavonoids. The biochemical basis for flavonoid synthesis is a coordinated up-regulation of phenylpropanoid and flavonoid metabolism, in which the enzymes phenylalanine ammonia lyase (PAL) and chalcone synthase (CHS) play a key role. PAL and CHS genes are encoded by multigene families and show differential expression patterns – depending on tissue type, tissue development, environmental stimuli, and other factors. In black locust four PAL and six CHS genes were identified. Sequence information served for the design of gene specific primers (GSPs) for the individual PAL and CHS genes. Using these GSPs differential up-regulation of the individual PAL and CHS gene family members were shown during the discoloration processes under investigation.

Age-dependent xylogenesis in timberline conifers

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Neither anatomical change nor physiological abnormalities have been observed in the cambia of older trees. However, different sensitivity and period of significant responses to climate suggest the existence of some age-related change in the patterns of cambial activity and/or wood cell formation. We compared weekly cambial activity and xylem formation in adult (50-80 years) and old (200-350 years) conifers at the Italian Alpine timberline during 2004 and 2005. Timings and durations of xylogenesis differed between adult and old trees, with 2-3 weeks shorter cambial activity found in the latter. The delayed onset of cambium division and lower cell production in old trees, with respect to adult trees, led to reductions of 15-20% in the overall duration of xylem differentiation.

These results demonstrate that cambial dynamics change during the tree lifespan and that the time window of tree-ring production shortens with age.

Chiral structures in trees

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The chirality of lignocellulosic materials is expressed at many length scales, from the twisting of tree trunks to the molecular chirality of the sugar units in cellulose and hemicellulose. Some chiral structures and effects observed in tree-trunks, wood and paper will be described. Explanations for the chirality are unclear, but purely physical interactions between cellulose microfibrils may contribute. Aqueous suspensions of Cellulose I nanocrystals spontaneously form a chiral nematic ordered phase, providing clear evidence for a chiral interaction between the cellulose nanocrystals. However, the source of this interaction and its relationship with chiral structures at larger length scales remain unclear.

Better wood for better products – from understanding to application

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Wood is produced by a complex sequence of interactions between gene expression and the local environment and it is not surprising that the variation in wood properties within a stem is large with the greatest variation is found within an annual ring. By studying the pattern of wood property variation, within the context of its growth history, insight into cause and effect relationships are obtained. Combining this with temporal, high-resolution measurements of stem growth and the environment enables us to better understand wood formation and the causes of variability in wood properties.

This knowledge is also critical when it comes to wood-based materials. Different species, species mixtures and qualities drive properties of manufactured composite materials. Experiments done with several softwood and hardwood species, juvenile and mature wood, and different quality levels, demonstrated to what extent physico-mechanical and chemical parameters of manufactures boards are affected. Overall, species dependencies were strong, while juvenile-mature and other quality effects had lower predictive strength. The outcome suggests that a detailed understanding of wood relationships is needed, which needs to be implemented in future processing control to optimize wood resource utilization.

Modelling the hygromechanics of wooden panel paintings from the cultural heritage

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The capacity of wood to withstand considerable durations of loading, provided it has been properly processed and protected against biological attacks, made it a widely used support of historical paintings. However, in panels painted on one face the asymmetry of moisture movement and resulting curvatures has often resulted in visible damage of the paint layers and, occasionally, the wood itself. Mechanical models were developed to describe the response of painted panels to humidity fluctuations. The results of the predictions will be compared to data obtained on a few panels, including the wooden support of Mona Lisa from the Louvre museum.

Wood cell walls and nanostructures: challenge for wood science and industry

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Nanotechnology as the study of wood cell structures with dimensions of 1-100nm or larger (microstructures) is promising research and industrial application field. Cellulose consists of microfibrillated nanostructures with high stiffness and strength (whiskers). Less clear is state of lignin nanostructures. The Riga's group formulated hypothesis of lignin primary nanostructures as fractals. In the development of new nanomaterials the relationship between the structure, function, and properties is a key issue. Recently also the average shape of a lignin particle that cannot be characterized by some exact molecular formula has been determined with small-angle x-ray scattering (SAXS) using synchrotron radiation.

Supra-molecular nano-particles bridge the gaps between isolated monomers and the bulk material of cell walls. The experimentally observed nano-particles making new cell wall modifications with specific properties manifest size-dependent properties of the steam explosion auto-hydrolysis (SEA) technology. The present discussion on the risks of nanotechnologies has largely focused on the potential dangers of nanoparticles.

Influence of temperature on and some other parameters on the shear strength of glued wood joints

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The investigation covered the influence of temperature (T=20 to 220°C) on the shear strength of glued wood joints. Different adhesive systems (1C PUR;

different types and with filler), MUF, UF, PRF and PVAc investigated. Also the strain distribution with Video Image Correlation was tested.

With increasing temperature, the shear strength of solid wood and also of glued wood joints decreases. There are big differences in thermal resistance and fracture behaviour between the adhesive systems. PVAc glue fails at low temperatures of about 50°C. Phenol resorcinol resin reached the maximum values. But there are also differences within the individual groups. The thermal resistance of one-component polyurethane systems can be varied by modifying their chemical structure and by fillers.

Abstracts - Posters

Cambial reactivation and xylem differentiation in hybrid poplar by localized heating and under natural conditions

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The cambial reactivation occurred earlier than natural cambial reactivation in the localized heated main stem of a deciduous hardwood hybrid poplar (*Populus sieboldii* x *P. grandidentata*). Cell division in phloem began earlier than cambial reactivation. Well-developed secondary xylem was produced in heated stem. When cambial reactivation was induced by heating, the buds of trees had not yet burst, indicating that there was no close temporal relationship between bud burst and cambial reactivation. In heated stems, after cambial reactivation, storage starch disappeared completely and it appeared again, near the cambium, during xylem differentiation. In addition, under natural conditions, earlier increases in ambient temperature induced earlier cambial reactivation. Our results suggest that, in deciduous diffuse-porous hardwood poplar growing in a temperate zone, the temperature in the stem is a limiting factor for reactivation of phloem and cambium. Localized heating in poplar stems provides a useful experimental system for studies of cambial biology.

Monitoring of wooden aircraft structure for the detection of compression failure

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The aim of this study was to identify non-destructive testing methods for crack detection in spars, which are structural components of light wooden aircraft. The term compression crack refers to a structural anomaly that occurs as a fine fracture perpendicular to wood fibres. A crack results from significant deformation followed by compression failure of the wood cells. Crack formation is accompanied by several transverse fissures in the material. Monitoring the spars helped to determine the inspection problem. The cracks were located on both the upper and lower surfaces of the wing. Cracks formed close to the wing/fuselage joint and extended to the landing gear attachments. The selected methods used in this study are: thermal imaging (surface inspection with direct access), X-ray analysis (deep inspection without direct access), ultrasound (deep inspection with direct access) and acoustic emission (passive detection without direct access – In-service monitoring).

Wood teak quality from plantations - Input of Near-Infrared Spectroscopy tool

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Quality control of the planting material is essential to guarantee the reliability and the future of teak plantation. Outcomes from Cirad collaborative researches on teak genetic improvement including selection on wood traits combined with the development of efficient nursery and in vitro propagation methods have led to the availability of superior quality planting material.

Near-infrared spectroscopy (NIRS) is useful for estimating chemical and physico-mechanical wood properties. Fibre saturation point and natural durability classes estimated by standard methods of teak wood samples from Malaysia-Sabah and Africa (Togo, Ivory Coast, Ghana) were correlated by partial least squares regression with NIRS spectra data taken on the same samples.

Predicted values from NIRS calibration models were compared to measured ones with success and associated with core sampling this approach will allow us to predict these traits of a large number of wood samples from different origin in short times.

Scanning electon microscopy on woody plant remnants from bronze age settlement (ebla, syria).

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The period of its greatest wealth and power of Ebla the ancient city excavated at the site of Tell Mardikh in Syria was in the middle of 3rd millennium. A large royal Palace of this period has yielded an archive of more than 15,000 clay tablets. The clayey tablets have revealed a wealth of information about the political organisation, economy, history and religion of the city which was an important commercial centre, exporting valuable furniture, woollen cloth to surrounding countries. In 2nd mill. B.C. after destruction the City was rebuilt with a great palace complex (Matthiae P., 1977; AA. VV., 1995). Plant remains found during excavations at Tell Mardik reveal the wooden taxa used in the city palaces. Timber was represented by building structures, poles and planks, by decorations or by door-cupboard or by various furnishings and yet by the inner structure of objects. Pillars too arranged all around the Ceremonial hall are no longer in sight but for the large round holes in the floor which show their original place and size. Timber used for small statues or for funitures was also carved with stone inlay works or covered by gold laminae. It has mostly been preserved as charcoal pieces due to the fires that spread all over the site several times. Up to now among these remnants a few taxa have been identified: cedar, pine, oak, olive, dogwood, maple, poplar.

Cambium phenology, wood formation and temperature thresholds in two contrasting years at high altitude in Southern Italy

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Xylogenesis was monitored during 2003 and 2004 in order to assess links between temperature, cambium phenology and wood formation. Wood microcores were collected weekly from May to October on ten trees of *Pinus leucodermis*, histological sections were cut and anatomical features of the developing and mature tracheids were observed and measured along the growing tree-ring. Spring 2003 was hotter than in 2004, with temperatures up to 2.6ºC above the averages which anticipate cambium activity and the differentiation phases of about 20 days. Air temperature at which xylogenesis is active was calculated and similar thresholds of 8ºC were estimated for both year. The dynamics of ring-width increase differed between the two years, with smaller ring-widths formed in 2004. These differences were mainly related to cell size since larger earlywood tracheids were produced in 2003. This study shows the plasticity of tree-ring formation in response to high temperatures by modifying the onset and duration of differentiation.

Anatomical and chemical characteristics of Miocene Taxodiaceae species from Bükkábrány (Hungary)

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Worldwide unique tree trunks were found in an outcrop mine near Bükkábrány (Hungary), in the July of 2007. Presumably as a result of an extraordinary motion of the field the Taxodiaceae trunks were hermetically embedded in sand, and their structure was preserved in the last near 8 million year; they didn't become siliceous. Samples were collected from the trunks, and the macroscopic and microscopic anatomical structure and chemical composition were examined. The aim was to identify the species, and to clarify degree of the morphological and molecular degradation. The first results show, that the cellulose content of the fossils are between 20 and 30%. Although the strength of the wood was decreased, it could preserve the original shape. The examinations of the annual rings and the cell types show, that more species from the Taxodiaceae were present in the same time (*Taxodium distichum, Sequoia sempervirens*) in that flora.

The patterns of cell death of rays in conifers

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We compared the pattern of cell death between ray parenchyma cells and ray tracheids in conifers by microscopy. The differentiation and cell death of ray tracheids occurred successively and both were related to the distance from the cambium. By contrast, in ray parenchyma cells, no successive cell death occurred even within the same radial cell line of a ray. In addition, cell death occurred earlier in ray parenchyma cells that were located in the upper and lower cell lines and that were in contact with ray tracheids than the others. Such ray parenchyma cells showed difference in the timing of initiation of cell wall thickening, the orientation of microtubules and the amounts of starch and polyphenols from the others. Our observations indicate that positional information is an important factor in the control of the pattern of differentiation and, thus, of the function of ray parenchyma cells in conifers.

Variations in mazur xylem structure in native finnish tree species

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Mazur birch (*Betula pendula* var. *carelica*) is a commercially important tree in Finland. In this variety the xylem is characterized by a "mazur flower" figure on the cross-sectional surface of the trunk, indented growth rings, brown streaks or elliptical figures and irregular or wavy grain often forming swirls. In the xylem brown figuration is variable and some trees lack it altogether. The formation of mazur xylem is caused by abnormal functioning of the cambium and is supposed to be a hereditary trait.

Our new project studies the mazur-like xylem found in a number of Finnish trees. We aim to answer the following questions: 1) Which mazur characters appear in each species? 2) Are the coniferous species different from the deciduous species? 3) Is it possible to describe a special kind of mazur xylem figure applicable to all species? 4) What is the relationship of bird's eye figure to mazur figure?

Functional Characterization of a Microtubule-Associated Protein, MAP20, in Poplar and *Arabidopsis*

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Cortical microtubules (MTs) are thought to be exerting their control on cellulose microfibrils (MFs) and other developmental aspects of plant biology via a host of different proteins collectively known as microtubule-associated proteins (MAPs). We are carrying out functional analysis of one such MAP, *PttMAP20* and its closest *Arabidopsis* homolog. Several transgenic poplar RNAi lines with much reduced expression of *PttMAP20* have been produced, as well as *35S::PttMAP20* overproducing lines. These transgenic lines are currently being phenotyped for wood characteristics using a battery of FuncFiber wood phenotyping tools for more conclusive understanding of its function. In *Arabidopsis* several T-DNA insertion lines have been identified without any obvious growth phenotype. More in depth analyses of Arabidopsis MAP20 function currently being carried out on the insertion lines, as well as a number of transgenic lines. These transgenic lines include over-expressers producing Arabidopsis and poplar MAP20, RNAi lines, promoter/GUS lines and fluorescent tag lines. Analysis of these plants will shed light on the role(s) MAPs play in plant growth.