plant Signaling & Behavior

Annual Meeting of the Society of Plant Signaling & Behavior 2013

July 8-10, 2013 | Vancouver, Canada

PROGRAM AT A GLANCE

Monday July 8th		
Session #	**Time**	**Venue**
S1	8:30am-10:00am	Irving K. Barber 182
Coffee Break	10:00am-10:20am	Irving K. Barber Lobby
S2	10:20am-11:40pm	Irving K. Barber 182
Lunch and Poster Session	12:00pm-1:00pm	Irving K. Barber 185
S3	1:00pm-3:10pm	Irving K. Barber 182
Coffee Break	3:10pm-3:50pm	Irving K. Barber Lobby
S4	3:50pm-5:50pm	Irving K. Barber 182
Opening Reception	6:00pm-9:00pm	Mahoney & Sons

Tuesday July 9th		
Session #	**Time**	**Venue**
S5	8:00am-9:50am	Irving K. Barber 182
Coffee Break	10:00am-10:15am	Irving K. Barber Lobby
S6	10:45am-12:05pm	Irving K. Barber 182
Lunch and Poster Session	12:00pm-1:00pm	Irving K. Barber 185
S7	1:00pm-3:00pm	Irving K. Barber 182
Coffee Break	3:00pm-3:20pm	Irving K. Barber Lobby
S8	3:20pm-5:20pm	Irving K. Barber 182
Conference Banquet	6:00pm-10:00pm	Cecil Green Park House

Wednesday July 10th		
Session #	**Time**	**Venue**
S9	8:00am-10:20am	Irving K. Barber 182
Coffee Break	10:15am-10:30am	Irving K. Barber Lobby
S10	10:30am-12:30pm	Irving K. Barber 182
Lunch and Poster Session	12:30pm-1:30pm	Irving K. Barber 185
S11	1:30pm-5:00pm	Irving K. Barber 182

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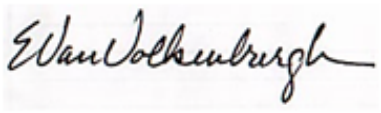
Welcome!

We are delighted to welcome you to the First International Symposium of the Society for Plant Signaling and Behavior, and to the University of British Columbia in Vancouver, BC Canada.

This is the first time this group has met in North America! Our previous symposia, held under the name of the Society for Plant Neurobiology, and were held in Europe (Italy, Slovakia) and Asia (China, Japan). We are excited to have this opportunity to bring our research and scientific discussions here, and to welcome travelers from other continents to this spectacular venue.

Our meetings are dynamic, presentations are wide-ranging, and conversations uncover new ideas, collaborations, and questions to pursue. The focus is scientific discovery of the basis for plant behavior: how do plants sense their environment, integrate sensory information and encode responses to optimize their existence? Research will be presented addressing: molecular and genetic mechanisms of sensing input and signaling, cellular processes involved in regulating metabolic responses, and ecological contexts that have driven evolution of complex, fascinating plant behaviors. The results inform fields not only in plant biology and agriculture, but also more generally neurobiology and behavior, ecology and evolution, philosophy, communication, and social sciences especially in those fields related to food and environmental issues.

We hope that you enjoy the meeting, the formal presentations, informal exchanges, social times and opportunities to wander on the UBC Campus. Please let us know if we can help you make the most of your time here,



Elizabeth Van Volkenburgh, President of the Society

Susan Murch, Symposium Organizer

Cover Design: The Pacific Dogwood (*Cornus Nuttallii*) is the provincial flower of British Columbia. The trees are native to the region, and frequently grow below or near to Douglas-fir (*Pseudotsuga Menziesii*).

CONFERENCE ORGANIZING COMMITTEES

Conference Management Committee

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University of British Columbia, Canada

Frantisek Baluska
University of Bonn, Germany

Mary Jane Beilby
University of New South Wales, Australia

Stefano Mancuso
University of Florence, Italy

Liz Van Volkenburgh
University of Washington, USA

Scientific Committee

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University of New South Wales, Australia

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Oscar Lorenzo Sánchez
Universidad de Salamanca, Spain

Narendra Tuteja
International Centre for Genetic Engineering & Biotechnology, India

Three Poems
Sonnet L'Abbé

Brain Stem

Strong neck the channel through which your roots become branches. Strong neck the trunk through which your impulses flow, tides of perception and reaction. You are a battery of cells, positive of material, anti-positive of nervous potential. You are a dyad of bunches of waving branches and bundled branches, of bunches of searching roots and rooting roots. The spine of your decision-making: a flexible stem of tension between head and heart. You, a moving tree that grows in more dimensions than knowledge: in knowledge's reach, yes, in its span, but also, if you are lucky, in wisdom's rootedness, in its pithy density. Your risked neck's bark has become thickened to injury, and lifts above its veiny heart a tender head of power—its stem ever spring-fond, ever fall-wise—a grey-green cauliflower that loves light.

Hue

In many languages hue is not separated into blue and green. It is all blue, greenish. The body sits like a greenblue stem under the sun. Human, all its greenness is inside, flowing back blue rivers from its extremities. Tides of blue sky come in, move out of the lungs. The system sips clear green water. Mouth tears up at the taste of lettuces. Who can know even all the blue leaves on the tree outside my window? How many monks sit writing in the walled city of the cell? Every breath a kind of autumn, the little green platelets reddening again.

Identify The Species In This Passage

Outside in the East Van street the green shapes were nameless all around me. Pinophyta and magnoliophyta expressing verdant, verdant, verdant. Teardrops of limebright in the throng of photosynthesis. Boathulls of emerald breathing our dioxides. Waxy dark green hexablooms, kelly green calligraphic tips. The thin green grass blades, thick green grass blades, populations of graminoids. Chlorophyllic fleshes of olivehue and moss. Jade tint turning its flat faces to the sky. Sprays of green scales, bursts of green platelets gathering the particles of thujaplicin. Celadon chroma drooping needles overhead. Evergreen spiralling up into sage canopies. Branches of green fans refusing anastomosis. Tender green lobing from spur shoots, sporophylls flagellating in love to live female fossils. Thickets of bluegreen sepaling ornament and sweeten. Everywhere the green smell of cis-3-hexanal.

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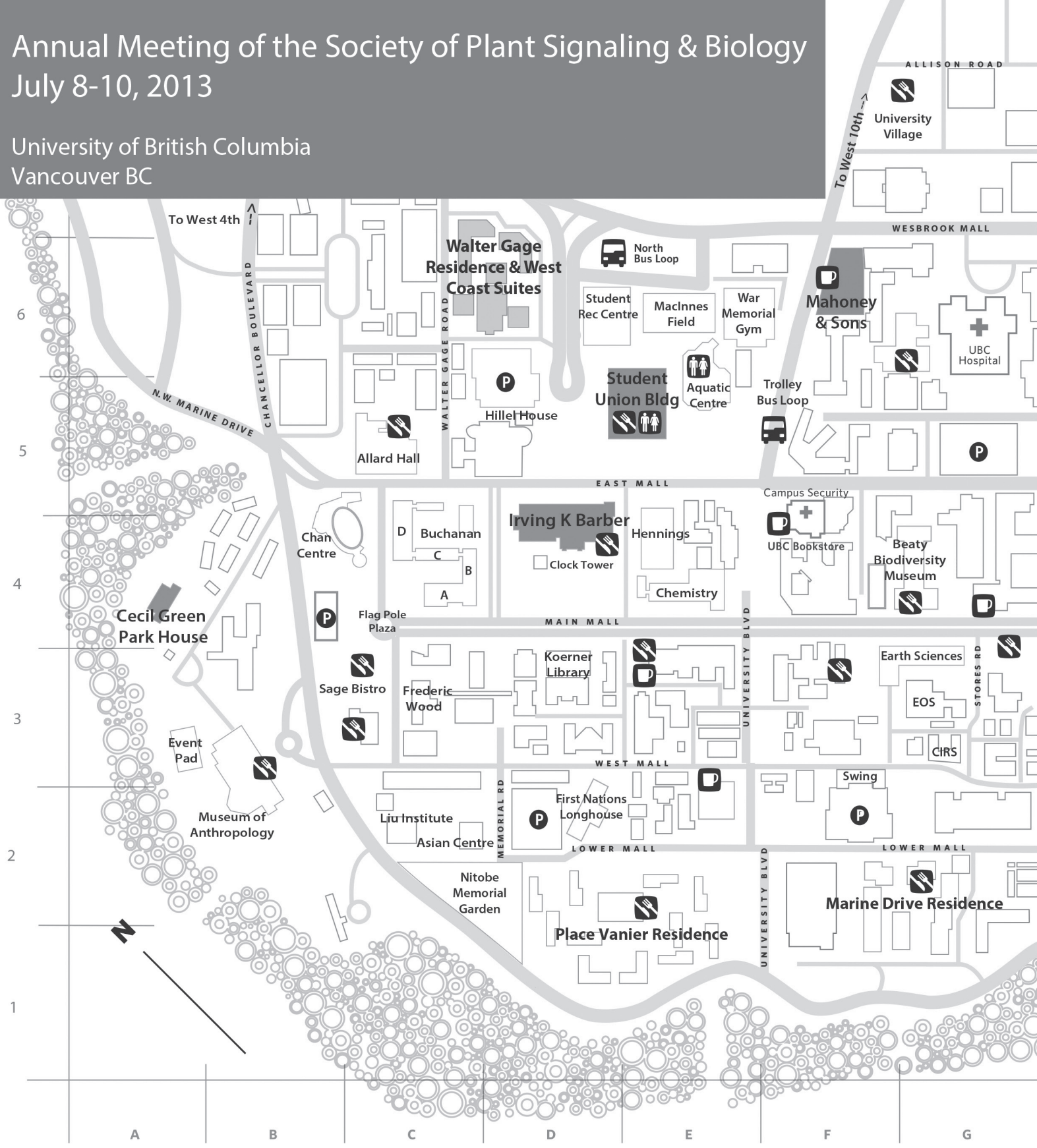
Vancouver BC



Accommodation

D 6 Walter Gage Residence & the West Coast Suites

Breakfast

E 5 Pacific Spirit Cafeteria, Student Union Building

Meeting Space

D 4 Irving K. Barber Learning Centre

Social Functions

A 4 Cecil Green Park House

F 6 Mahoney & Sons

PSB 2013 GENERAL INFORMATION

Registration Desk Hours

Sunday, July 7	4:00 PM – 6:00 PM
Monday, July 8	8:00 AM – 11:00 AM
Tuesday, July 9	8:00 AM – 11:00 AM
Wednesday, July 10	8:00 AM – 11:00 AM

Registration fees include all coffee breaks and lunches during the conference, as well as entrance to the Opening Reception and Conference Banquet.

Conference Banquet
Tuesday, July 9 from 6:00 PM – 10:00 PM
Cecil Green Park House

Conference Venues
Academic sessions will be held on the lower level of the Irving K. Barber Learning Centre.

Presentation Guidelines
Oral presentations should be prepared in PowerPoint and saved on a USB flash drive. Please bring your presentation to the conference office (Irving 192) at least two hours prior to the start of your session. For presenters in the first morning session, please deliver your presentation the evening prior to your session.
The lecture room is equipped with a podium PC which operates with Microsoft Office 2010 and Windows 7, and it is the delegate's responsibility to ensure their presentation is compatible with UBC's operating system.

Poster presentation – Posters should measure not larger than 40" x 40" (1 m x 1 m) with fonts not smaller than 28 pt. Set up is Monday, July 8 from 7:00 AM – 12:30 PM in Irving 185.

Name Badge
Admission to all conference activities is by name badge only. Please be sure to wear your badge at all times.

Responsibility
The Organizing Committee assumes no responsibility for accident, losses, damage, delays, or any modifications to the program arising from unforeseen circumstances. It accepts no responsibility for travel or accommodation arrangements.
The participant acknowledges that he or she has no right to lodge damage claims against the Organizing Committee should the conference proceedings be hindered or prevented by unexpected political or economic events or generally by acts of god, or should the non-appearance of speakers or other reasons necessitate program changes.

Internet Access
Wireless internet access is available in most buildings and outdoor spaces on campus by choosing the "ubcvisitor" network from your wireless options. Additional internet stations are available at any UBC library. Guest terminals are available on main floors.

On-Campus Accommodation
Walter Gage Residence - 5959 Student Union Boulevard
Marine Drive Residence - 2205 Lower Mall
Place Vanier Residence – 1935 Lower Mall
Totem Park Residence – 2525 West Mall

All residences are open 24 hours per day, 7 days per week. Check-in is from 3:00pm and check-out is by 11:00am. For more information, please contact the front desks through the Conferences and Accommodation Reservations Office at 604-822-1000.

Banking and Foreign Exchange
The Bank of Montreal, open Monday – Friday, and the Canadian Imperial Bank of Commerce, open Monday – Saturday, are both located in the University Village, and provide banking and exchange facilities. Automated teller machines are available in all banks, in the lobby of Walter Gage Residence, and in the Student Union Building.

Taxis
Taxis are available in front of Walter Gage Residence, or by calling 604-681-1111. Fare to the airport or downtown is about $40 CAD.

Public Transit
The Translink (Vancouver's public transit system) Bus Loop is located across the street from Walter Gage Residence. Bus schedules are available in the Student Union Building. Buses require exact change ($2.75 for a One Zone/one-way trip within Vancouver). Packs of bus tickets ($21 for 10 one-zone tickets) may be purchased in the Student Union Building or at Shoppers Drug Mart. See www.translink.ca for more information.

Childcare
Childcare services are not offered by the conference.

Campus Safety
Campus Security can be reached 24/7 at 604-822-2222. There are also blue light phones located on campus, which provide a direct connection to Security for emergency situations or general assistance.

Emergency Telephone Numbers
Emergency – Police, Ambulance, and Fire 911
Police (RCMP) Non-Emergency 604-224-1322

Emergency Care
Urgent Care Centre at UBC Hospital
Open daily from 8:00 AM to 10:00 PM
Phone: 604-822-7662 or 911
Address: 2211 Wesbrook Mall

Insurance
Liability insurance is the responsibility of each individual delegate. Visitors are not covered by the Canadian Medical Health Insurance Plan. Delegates should have their own medical coverage.

Lost and Found
All materials lost or found in academic buildings are brought to the Lost and Found Office located in the Campus Security Office. The Security Office is located at 2133 East Mall, or can be reached from 9:00 AM to 5:00 PM, Monday through Friday at 604-822-9922. Visit security.ubc.ca/content/lost-and-found to report a lost item.

On Campus Walk-In Clinics
University Village Medical and Dental Clinic
Walk-in and appointments welcome
Open Monday to Friday, 8:00 AM – 6:00 PM
Phone: 604-222-2273
Address: 228-2155 Allison Road (upstairs from Staples)

On Campus Pharmacies
University Pharmacy
Open Monday to Friday, 9:00 AM – 8:00 PM
Saturday & Sunday, 10:00 AM – 6:00 PM
Phone: 604-224-3202
Address: 5754 University Blvd

Shoppers Drug Mart
Open daily from 8:00 AM – 10:00 PM
Phone: 604 228-1533
Address: 5950 University Blvd

Student Union Building (SUB) and University Village
Central to the conference venues, the SUB offers a number of food outlets, shops, and postal services.
At the entrance to the campus on University Boulevard is a small shopping centre, within walking distance of the conference venues. The University Village includes two banks, a pharmacy, photocopying service, restaurants and fast food outlets.

Parking
Limited parking is available at the Residences for those guests staying on-campus for a daily rate. Delegates staying off campus can park in the one of the parkades or budget surface lots on campus.

Printing and Copying Services
CopyRight (basement of the SUB): Offers copying, printing, laminating, binding and faxing.
Hours: Monday to Friday 10:00 AM – 4:00 PM. Self-serve copiers available from 7:00 AM – 11:00 PM.
Copiesmart (in the University Village): Hours: Monday – Friday from 8:30 AM – 5:00 PM, and Saturday from 11:00 AM – 5:00 PM
Staples (in the University Village): Hours: Monday – Friday from 9:00 AM – 7:00 PM, Saturday from 10:00 AM – 6:00 PM, and Sunday from 12:00 noon – 5:00 PM.

Recreational Facilities
The BirdCoop is located in the Student Recreation Centre with a comprehensive range of exercise equipment, and is open seven days a week. Visit birdcoop.ubc.ca for more information.
The UBC Aquatic Centre has public drop-in times for its pool, gym, sauna and whirlpool facilities.
Visit aquatics.ubc.ca for hours.

UBC Bookstore
The University Bookstore is located on the corner of University Boulevard and East Mall. The bookstore is open Monday to Friday, 9:30 AM – 5:30 PM, and Saturday, 11:00 AM – 5:00 PM.

Construction on Campus
The Organizing Committee greatly appreciates the patience of all our conference delegates with regards to the construction on campus. UBC is undergoing several major projects to improve the layout and sustainability of campus facilities for students and visitors.

UBC Sustainability Initiatives
UBC offers a comprehensive set of sustainability projects and initiatives to help facilitate the change towards a sustainable future. UBC demonstrates leading practices in both institutional and residential green building on campus.
See ubcconferences.com/about/sustainability/ for more information on our sustainability practices.

***Please note that times listed are subject to change; to confirm current hours please contact the facility or store directly.*

Monday, July 8

Conference Opening: Plant Signaling and Behavior describes a growing, but also old and fascinating field in plant biology addressing the physiology of adaptive behavior in plants.

Chair: Elizabeth Van Volkenburg

Session Number	Abstract Number	Time	Speaker	Title
S1	none	8:30 AM	Elizabeth Van Volkenburg	Welcome & Opening Ceremony
	2999	8:45 AM	Dieter Volkmann	Eduard Strasburger (1844 - 1912) Inspirator of plant signaling
	3048	9:20 AM	Jack Schultz	Talking plants: a brief history and big future
Coffee and Poster Session (10:00 AM)				

Mechanisms of Plant Communication: Our view of plants is changing dramatically. Plants are revealing themselves to be very dynamic and highly sensitive organisms that actively and competitively forage for limited resources, both above and below ground, organisms that accurately gauge their circumstances, use sophisticated cost-benefit analysis, and take clear actions to mitigate and control diverse environmental threats. Moreover, plants are capable of complex recognition of self and non-self and are territorial in behavior. Indeed, their behaviors are as sophisticated as those observed in animals but their potential importance has been masked by the fact that plants operate on time scales many orders of magnitude slower than their animal counterparts. The study of plant behavior and their ability to communicate in complex environments clearly is of great ecological and evolutionary interestbut most importantly, of significant applied value. Indeed, our ability to achieve crop production adequate to meet population growth while using dramatically reduced arable land relies largely on the production of healthy plants through novel methods and innovative approaches. Understanding plants in their whole communicative and signaling complexity is expected to support the development of such new strategies to meet these critical challenges.

Chair: Monica Gagliano

Session Number	Abstract Number	Time	Speaker	Title
S2	3010	10:20 AM	Martin Heil	Volatile organic compounds play multiple roles in plant resistance
	2870	10:40 AM	Richard Karban	Plant Communication and Kin Recognition for Sagebrush
	3008	11:00 AM	Ariel Novoplansky	Anticipating stress by eavesdropping on neighbors
	3068	11:20 AM	Rainer Hedrich	Humidity sensing in guard cell

"The Society of Plant Signaling and Behavior opened up wider perspectives to my research in membrane electrophysiology. With my background in Physics I tended to think of plant cells as black boxes with resistors and capacitors, rather than fellow creatures with survival strategies. New collaborations, initiated at the society conferences, are taking my research in new and interesting directions."

- Mary Jane Beilby, The University of New South Wales

Lunch and Poster Session (12:00 PM)

Plant Signaling Molecules: Plants use a wide variety of molecules to send information between cells and stimulate responses to environmental cues. These plant signals are transient and highly variable making plant signaling molecules among the most difficult to study and understand. This session will focus on the signals and receptors that control the flow of information in plant metabolism.

Chair: Max Jones

Session Number	Abstract Number	Time	Speaker	Title
S3	2992	1:00 PM	Baluska, Frantisek	Neurobiological View of Higher Plants - The Case of Auxin
	3026	1:30 PM	Patrick Masson	Gravity Signal Transduction in Arabidopsis Roots
	3014	1:50 PM	Roni Aloni	Transport pathways of auxin and ethylene and their role in controlling vascular differentiation and lateral root initiation
	3024	2:10 PM	Lai-Hua Liu	The function of a glutamate receptor-like gene mediates the root response to external L-Glu
	3033	2:30 PM	Frank Ludewig	GABA is involved in stomatal movement
	3052	2:50 PM	Christina Turi	Metabolomics Analysis as a Tool to Understand Abiotic Stresses

Coffee and Poster Session (3:10 PM)

Session Number	Abstract Number	Time	Speaker	Title
S4	3022	3:50 PM	Tomokazu Koshiba	YUCASIN is a novel potent inhibitor of a key enzyme YUCCA(s) in plant auxin biosynthesis
	3021	4:10 PM	Christopher Keller	A possible role for abscisic acid in controlling the growth effects of indole-3-acetic acid in expanding Arabidopsis leaves
	3025	4:30 PM	Hiromi Suzuki	Possible involvement of ZmPHOT1 and ZmPHOT2 in blue light perception to phototropic curvature in maize coleoptiles
	3039	4:50 PM	Max Jones	Self destructive behaviour of plants in vitro
	3046	4:10 PM	Jorge Nieto-Sotelo	Evolution and role of mayehuelin, a developmentally-regulated protein from the central spike leaves of Agave tequilana with high similarity to RIPs
	3045	5:30 PM	Chhavi Aggarwal	Interplay between phosphoinositides and Ca2+ in phototropin1- and phototropin2-mediated chloroplast movements in Arabidopsis

"The Society of Plant Signaling and Behavior is the reflect of a whole plant organism composed of very specialized scientists working at different scales of time and space linked together by some messages allowing them to make evolve the research in function to environmental changes."

- Jean-Louis Julien, Blaise Pascal University

Tuesday, July 9

Animal-Like Behaviors of Plants: Plant behavior is emerging new topic of plant sciences. After our first plant neurobiology symposium in 2005, establishment of journal 'Plant Signaling and Behavior' as well as the society 'Plant Neurobiology' (renamed later in the society of 'Plant Signaling and Behavior'), some new topics/terms successfully entered into the mainstream of contemporary plant sciences. Plant behavior belongs to them and it is generally accepted now that plants behave in similar ways as also animals do. Of course, this was known already more than 150 years ago, when Charles and Francis Darwin's published their famous book 'The Power of Movements in Plants'. Unfortunately, the mainstream did not accept this more active view of plants which included sensory modalities and active behavior of higher plants. Presently, the number of examples and systems is increasing and it is getting obvious that plants actively sense their surroundings and the sensory receptors feed into diverse signaling networks, allowing both memorization and integration of obtained sensory information. Plants can share this information with other plants using chemical communication. Informed plants then modify their behavior accordingly. Roots are particularly active in their behavior as they navigate through soil, exploring large soil areas. Their behavior includes recognition of self – non/self, kin recognition, swarming intelligence, navigation towards water and nutrition, as well as avoidance or escape tropisms from poor or dangerous/toxic soil areas. Some roots even can show aggressive behavior and they can kill roots from competing plants using secreted toxic substances. At the root apex tip, the root cap represents the major sensory organ of plants which instructs growth responses in the elongation regions. Control of root growth and navigation includes animal-like sensory / motoric circuits. In words of Charles and Francis Darwin's root tips '… having the power of directing the movements of the adjoining parts, act like the brains of lower animals; the brains being seated within the anterior ends of the body, receiving impressions from the sense-organs, and directing the several movements."

Chair: Frantisek Baluska

Session Number	Abstract Number	Time	Speaker	Title
S5	2861	8:00 AM	Michael Marder	Plant Intelligence and Bio-Attention
	3067	8:30 AM	Rainer Hedrich	Carnivorom – towards the senses of the Darwin plant
	2954	9:00 AM	Axel Mithöfer	New aspects of captured prey-induced leaf movement in carnivorous Drosera
	2860	9:30 AM	Gladys Cassab	Do hydrotropism and phototropism evolved in parallel to secure carbon and water in the plant?
Coffee and Poster Session (10:00 AM)				

Regulation of plant behaviors by artificial lights: Light can be considered as the mean of conveying energy (in case of photosynthesis) and information (natural and artificial environmental stimuli) captured or sensed by living plant cells. Nowadays, variety of novel light sources such as high brightness light emitting diodes (HB-LEDs) and organic light-emitting diodes (OLEDs) are available. This session highlights the ongoing studies applying such new lighting devices for both positive and negative regulations of plant signaling and behaviors in both higher plants and green algae. Topics covered include the search for novel plant pigments required for perception of specific light, and the light-dependent regulation of ROS generation, programmed cell death, biosynthesis of pigments, seed and bulb dormancy, host harvest fruit maturation, root growth and morphology, and photosynthetic efficiency (by modification of carbon dioxide uptake and optimization of photon usage). In addition, phototropic behaviors in growing roots and swimming green algae may contribute to future development of enhanced plant production protocols and micro-biorobotic applications (BioMEMS), respectively.

Chair: Tomonori Kawano

Session Number	Abstract Number	Time	Speaker	Title
S6	3058	10:15 AM	Tomonori Kawano	Micro-biorobotic controls of green paramecia under artificial lights
	3055	10:45 AM	Nguyen Hoang Trung Hieu	High-speed pulsing control of HB-LED for efficient photosynthesis
	2994	11:05 AM	Ken Yokawa	ROS-mediated UV-B avoidance behavior in Arabidopsis roots
	3056	11:25 AM	Kiyoshi Moritaka	Action spectra for inhibition of radicle elongation in Cucurbita embryo: Search for the key pigments as potential photoreceptors
	3054	11:45 AM	Diego Comparini	Go green, stay green under green light

Lunch and Poster Session (12:00 PM)

Electrophysiology and interaction of ion transporters: The electrical nature of living organisms is well known in animals, with action potentials underpinning the sensory systems and muscular movement. In plant cells ion transporters are just as important. In this session we explore the importance of ion channels working in synergy and responding to chemical and mechanical signals. Action potentials lead to fast closure of insect trap in Venus flytrap and to sudden leaf movements in Mimosa. Ion channels respond to reactive oxygen species to program cell death. Turgor change in neighbour cell is transduced into electrical wound signals. Faced with increase in salinity, salt tolerant plants restore their turgor by importing osmotica into vacuoles and exporting sodium ions from the cytoplasm. These and other examples of importance of ion transporters in plants will be covered in this session.

Chairs: Francois Bouteau and Mary Beilby

Session Number	Abstract Number	Time	Speaker	Title
S7	2883	1:00 PM	Alexander Volkov	Electrophysiology of biological sensing and signal transduction in the Venus flytrap and Mimosa pudica
	3051	1:30 PM	Teruo Shimmen	Characeae as a model system for electrophysiological studies on intercellular communication
	3031	2:00 PM	Francois Bouteau	Ion channel regulations during Ozone-induced programmed cell death
	3023	2:30 PM	Mary Jane Beilby	Ion transporters involved in salt tolerance/sensitivity of characeae

Coffee and Poster Session (3:00 PM)

Session Number	Abstract Number	Time	Speaker	Title
S8	3066	3:20 PM	Tracey Ann Cuin	Deciphering the mechanisms underlying action potential initiation and propagation in plants - the role of K+-selective channels
	3032	3:40 PM	Lars Lehner	Surface Sum Action Potentials (APs) and Electro-Physiograms (EPGs) as a Basis for Systems Biological Analysis of Plant Behavior
	3027	4:00 PM	Pilar Gil	Quantifying effects of soil water content, vapor pressure deficit and electrode position on electrical potentials in *Juglans regia* and *Vitis vinifera* using multivariate statistical methods
	3006	4:20 PM	Luis Gurovich	A new plant water stress sensor based on the electrophysiology behaviour of fruit bearing trees
	3050	4:40 PM	Elisa Masi	Action potentials in the root apex are dependent on gravity
	3035	5:00 PM	Jean Marie Frachisse	Mechanosensitive Channels and Plant Signaling

Conference Dinner: Cecil Green - 6:00 PM

"The Society of Plant Signaling and Behavior is a leader in integrative systems physiology."

- Dr. Günther Scherer, Leibniz University Hannover

Wednesday, July 10

Learning from the plant kingdom: The Plant Kingdom represents an amazing source of inspiration. The aim of the session is to present and discuss the importance of investigating plants for learning from their structure and behaviour, and for mimicking their features to develop new technologies and systems. Despite their amazing abilities plants have rarely been a source of inspiration for fields as robotics and artificial intelligence, doubtless because of misconceptions on their capabilities and their radically different functional principles as compared to other living organisms. Mimicking plants requires deep investigation of new materials, mechanisms, sensors, actuators, and control schemes and can lead to breakthrough advances of technologies. In this session, we wish to contribute to the discussion on the development of biomimetic solutions inspired by plants looking at the importance of integrating knowledge coming from different fields as biology, engineering, chemistry, computer science, and physics to conceive and develop advanced systems, with the objectives of providing an authoritative overview of solutions inspired by plants.

Chair: Stefano Mancuso

Session Number	Abstract Number	Time	Speaker	Title
S9	TBD	8:00 AM	Stefano Mancuso	Learning from the plant kingdom
	3062	8:30 AM	Barbara Mazzolai	Plantoid: A new robot inspired by plant roots
	3041	8:50 AM	Camilla Pandolfi	On the mechanisms of the self-burial seed dispersal of *Erodium cicutarium*
	3053	9:10 AM	Ramsey Affifi	Plant learning and intentionality: Some research questions and directions
	2858	9:30 AM	Monica Gagliano	Animal-like learning in *Mimosa pudica*
	3069	10:00 AM	Sonnet L'Abbe	The Plant Intelligence Project
Coffee and Poster Session (10:15 AM)				

Plant Responses to Environment: Plants are highly dynamic in their acclimations to the prevailing environmental conditions. Environmental challenges that plants need to deal with include biotic and abiotic factors. Biotic challenges include herbivores, pathogens and competing other plants, whereas abiotic stresses are wide-ranging and include, but are certainly not limited to, salinity, drought, flooding, temperature extremes, heavy metals, and more. Plants show a wide variety of responses to these various environmental stresses, thereby adjusting their behavior to the prevailing conditions. Understanding the molecular and physiological mechanisms that enable plants to show adaptive responses to these environmental challenges is the central theme of this session. The invited speakers will address responses to biotic and abiotic stresses, as well as their interactions. They will address both above- and below-ground responses and will touch upon such various aspects as herbivory, plant competition, salt stress, mechanical stress, plant hormones, light signaling and root and shoot growth.

Chair: Ronald Pierik

Session Number	Abstract Number	Time	Speaker	Title
S10	3028	10:30 AM	Ronald Pierik	Multiple ways to detect and respond to competing neighbors in dense stands.
	3071	10:50 AM	Wassim Chehab	Plant Environmental Stress Resistance: Roles for Touch and Time
	3072	11:10 AM	Christa Testerink	Take it or leave it: cellular signaling pathways linking salinity stress to root
	3070	11:30 AM	Neil Emery	Cytokinin and plant-organism associations
	3009	11:50 PM	Marcus Maeder	Downy Oak: Rendering ecophysiological processes in plants audible
	3047	12:10 PM	Heidi Appel	Plant perception of insect herbivores includes leaf vibrations caused by chewing.

Lunch and Annual General Meeting (12:30 PM)

Crop Improvement Under Adverse Conditions: Being sessile, plants developed adaptive responses during evolution to survive under fluctuating environmental conditions. However, unlike animals, the plant intelligence for adaptive behavior has been unnoticed for long. Recent research has indicated that plants show evidence of intelligent behavior and has very sensitive behavior to variety of signals such as environmental stimuli, water, light, minerals, gravity, soil structure, neighbor competition and regulate the normal processes like growth, germination, development and initiation of flowering etc. Plants have an astonishing capacity to cope with the limited biotic and abiotic stress conditions. Stress is a widespread problem limiting crop productivity worldwide. This scenario is further aggravated by changing climatic conditions, increase in land erosion and degradation and the increasing demand for feeding the million more mouths. One of the main goals of modern agriculture is to improve the yield potential of crop plants under adverse conditions. The genetic modification could be one of the best approaches for improvement of crop plants. The genome sequencing of many plants enabled us to better understand the signal transduction to environmental stimuli. Furthermore, genomics studies shed light on the complexity of gene families which encode signaling molecules. The adaptive responsive genes can also be highlighted by quantitative trait locus (QTL) mapping and reverse genetic approaches. The reverse genetic approach is applied to analyze genetic architectures by QTL mapping, linkage mapping or other methods. Comprehensive efforts to isolate and characterization of these adaptive genes will further help us to improve our understanding of natural selection's effect on genes and genomes. Genetic engineering approaches enabled us to clone the desirable stress tolerant genes to respond to unfavorable environmental conditions for crop improvement.

Chair: Narendra Tuteja

Session Number	Abstract Number	Time	Speaker	Title
S11	2869	1:30 PM	Narendra Tuteja	Role of PDH45 in crop improvement under adverse conditions of salinity stress
	3059	2:00 PM	Satish C. Bhatla	Understanding of the salt tolerance mechanisms during seed germination in sunflower
	3016	2:30 PM	Ralf Oelmüller	REDOX RESPONSIVE TRANSCRIPTION FACTOR1 amplifies the formation of reactive oxygen species in *Arabidopsis thaliana* shoots and roots
	2868	3:00 PM	Bharti Garg	Pyramiding of the PDH45 gene with EPSPS for developing salt and herbicide tolerant plants
	3020	3:20 PM	Shucai Wang	Regulation of Trichome Development by Single-repeat R3 MYB Transcription Factors
	3063	3:40 PM	Swati Tripathy	Identification of N-Acylethanolamines Binding Protein in *Arabidopsis thaliana*
	3044	4:00 PM	Arathi (H.S) Seshadri	How does maternal abiotic stress affect offspring reproductive traits?
	3015	4:20 PM	Francynês Macedo	Self/non-self discrimination in pea (*Pisum sativum*) cv. Mikado
	3013	4:40 PM	Root Gorelick	Sexual selection inside a fertilised egg?

"The Society of Plant Signaling and Behavior is a union of plant biologist who is interested in sensory plant biology, signalling, information processing and communicative ecology. Hopefully, it will be a communication platform for molecular, biological, physiological, electrophysiological, and ecophysiological plant sciences."

- Kang Chong, The Chinese Academy of Sciences

ORAL PRESENTATIONS (abstracts organized by session order)

Session: 1.1
Abstract Number: 2999
Title: Eduard Strasburger (1844 - 1912) Inspirator of plant signaling
Author: Volkmann, Dieter

Plant signaling and behavior is not just the title of a new journal and the name of young and growing scientific society, it is also one of the most fascinating research area which is integrating plant signaling processes with realm of systems biology including insects, herbivorous animals and humans. Plant signaling dates back to the end of the 19th century when, among others, Eduard Strasburger (Professor of Botany at the University of Bonn) observed phenomena like interactions between the cell periphery and nucleus during mitosis and cytokinesis, cytoplasmic streaming in growing root hairs and pollen tubes, cell-cell communication via plasmodesmata; as well as between pollen tubes and synergides in the sexual plant reproduction. Most of the recent results in the field of plant signaling are related to Eduard Strasburger's observations and interpretations; but neither recognized nor appreciated as such by recent authors.
D Volkmann, F Baluska, D Menzel (2012). Eduard Strasburger (1844 - 1912): founder of modern plant cell biology. Protoplasma 249, 1163-1172.

Session: 1.2
Abstract Number: 3048
Title: "Talking plants": a brief history and big future
Author: Schultz, Jack

The discovery that plants emit volatile signals was met with substantial public interest and considerable scientific skepticism. This placed those involved in a curious scientific and social context that slowed further research on the topic. Over the next 20 years research on plant volatiles took new directions, including a focus on "bodyguard attraction". This function seemed more acceptable than plant-plant communication and spurred acceleration in research. Along the way the idea of plant communication worked its way into popular culture in many ways and has now finally become an acceptable, if strange, part of our common understanding of plants. This talk will present an entertaining and informative review of the history of "plant communication", its cultural impact, what we do and do not know, and its promise for the future.

Session: 2.1
Abstract Number: 3010
Title: Volatile organic compounds play multiple roles in plant resistance
Author: Heil, Martin

Plants respond to biotic and abiotic stress with the release of increased amounts of specific volatile organic compounds (VOCs). The two most commonly reported effects of these VOCS are the attraction or carnivores as means of an indirect defence against herbivores and the induction of resistance responses in neighbouring plants ('plant-plant signalling'). However, VOCs are also induced in response to infection by pathogens and then enhance plant resistance to microorganisms, plant-plant signalling by VOCs can also occur among healthy (non-induced) plants in the same or different species, VOCs can lead to associational resistance rather than induced resistance, and induced VOCs function as systemic signals within a locally attacked plant ('within-plant signalling'). Finally, many VOCS contribute to the direct resistance of the emitter, either as repellents to herbivores or via direct antimicrobial effects. I will highlight the new developments in the field and discuss the importance of these multiple functions of individual VOCs, which need to be considered when one aims at understanding the ecological and, ultimately, evolutionary role of plant VOCs.

Session: 2.2
Abstract Number: 2870
Title: Plant Communication and Kin Recognition for Sagebrush
Author: Karban, Richard

Some plants, including sagebrush, respond to the volatile cues emitted by experimentally clipped neighbors to alter defenses against herbivory. Sagebrush plants exposed to cues from clipped neighbors experienced less leaf damage over the growing season and had enhanced seedling survival, and production of new branches and inflorescences compared to plants receiving cues from unclipped neighbors. Sagebrush responded more effectively to cues from genetically identical tissue suggesting that communication may have evolved to allow individuals to coordinate their own defenses. The ability of many animals to recognize kin has allowed them to evolve diverse cooperative behaviors; such ability is less well studied for plants. We found that communication was more effective among sagebrush plants that were more closely related, based on microsatellite markers. Plants that received cues from experimentally clipped close relatives experienced less leaf herbivory than those that received cues from clipped neighbors that were more distantly related. These results indicate that plants can respond differently to cues from kin, making it less likely that emitters will aid strangers and making it more likely that receivers will respond to cues from relatives. More effective defense adds to a growing list of favorably consequences of kin recognition in plants.

Session: 2.3
Abstract Number: 3008
Title: Anticipating stress by eavesdropping on neighbors
Author: Novoplansky, Ariel

One of the main limitations of phenotypic plasticity is the lag between the perception of the environment and the time the products of the plastic responses are fully operational. Accordingly, selection is expected to promote responsiveness to cues that bear information regarding probable future conditions. We tested the hypothesis that plants are able to perceive cues of anticipated stress by eavesdropping on their stressed neighbors. Plants were grown so their roots shared their rooting volume with the roots of different neighbors. Unstressed target plants rapidly closed their stomata following drought induction of their neighbors but no such communication took place when the roots of the stressed and the target plants did not share rooting volumes, demonstrating that the stress cues were communicated amongst roots. Furthermore, shortly after the drought induction, remote unstressed target plants, which did not share their rooting volume with the stressed plant, also closed their stomata. Following the perception of stress cues from their neighbors, plants better survived and resisted subsequent drought stress. The results demonstrate a novel type of communication whereby unstressed plants not only eavesdrop on their stressed neighbors but also 'leak' warning signals which are perceived and utilized by other unstressed plants. Exploring the ecological implications and mechanisms of belowground plant communication and networking is expected to shed new light on the ways plants learn their immediate environment and anticipate future challenges and opportunities.

Session: 2.4
Abstract Number: 3068
Title: Humidity Sensing in Guard Cell
Author: Hedrich, Rainer
Co-Authors: Bauer, Hubert; Ache, Peter; Al-Rasheid, Khaled; Hetherington, Alistair

Understanding how stomata respond to changes in atmospheric relative humidity has been a key challenge since Francis Darwin first described the phenomenon. Thereby stomatal guard cells sense changes in humidity directly. Our current studies highlight the primacy of abscisic acid (ABA) in the stomatal response to drying air. We showed that guard cells possess the entire ABA biosynthesis pathway and that it appears up regulated by positive feedback by ABA. When the relative humidity drops stomata located in the leaf boundary to the atmosphere are the first to face dry air. Upon perception of dry air guard cells produce their ABA. The endogenous stress hormone is then recognized by a cytosolic ABA receptor. The underlying fast ABA signalling pathway is initiated when the cytosolic threshold of the stress hormone is passed and binding of ABA to the cytosolic receptor facilitated. The ABA-bound receptor in turn addresses guard cell anion channels. In this process the protein kinases phosphorylate and thereby activate SLAC1. Opening of anion channels depolarizes the plasma membrane and anions and K+ released drag water out of guard cells. In turn, turgor drops and stomata close. Although we can construct a broad picture of how rapid ABA signalling works, the mechanism behind adaptation to air drying of plants remained unknown. We studied the ability of guard cells adapt ABA metabolism and signal transduction upon a long term drop in relative humidity. The identification of the ABA signalling kinase OST1 and its target SLAC1 as being required for the proper response of stomata to both ABA and dry air, prompted us to compare the guard cell gene activation of ost1 and slac1 mutants under ABA/drought. As a result we identified a set of genes that very likely forms the core of the signalling pathway that is used in the guard cell for the adaptation of stomata aperture to drought episodes.

Session: 3.1
Abstract Number: 2992
Title: Neurobiological View of Higher Plants - The Case of Auxin
Author: Baluska, Frantisek

Similarly as animals, also plants monitor numerous parameters of their physical environment, especially light and gravity. Higher plants are equipped with sophisticated sensory systems, when specialized cells are evolutionarily optimised to translate sensory information obtained from this environment into adaptive motoric responses. We need to understand those processes which sense and transform physical information into biological information and behaviour. Already in 1880, Charles and Francis Darwin revealed in their book 'The Power of Movements in Plants' that plants have sensory-motoric circuits which underly their tropisms. Although this neuronal view of plants was not accepted by leading botanists of that early time, and still continues to be controversial, it is gaining very strong support in the last decade. Darwins implicated moveable transmitter mediating integration of sensory events at the apex with the subapical motoric events of axial plant organs. Subsequently, auxin was discovered and established as the plant hormone underlying plant tropisms. Current popular concept considers auxin PIN transporters to transport auxin across the plasma membrane. However, there are numerous data incompatible with this favoured concept. In the root apex transition zone, besides the classical transport mode across the plasma membrane, significant portion of auxin is transported via the neurotransmitter-like secretion of auxin across plant synapses; integrating sensory-motoric circuits of root apices and driving their plant-specific behaviour.

Session: 3.2
Abstract Number: 3026
Title: Gravity Signal Transduction in Arabidopsis Roots
Author: Masson, Patrick

The primary roots of Arabidopsis seedlings tend to grow downward, parallel to the gravity vector. When reoriented within the gravity field, these roots sense the gravistimulus through the sedimentation of dense amyloplasts within the columella cells of their cap. This triggers a gravity signal transduction pathway that leads to cytoplasmic alkalinization and cell repolarization, a process accompanied by a relocalization of the plasma membrane-associated auxin efflux facilitators PIN3 and PIN7 to the lower membrane of these cells. This repolarization promotes the development of a lateral gradient of auxin across the cap, with accumulation at the bottom flank. Upon transmission to the elongation zones, this gradient triggers differential growth and tip curvature. We have used strategies derived from Genetics and Systems Biology to characterize the molecular mechanisms that govern gravity signal transduction in the columella cells of the root cap. ARG1 and ARL2 are two genes that encode J-domain proteins associated with the plasma membrane and other membranes along the vesicular trafficking pathway, and are needed for gravity-induced cytoplasmic alkalinization of the columella cells, PIN3 relocalization and auxin-gradient formation. Hence, these proteins function early in gravity signal transduction. ADK1 was identified in a proteomic screen as being differentially represented in the root tip upon gravistimulation. Mutation in the ADK1 gene led to altered PIN3 relocalization upon gravistimulation, even though it did not affect the cytoplasmic alkalinization of the statocytes. Hence, ADK1 may function downstream of ARG1 and ARL2 in the pathway. A third group of mutations was subsequently isolated based on their ability to enhance the gravitropic defect associated with arg1-2. These modifiers of arg1 (mar1 and mar2) were shown to affect genes that encode components of the plastidic outer envelope protein-import (TOC) complex. Single mutations in toc132 and toc75 had no or little effect on root gravitropism. However, in an arg1 mutant background, they completely obliterated the response, demonstrating strong genetic interactions with arg1. Work will be presented that further documents the role of the TOC complex in gravity signal transduction. Transgenic rescue experiments strongly suggest that the protein-import function of TOC is important for its role in gravity signal transduction. Preliminary results from a proteomic analysis of toc132 mutant root tips relative to wild type will also be presented, which identify several nuclear-encoded genes as differentially expressed in the mutant relative to wild type, with potential implications for our understanding of plastid-nucleus crosstalk and gravitropism. Finally, a global transcriptomic and proteomic investigation of root gravitropism and mechanotransduction provides lists of differentially expressed genes and proteins that are currently being investigated for their contribution to gravity signal transduction.

Session: 3.3
Abstract Number: 3014
Title: Transport pathways of auxin and ethylene and their role in controlling vascular differentiation and lateral root initiation
Author: Aloni, Roni

The vascular system in plants is induced and controlled by streams of inductive hormonal signals. Auxin produced in young leaves is the primary controlling hormone in vascular differentiation. New evidence for its downward polar transport pathways in both the epidermis-phellogen and the procambium-cambium, as well as the non-polar auxin transport in the sieve elements originating in mature leaves will be presented.
High auxin concentrations induce ethylene biosynthesis. Likely, therefore, auxin which induces vessel differentiation promotes the emission of ethylene from the maturing conduits. In young roots, the centrifugal movement of ethylene from maturing protoxylem vessels inhibits polar auxin movement in the pericycle, which determines the site of lateral root initiation at the xylem pole, immediately above the inhibition site.
The radial component of the secondary vascular tissues is the vascular rays. Usually, the appearance of rays indicates the transition from procambium to cambium. In the secondary body, the centrifugal ethylene flow from auxin-induced differentiating vessels through the cambium promotes the initiation of vascular rays and regulates their size and spacing. A substantial increase in ray dimensions occurs in response to wounding. This wound effect on ray size can be experimentally induced by ethylene application.

Session: 3.4
Abstract Number: 3024
Title: The function of a glutamate receptor-like gene mediates the root response to external L-Glu
Author: Liu, Lai-Hua
Co-Authors: Gong, Yuan-Yong; Li, Zhi; Cao, Feng-Qiu; Walch-Liu, Pia; Mark, Tester

It has recently been shown that root tips of plants are highly sensitive to an organic form of N (Walch-Liu et al. 2006), the ubiquitous amino acid L-glutamate (L-Glu). When the primary root tip occurs directly to L-Glu, root growth is inhibited but root branching is stimulated, causing a major change in root architecture (Walch-Liu et al. 2006). This phenomenon would imply a foraging response that enhances the precision of root placement when roots encounter an organic N-rich patch. However, nothing is known about how external L-Glu is sensed at the root tip to trigger changes in root architecture.

In this work we focused on the existence of promising candidates, the members of the GLR family of glutamate receptor-like genes for the role of L-Glu sensor in the root tip. In Arabidopsis there are twenty GLR genes, clustered into three clades, which are homologous to the ionotropic glutamate receptors (iGluRs) responsible for excitatory synaptic neurotransmission in the mammalian brain (Davenport, 2002; Chiu et al, 2002). To investigate the possible role of GLR genes in mediating the root response to external L-Glu, we have been screening a collection of Arabidopsis mutants carrying T-DNA insertions in all 20 of the AtGLR genes, and revealed that disruption of the AtGLR2.5 gene leads to a significant decrease in the root's sensitivity to L-Glu but a marked increase in Glu-elicted Ca2+ fluxes at the root tip. We provide further evidence that one of four splice variants of GLR2.5, which is predicted to encode a truncated version of the GLR protein lacking part of the GlnH1 ligand-binding domain, has a positive role in conferring L-Glu sensitivity while having a negative effect on Glu-elicited Ca2+ fluxes at the root tip. Our detailed date will be presented and discussed in the conference.

Reference :

Walch-Liu P., Liu L.-H, Remans ., Tester M. and Forde B. G. (2006). Evidence that L-glutamate can act as an exogenous signal to modulate root growth and branching in Arabidopsis thaliana. Plant Cell Physiol., 47(8): 1045-1057.
Davenport R. (2002) Glutamate receptors in plants. Annals of Botany 90, 549–557.
Chiu J.C., Brenner E.D., DeSalle R., Nitabach M.N., Holmes T.C. and Coruzzi G.M. (2002). Phylogenetic and expression analysis of the glutamate-receptor-like gene family in Arabidopsis thaliana. Molecular Biology and Evolution 19,1066–1082.

Session: 3.5
Abstract Number: 3033
Title: GABA is involved in stomatal movement
Author: Ludewig, Frank
Co-Authors: Mekonnen, Dereje

The four-carbon non-proteinogenic amino acid γ -aminobutyric acid (GABA) is produced from glutamate by the action of the GABA-forming enzyme glutamate decarboxylase (GAD) in the cytosol. GABA is known to increase in the plant's response to several abiotic stresses, among them drought and salt stress.

By impairing GAD activity, we created GABA-defective plants that were unable to respond to drought and salt stress in an adequate manner, i.e., they displayed an early wilting phenotype upon stress application. The plants were found to have a constitutively increased transpiration rate leading to early wilting when drought or salt stress is applied. Possible roles of GABA in stomatal movement will be discussed.

Session: 3.6
Abstract Number: 3052
Title: Metabolomics Analysis as a Tool to Understand Abiotic Stresses
Author: Turi, Christina
Co-Authors: Glover, W. Broc; Hammer, Trent; Moss, Ryan; Saxena, Praveen; Murch, Susan

Metabolomics is the qualitative and quantitative analysis of all small metabolites in a biological sample. It has been estimated that the average leaf contains about 30,000 distinct phytochemicals but research approaches need to be developed that will capture this chemical diversity. In general, statistical analysis methods normally use multivariate statistics such as principal component (PCA), partial least square discriminant (PLS-DA), or orthogonal partial least square (OPLS) analysis but these approaches provide very limited data interpretations. We propose to use mass spectrometry-based metabolomics technology to understand phytochemical changes that occur as a result of abiotic stress. Hazelnut (Corylus avellana) was grown in vitro on media supplemented with 3 levels of Fe-EDDHA. Between 22,433-24,070 phytochemical compounds were detected in each tissue. By comparing individual phytochemicals that increased and decreased with treatment, we were able to identify previously unknown antioxidants and other metabolites influenced by chelated iron. These data demonstrate the potential for metabolomics technologies to discover novel phytochemical pathways in respond to environmental stressors.

Session: 4.1
Abstract Number: 3022
Title: YUCASIN is a novel potent inhibitor of a key enzyme YUCCA(s) in plant auxin biosynthesis
Author: Koshiba, Tomokazu
Co-Authors: Nishimura, Takeshi; Hayashi, Ken-ichiro; Suzuki, Hiromi; Gyohda, Atsukko

Indole-3-acetic acid (IAA), a plant auxin, is biosynthesized from tryptophan. The indole-3-pyruvic acid (IPyA) pathway, involving TAA1 and YUCCA (YUC) enzymes, was recently found to be a major IAA pathway in Arabidopsis. TAA1 catalyzes the conversion of tryptophan to IPyA and YUC produces IAA from IPyA. Using a chemical biology approach with maize coleoptiles, we identified 5-(4-chlorophenyl)-4H-1,2,4-triazole-3-thiol (yucasin), which effectively decreased IAA biosynthesis in YUC-expressing coleoptile tips. Phenotypic analysis of ArabidopsisYUC1 overexpression (35S::YUC1) lines indicated that yucasin specifically acts in IAA biosynthesis catalyzed by YUC. Enzymatic analysis of recombinant AtYUC1 suggested that yucasin strongly inhibited YUC1 activity in a competitive manner against the substrate IPyA. A loss-of-function mutant of TAA1, sav3-2, was hypersensitive to yucasin in root growth and hypocotyl elongation of etiolated seedlings. Yucasin combined with the TAA1 inhibitor L-kynurenine acted synergistically in Arabidopsis seedlings, indicating the importance of IAA biosynthesis via the YUC pathway in root growth and leaf vascular development. The present study showed that yucasin is a potent inhibitor of YUCs that offers an effective tool for analyzing the contribution of IAA biosynthesis to plant development and physiological actions.

Session: 4.2
Abstract Number: 3021
Title: A possible role for abscisic acid in controlling the growth effects of indole-3-acetic acid in expanding arabidopsis leaves
Author: Keller, Christopher
Co-Authors: Zerr, Jakob; Wagner, Samuel; Roise, Amanda

Previously we have shown that increasing the indole-3-acetic acid (IAA) content of expanding Arabidopsis leaves increases growth if tissues are both wounded and detached from the plant (Plant Signaling & Behavior 6: 1997-2007). Implied is an entity, supplied by the rest of the plant, interacts with IAA signal transduction to block growth in a wound-sensitive fashion. Here we report evidence suggesting abscisic acid (ABA) is the hypothesized interacting entity. ABA is a potent inhibitor of leaf growth in Arabidopsis and of IAA-induced growth of excised leaf strips over 24 h. Both attached and detached leaves of mutant plants, (CS5736) deficient in ABA synthesis, were not growth-inhibited by IAA. Detached wild-type leaves treated with AbamineSG (ABA synthesis inhibitor) grew more than controls while leaves floated on AbamineSG plus IAA grew more than leaves floated on IAA alone. The results suggest IAA induces ABA synthesis in roots and intact leaves leading to slower leaf growth or IAA increases the growth-inhibition sensitivity to ABA of leaves. This project is supported by grants (P20RR016471) and (P20 GM103442) from the National Institutes of Health.

Session: 4.3
Abstract Number: 3025
Title: Possible involvement of ZmPHOT1 and ZmPHOT2 in blue light perception to phototropic curvature in maize coleoptiles
Author: Suzuki, Hiromi
Co-Authors: Koshiba, Tomokazu

Phototropic curvature is one of the typical plant responses to control the first and sensitive movements in plants, since the pioneering work of Charles and Francis Darwin in 1880. Later studies showed that a blue light receptor PHOT1 and lateral IAA movement are the key factors in the phototropic response. Our previous work with maize coleoptiles showed that an apical 2 mm of the coleoptile was not only the site of IAA biosynthesis but also blue light perception for 1st positive phototropic curvature. In the present report, firstly we analyzed qualitative or quantitative changes of ZmPHOT1 at a protein level after a blue light stimulation. Secondly, we checked the phototropin gene family to find PHOT2-like gene in maize, because only one ZmPHOT1 gene has been reported.

To analyze rapid changes in ZmPHOT1 protein after a lateral blue light irradiation, we used two anti-OsPHOT1 antibodies recognized LOV domain or kinase domain of ZmPHOT1. Microsomal proteins of maize coleoptiles (top 5 mm regions) after a weak blue light stimulation (0.33 μm/m ^{2} /s x 8 sec) were analyzed, but apparent changes in ZmPHOT1were not detected in the amount and mobilization in SDS-PAGE. While, a strong blue light irradiation (10 μm/m ^{2} /s x 1 min) caused a rapid band sift (protein phosphorylation) in SDS-PAGE. We are in progress more detail analysis of ZmPHOT1 modification comparing between irradiated and shaded sides after the blue light irradiations.

Earlier studies showed that there are two genes, PHOT1 and PHOT2, in rice, which are orthologs of AtPHOT1 and AtPHOT2 in Arabidopsis, respectively. While, there was only PHOT1 in maize. We did BLAST searches of phototropin(s) in maize and found a homolog. From the data-base analyses, the homolog belongs to a group of PHOT2 in plants. We investigated the expression patterns of ZmPHOT1 and ZmPHOT2 mRNA in maize coleoptiles and young leaves. ZmPHOT1 was relative strongly expressed in coleoptiles than ZmPHOT2, whereas ZmPHOT2 was expressed higher in leaves of etiolated seedlings. The expression of ZmPHOT1 was relatively even from the top to sub-apical 6 mm, but ZmPHOT2 was more specific in apical 0-2 mm regions, where the site of IAA biosynthesis, lateral blue light-perception, as well as IAA lateral transport. We will discuss about phototropic curvature in maize coleoptiles in relation to the role(s) of ZmPHOT1 and ZmPHOT2 in the blue light perception.

Session: 4.4
Abstract Number: 3039
Title: Self destructive behaviour of plants in vitro
Author: Jones, Max
Co-Authors: Saxena, Praveen

As sessile organisms, plants have evolved intricate chemical defenses to deter herbivores, prevent infection, and adapt to environmental change. While these systems protect plants in natural conditions, they can interfere with growth and development in vitro and often kill the plant they are meant to defend. Of particular importance in this regard is the phenylpropanoid pathway, which produces myriad compounds that protect plants from UV damage, increase cold tolerance, deter herbivores, and prevent microbial infection. During the process of tissue culture this pathway can be elicited in response to physical wounding and transition into an artificial environment. The effects of this response can be elucidated through the use of 2-aminoindane-2-phosphonic acid, a potent inhibitor of the phenylpropanoid pathway, to compare plant growth and development in the presence and absence of phenolic biosynthesis. In this presentation, the self destructive behaviour of plants in vitro and the regulatory roles of phenylpropanoids will be demonstrated in a variety of plant species.

Session: 4.5
Abstract Number: 3046
Title: Evolution and role of mayehuelin, a developmentally-regulated protein from the central spike leaves of Agave tequilana with high similarity to RIPs
Author: Nieto-Sotelo, Jorge
Co-Authors: Lledías, Fernando; Reyes, Sandi; Hernández, Felipe; Ávila, Xóchil; Rojas, Idalia; Cabanillas, Oliv

Ribosome-inactivating proteins (RIPs), originally described as cytotoxic enzymes that depurinate rRNA and inhibit protein synthesis, have a controversial biological role because not all RIPs share these properties. Here, we isolated mayehuelin, a RIP from A. tequilana, by developing a novel extraction method that eliminates waxes, pigments, and carbohydrates and avoids protein degradation due to high proteolytic activity in agave leaves. Mass spectrometry sequencing revealed that mayehuelin is a type-I RIP of 27 kDa. Isolation of a cDNA clone confirmed mayehuelin´s amino acid sequence. Identification of N- and C-terminal residues of mayehuelin indicated that both N- and C- terminal sequences are removed from a precursor protein. Expression analyses confirmed that mayehuelin, at the protein and transcript levels, was expressed in central spike leaves, being more abundant in the youngest leaf, located near the shoot apical meristem, and less abundant in the more mature leaves. Mayehuelin was absent in the unfolded leaves of the rosette. Interestingly, a highly conserved tyrosine in the active site of all RIPs is not conserved in mayehuelin from A. tequilana and from some species within the Agavaceae Family. Expression of mayehuelin in E. coli and yeast cells had not toxic effects. Mayehuelin may have a role as a stress protective agent, since the central spike leaves are the most heat-tolerant part in A. tequilana1.
Luján, R. et al. (2009). Small heat-shock proteins and leaf cooling capacity account for the unusual heat tolerance of the central spike leaves in Agave tequilana var. Weber. Plant Cell and Environment 32, 1791-1803.

Session: 4.6
Abstract Number: 3045
Title: Interplay between phosphoinositides and Ca2+ in phototropin1- and phototropin2-mediated chloroplast movements in Arabidopsis
Author: Aggarwal, Chhavi
Co-Authors: Labuz, Justyna; Gabrys, Halina

Light-dependent chloroplast movements are mediated by UVA/blue light receptors – phototropins. In A. thaliana, phot1 and phot2 have overlapping roles in the control of these movements. Our aim was to determine phosphoinositides (PIs) involved in the control of chloroplast relocations and to elucidate the nature of their involvement. We inquired in what way the inactivation of phospholipase C (PLC) or PI3- and 4- kinases (PI3K & PI4K) affects chloroplast relocations. The inhibition of the PI4,5-bisphospahte – PLC pathway, using neomycin and U73122, suppressed the phot2-mediated chloroplast accumulation and avoidance without affecting movement responses controlled by phot1. In contrast, inactivation of PI3K and PI4K by wortmannin and LY294002 affected the weak light-activated accumulation but had little effect on the strong light-activated avoidance response. The suppressive effect of PI metabolism inhibitors was partly due to disturbed Ca2+ signaling. With the transgenic aequorin system we showed that these inhibitors suppressed the blue-light-induced transient Ca2+(c) rise. A hypothetical model showing differential PI control over chloroplast responses has been proposed.

Session: 5.1
Abstract Number: 2861
Title: Plant Intelligence and Bio-Attention
Author: Marder, Michael

Phenomenological investigations have yielded fruitful findings on the topic of attention. The goal of this presentation is to apply two of its most fecund conclusions to plant intelligence and, in so doing, to define the role of attention in plant intelligence. The first conclusion has to do with the selectivity of a stimulus that stands out in the sphere of attention. When plants and other living organisms attend to their environment, they privilege some pieces of information conducive to their adaptability and survival over others. At or before the onset of draught, for instance, it would be expected that more importance would be attributed to sensitivity to humidity gradients of the soil, as well as to information from neighboring plants about encroaching drought conditions. These inputs would, thus, stand out from the indefinite sphere of stimuli, experienced as background “white noise” and would become meaningful at the same time as they are individuated from the general horizon of relative indifference. As environmental conditions change, the previously important object of attention would recede back to this horizon, while other objects are individuated and selected for attentive uptake. The second conclusion refers to the intrinsic relation of attention to intentionality and, hence, to the general concept of mind or intelligence. For the founder of phenomenology, Edmund Husserl, to attend to something is already to intend something, to be directed toward this as an object. Attention as a general feature of intelligence entails the interrelation of various stimuli that cohere into an intentional object. While plant intelligence does not operate with discrete objects, its attentive/intentional response to environmental conditions satisfies the broad phenomenological notion of attention. Finally, I consider the nexus of attention and freedom, insofar as it is applicable to plant intelligence.

Session: 5.2
Abstract Number: 3067
Title: Carnivorom - towards the senses of the Darwin plant
Author: Hedrich, Rainer
Co-Authors: Bemm, Felix; Hackl, Thomas; Scherzer, Sönke; Krol, Elsbieta; Al-Rasheid, Khaled; Kreuzer, Ines; Becker, Dirk; Neher, Erwin

Predation plays a major role in energy and nutrient flow in the biological food chain. Carnivory is best known from the animal kingdom, but the plant kingdom has flesh eaters as well. The Venus Flytrap (Dionaea muscipula) is a carnivorous plant recognized as such by Darwin. Living on nutrient poor soils, Dionaea requires its flesh diet to counterbalance the malnutrition. Pray getting in contact with the touch-sensory organs protruding from the trap surface activate mechanosensitive ion channels and induce action potentials eliciting trap closure in a fraction of a second entrapping he visiting prey. Since the time of Charles Darwin, scientists have struggled to understand the sensory biology of this carnivore. Recently we could show that prey-catching with Dionaea combines plant-specific signaling pathways, involving the touch hormone OPDA and stress hormone ABA that trigger ion channels, action potentials, and Ca2+ signals. Upon recognition of the prey's nature by motion and chemical stimuli, glands on the inner surface of this "green stomach" start secreting a lytic cocktail. Following prey digestion, the same gland-based endocrine system absorbs the animal-derived nutrients. On the basis of an ERC Advanced Grant "Carnivorom" we are currently investigation the nature of receptors, channels, and signaling pathways behind the mechano-electric (trap)contraction-coupling and behind the senses of touch and taste. To understand the genomic basis of these remarkable features, we sequenced Dionaea's 3 gigabase (homo-sapiens-like) genome. By projecting transcriptomic data from the non-excitable petiole and different trap tissues onto the genome, we created a functional resource to explore the genetic landscape of the flytrap. Our data suggest that nature and roots of flesh eating with Darwin plant evolved from predator defense towards the acquisition of animal-derived nutrients. In other carnivores like Dionaea to survive `simply´ turned sword around.

Session: 5.3
Abstract Number: 2954
Title: New aspects of captured prey-induced leaf movement in carnivorous Drosera
Author: Mithöfer, Axel

Carnivorous plants of the worldwide occurring genus Drosera catch their prey by employing adhesive traps, which present sticky polysaccharide mucilage. The glue is produced by stalked glands, tentacles, on the leaves surface. The glands also secrete enzymes to digest captured prey and subsequently absorb generated nutrients. The whole process is elicited by mechanical and chemical stimuli from the prey that induce electric potentials in the glands, which moves towards the basis of the tentacles in the epidermal layer of the leaf. Beside this fast tentacle movement a second, slower movement of the whole leaf starts to enclose the caught prey and to form a so-called outer stomach. Although Darwin already described this leaf bending phenomenon, the prey-induced endogenous plant signals that direct this movement remained to be identified. Using fruit flies, Drosophila melanogaster, and the sundew species Drosera capensis, the prey-derived signal, the timing of the leaf movement, and the nature of the endogenous factors involved have been analysed and identified and will be presented. Based on these results, a novel concept for leaf bending will be discussed.

Session: 5.4
Abstract Number: 2860
Title: Do hydrotropism and phototropism evolved in parallel to secure carbon and water in the plant?
Author: Cassab, Gladys
Co-Authors: Eapen, Delfeena; Campos, María Eugenia; Noriega, Laura; Valle, Nuvia; Benítez, Citlali; Manuel, Saucedo; Hernández, Oralia; Martínez, Jesús

While water shortage remains the single-most important factor influencing world agriculture, there are very few studies on how plants grow in response to water potential, i.e., hydrotropism. Terrestrial plant roots dwell in the soil, and their ability to grow and explore underground requires many sensors for stimuli like gravity, humidity gradients, light gradients, mechanical stimulations, temperature, oxygen, etc. To date, extremely limited information is available on the components of such sensors; however all of these stimuli are sensed in the root cap. Directional growth of roots is controlled by gravity, which is fixed in direction and intensity. However, other environmental factors, such as water potential gradients, which fluctuate in time, space, direction, and intensity, can act as a signal for modifying the direction of root growth accordingly. Hydrotropism may help roots to obtain water from the soil and at the same time may participate in the establishment of the root system. Current genetic analysis of hydrotropism in Arabidopsis has offered new players, mainly AHR1, AHR2, NHR1, MIZ1, and MIZ2, which seem to modulate how root caps sense and choose to respond hydrotropically. We will discuss the mechanism(s) by which these genes and those that regulated phototropism in conjunction with the plant hormones abscisic acid and cytokinins coordinate the root hydrotropic response. We hypothesized that some aspects of water stress avoidance have evolved by natural selection of root tropic responses, most probably hydrotropism and phototropism. For testing this hypothesis, we are also using crop plants such as maize and beans to examine root hydrotropic and phototropic responses and to test their growth responses to drought in the field conditions in a research program for encouraging agricultural diversity and sustainability in Mexico. We think that it should be a priority of plant scientists to use their creativity and resources for the implementation of sustainable agriculture on Earth since the global agricultural sector will need 19% more water by 2050 to meet a 70% increase in demand for food (Hoekstra and Mekonnen, 2012).
Hoekstra, A.Y., and M. M. Mekonnen 2012. The water footprint of humanity. Proceedings of the National Academy of Sciences, USA 109: 3232-3237
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Session: 6.1
Abstract Number: 3058
Title: Micro-biorobotic controls of green paramecia under artificial lights
Author: Kawano, Tomonori
Co-Authors: Otsuka, Kohei; Noriyasu, Atsuko; Comparini, Diego; Mancuso, Stefamp; Bouteau, Francois

Members of Paramecium species are often referred to as “swimming neurons or sensory cells” applicable to micro-biorobotics or BioMEMS (biological micro-electro-mechanical systems). Paramecium bursaria known as green paramecia is an unicellular organism that lives widely in fresh water environments such as rivers and ponds. Our studies have suggested that in vivo cellular robotics using the living cells of green paramecia as micro-machines controllable under electrical and magnetic signals, has a variety of engineering applications such as transportation of micro-sized particles (ingested within the cells) in the capillary systems. More recent demonstration showed that green paramecia can be implementable on a series of microchips designed as cellular swimming platform for green paramecia. In this presentation, we report on our attempt to control the movement of green paramecium under irradiation by artificial light sources such as commercial white fluorescent lamp, multi-colored HB-LEDs, and infrared. Data suggested that green paramecia can be used as photo-controllable carriers of micro- and nano-sized materials. In addition, photo-controlled release of nano-sized materials from the cells was also performed. Lastly, controllability of green paramecia was compared with other mobile green algae such as Chlamydomonas reinhardtii and Euglena gracilis.

Session: 6.2
Abstract Number: 3055
Title: High-speed pulsing control of HB-LED for efficient photosynthesis
Author: Hieu, Nguyen Hoang Trung
Co-Authors: Moritaka, Kiyoshi; Otuska, Kohei; Noriyasu, Atsuko; Masago, Hiroaki; Fujita, Yoji; Ohta, Ryoji; Fujiwara, Takashi

Light can be considered as the mean of conveying energy (in case of photosynthesis) and information (natural and artificial environmental stimuli) captured or sensed by living plant cells. Nowadays, a variety of novel light sources such as high brightness light emitting diodes (HB-LEDs) are available. Using HB-LEDs, our group has been engaged in development of a novel lighting systems for enhanced photosynthesis. Our preliminary demonstrations in past five years suggested that energy utilization efficiency for photosynthesis can be enhanced through four different approaches, namely, (1) selection of narrow wavelengths specifically targeting antenna-chlorophylls, (2) optically focused illumination over plant tissues, (3) optimized light intensity within the range below the light saturation point, and (4) application of high-speed pulsing protocol. The last approach can be achieved by using newly invented 660 nm HB-LED equipped with IC-driven pulse control unit. This presentation highlights the ongoing studies applying such new lighting devices for enhancement of photosynthesis in both higher plants and photosynthetic bacteria. By modification of pulse frequency, energy utilization efficiency under limited light input was enhanced by ca. 50% in Synechocystis spp. PCC 6803 and seedling of rice (Oryza sativa L.). Metaphorically, in order to perform such enhancement, blinking by HB-LED must be much faster than plant does. Lastly, progress on our ongoing project for developing the hydroponic cultivation of rice under artificial light will be reported.

Session: 6.3
Abstract Number: 2994
Title: ROS-mediated UV-B avoidance behavior in Arabidopsis roots
Author: Yokawa, Ken
Co-Authors: Baluska, Frantisek

In roots, many photoreceptors and relevant molecular mechanisms for perception of light have been reported and characterized. Previously, we have reported that short period of visible -light illumination to roots provoke the generation of reactive oxygen species (ROS) in the root apex region, resulting in the acceleration of Arabidopsis root growth. This light-induced root growth can be considered as new type root phototropism behavior, escape tropism from unfavorable light conditions.
UV-B receptors, RUS1, RUS2 and UVR8 are expressed in Arabidopsis roots. However, it is still unclear whether roots show the light-induced escape tropism behavior also after the UV-B exposure.
Recently, we have found that daily UV-B (311 nm) supplement to Arabidopsis seedlings stimulates root growth rate at modest intensity (less than natural daily exposures in summer season in northern mid-latitude). When young seedlings were illuminated with UV-B from one side, roots started to bend toward the opposite direction. Interestingly, the generation of ROS in Arabidopsis root apex was instantly induced by UV-B irradiation, and this response is associated with increases of the endocytic vesicle-recycling rates scored with brefeldin-A (BFA) treatment. Acceleration of endocytosis and endocytic vesicle-recycling is essential to promote the polar auxin transport for root tropisms.
In addition, the actin cytoskeleton of root cortex cells also altered their alignment after these short UV-B exposures.
All these root reactions can be regarded as part of the root escape behavior from the UV-B stress. In this report, ROS-mediated UV-B avoidance responses, and related biochemical signaling in Arabidopsis roots, will be discussed.
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Yokawa K, Kagenishi T, Baluška F. Root photomorphogenesis in laboratory-maintained Arabidopsis seedlings. Trends Plant Sci, In press (2013).

Session: 6.4
Abstract Number: 3056
Title: Action spectra for inhibition of radicle elongation in Cucurbita embryo: Search for the key pigments as potential photoreceptors
Author: Moritaka, Kiyoshi
Co-Authors: Kawano, Tomonori

Effect of lights on radicle elongation in germinating seeds of Japanese squash (Cucurbita maxima L. cv . Ebisu Kabocha) was examined by using high brightness-light emitting diodes (HB-LEDs). After removing the outer seed coat, seeds were immersed in water for 12 hours in darkness. On wet paper, germination of seed embryos without testa was allowed with and without irradiation by broad-band (white light) and narrow-band (wavelength, 365, 430, 525, 625, 660, 735 nm) HB-LEDs for 48 hours. Elongation of radicles was terminated by ice-chilling the samples and the lengths of radicles were determined. Radicle elongation was significantly inhibited by white, ultraviolet, blue, short-wavelength red (625 nm), and infrared lights while green and long-wave red (660 nm) lights showed no inhibition. Opposing effects of 660 nm and 735 nm lights imply the action of phytochrome. As the candidate for additional photoreceptors, major pigments in the germinating embryos were extracted in N,N -dimethylformamide and used for spectroscopic analyses and determination by HPLC. Interestingly, the major pigment in the germinating embryos extracted prior to illumination was shown to be protochlorophyllide (absorption maxima: 425, 625 nm). Therefore, it is tempting to speculate that light components absorbed by this pigment might show inhibitory action on radicle elongation. In conclusion, there would be three different modes of light actions inhibiting the radicle elongation, namely (i) UV response (non-selectively targeting the cell components), (ii) phytochrome response, and (iii) novel mechanism involving the 425- and 625-nm light-absorbing pigment. Lastly, photochemical events in the third mechanism will be discussed.

Session: 6.5
Abstract Number: 3054
Title: Go green, stay green under green light
Author: Comparini, Diego
Co-Authors: Yamamoto, Yasuhisa; Moritaka, Kiyoshi; Hieu, Nguyen Hoang Trung; Kihara, Toshihiko; Masago, Hiroaki; Mancuso, Stefano

Recently, green light attracts the attentions by researchers since growing number of reports suggest the potential roles for green light throughout the plant lifecycle such as regulation of morphogenesis and stress responses. Our study using high-brightness light emitting diodes (HB-LEDs) enabled us to thoroughly investigate the action light spectra affecting the plant growth and development. In the present report, we describe our recent data showing how green light can enhance the greening process in young shoots and cotyledons or delay the maturation of fruits (thus help keeping greenness). We observed that chlorophyll biosynthesis in etiolated cotyledons or shoots of both monocots and dicots such as Arabidopsis, tomato, radish, pumpkin, cucumber and rice can be initiated by green light. The key steps in the chlorophyll biosynthetic pathway stimulated by green light were shown to be the conversions of (1) protochlorophyllide into chlorophyllide a catalyzed by light-responsive protochlorophyllide oxide-reductase (POR) and of (2) chlorophyll a to chlorophyll b via chlorophyll cycle involving chlorophyllide a oxygenase (CAO). Data suggest that the reaction catalyzed by POR is light-dependent (thus no additional receptors are required). However, the reaction catalyzed by CAO is not light dependent thus there should be photo-receptor(s) in the upstream of CAO. Furthermore, a study on the post-harvest maturation process indicated that strawberry fruits maintained under green light show high acid content, low sugar content, and delayed coloration (anthocyanin biosynthesis and de-greening), while dark storage or irradiation with differently colored lights other than green all allowed the maturation.

Session: 7.1
Abstract Number: 2883
Title: Electrophysiology of biological sensing and signal transduction in the Venus flytrap and Mimosa pudica
Author: Volkov, Alexander
Co-Authors: Volkova, Maia; Markin, Vladislav

Many plants have the ability to morph and become shape-changers with optimal performance with low turning radius, long endurance, and high speed (Volkov at al., 2007, 2008, 2009, 2010, 2011, 2013). Biologically closed electrical circuits operate over large distances in biological tissues. The activation of such circuits in plants can lead to various physiological and biophysical responses. The rapid closure of the Venus flytrap upper leaf in about 0.1 s is one of the fastest movements in the plant kingdom. We found that the electrical stimulus between a midrib and a lobe can close the Venus flytrap without mechanical stimulation. The Venus flytrap has a short term electrical memory. We found that the Venus flytrap can accumulate small subthreshold charges, and when the threshold value is reached, the trap closes. Thigmonastic movements in the sensitive plant Mimosa pudica, associated with fast responses to environmental stimuli, appear to be regulated through electrical and chemical signal transductions. The thigmonastic responses of Mimosa pudica occur in three stages: stimulus perception, electrical signal transmission, and induction of mechanical, hydrodynamical and biochemical responses. We investigated the morphing structures of the pinnae, pulvini, pinna, and petioles in Mimosa pudica induced by the electrical stimulation. Both voltage and electrical charge are responsible for the electro stimulated closing of a leaf. The hydroelastic curvature mechanism (Markin et al., 2008) closely describes the kinetics of Mimosa pudica and the Venus flytrap leaf movements.

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Session: 7.2
Abstract Number: 3051
Title: Characeae as a model system for electrophysiological studies on intercellular communication
Author: Shimmen, Teruo
Co-Authors: Ogata, Koreaki; Yanagihara, Nobuyuki

Characeae has been a suitable material for studies on membrane physiology of plants. Many important aspects have been revealed by taking advantage of this material. We developed a model system for analyses of intercellular communication. Specimens composed of two tandem internodal cells were prepared and two phenomena were analyzed: wounding response and pressure sensing. 1) Wounding response. It is suggested that neighboring cells first sense death of victim cells upon wounding of tissue. In higher plants, however, it is hard to selectively monitor the response of the neighboring cell. Owing to large cell size and simple morphology, monitoring of signals from the neighboring cell is easy. In the present study, one cell (victim cell) was cut and the electrical response of another cell (receptor cell) was monitored. Upon cutting the victim cell, two depolarizations were generated by the receptor cell: rapid spike and long-lasting depolarization. It was found that these depolarizations were generated at the nodal end of the receptor cell. Systematic analyses revealed that the first one was triggered by sudden disappearance of turgor pressure of the victim cell and that the second one was triggered by potassium released from the victim cell. 2) Pressure sensing. When turgor pressure of the victim cell was decreased by adding sorbitol to the external medium, a transient depolarization was generated. It was found that refractory period was very long, more than two hr. In the presence of an inhibitor of protein synthesis, cell could not recover from refractoriness. It was discussed that factor(s) responsible for generation of the depolarization was lost or inactivated during the depolarization and that protein synthesis was necessary for recovery from the refractoriness.

Session: 7.3
Abstract Number: 3031
Title: Ion channel regulations during Ozone-induced programmed cell death
Author: Bouteau, Francois
Co-Authors: Tran, Daniel; Kadono, Takashi; El-Maarouf-Bouteau, Hayat; Rossi, Marika; Kawano, Tomonori; Mancuso, Stefano

Programmed cell death (PCD) is a fundamental process remarkably conserved in eukaryotes and controlled by regulations of ion channel activity . In plants as well as animals or simple eukaryote oxidative stress conditions, like exposition to ozone (O3), were shown to induce such PCD. Ozone is a major secondary air pollutant often reaching high concentrations in urban areas under strong daylight. Using A. thaliana cultured cells we analyzed early events participating to development of O3-induced PCD. This consist in an oxidative dependent controlled cell death process involving cell shrinkage due to an early activation of anion channels and a delayed activation of K+ outward rectifying currents mediated by GORK channels. We further highlighted the early interplay between anion channel activation, Ca2+ influx and NADPH-oxidase generated reactive oxygen species (ROS) which might be fuelled by several mechanisms in addition to the direct ROS generation by O3; namely, increase in anion channel activity by oxalate generated from ascorbate degradation by O3 and ROS generation by salicylic and abscisic acids. We further provide evidence that most of these early events act downstream of caspase-like activities to promote O3-induced programmed cell death.

Session: 7.4
Abstract Number: 3023
Title: Ion transporters involved in salt tolerance/sensitivity of characeae
Author: Beilby, Mary Jane
Co-Authors: Al Khazaaly, Sabah

Characeae are closely related to ancestors of land plants and provide an excellent electrophysiological model. Most characeae inhabit freshwater ponds. Chara australis cannot survive salinities above 50 mM NaCl. Only a small number of characeae species display some degree of salt tolerance. The genus Lamprothamnium stands out, as it can grow in brackish to hypersaline environments and plants can reproduce in salinities exceeding those of seawater.
The transporters involved in salt tolerance: (1) non-selective voltage independent channels that let the Na+ in, (2) Na+/H+ antiporter that exports Na+ out of cytoplasm, (3) the 2H+/Cl- symporter to import Cl- for turgor regulation, (4) the proton pump that provides the proton gradient, (5) inward rectifying K+ channels for turgor regulation, (6) mechano sensitive channels to start the hypotonic regulation, (7) large conductance K+ channels for hypotonic regulation, (8) Ca2+-activated Cl- channels for hypotonic regulation and (9) H+/OH- channels that facilitate photosynthesis by participating in the characeae banding system. Interestingly, both sensitive and tolerant characeae contain same type of transporters, but the tolerant Lamprothamnium appears to coordinate their function better.
The electrical responses of Lamprothamnium sp. and Chara australis were investigated, while challenged by turgor decrease and saline media. In both Chara and Lamprothamnium background conductance did not change upon non-plasmolysing turgor decrease, but it increased in a Ca2+ dependent manner in saline medium. The salt-tolerant Lamprothamnium could detect a decrease of turgor and an increase of Na+, and respond by activating the proton pump to maintain negative membrane potential and large H+ concentration gradient. The turgor was regulated by importing more K+, Cl- and Na+. Salt-sensitive Chara australis did not respond to turgor decrease, did not regulate turgor, lost the pump function and negative membrane potential, exhibiting spontaneous repetitive action potentials and loosing more K+ and Cl-. The global opening of H+/OH- channels dissipated the H+ concentration gradient, further depolarising the membrane potential and promoting K+ loss through outwardly rectifying channels. We contrast the ion transporter synergies in Lamprothamnium and Chara australis to gain insight into salt tolerance in characeae and higher plants.

Session: 8.1
Abstract Number: 3066
Title: Deciphering the mechanisms underlying action potential initiation and propagation in plants - the role of K+-selective channels
Author: Cuin, Tracey Ann
Co-Authors: Michard, Erwin; Dreyer, Ingo; Degli Agosti, Robert; Trebacz, Kazimierz; Thibaud, Jean-Baptiste

Inter-organ communication is essential for the survival of a plant. Being able to rapidly broadcast a signal that notifies the whole plant of a localised threat or stress is vital for it to formulate the appropriate response. Electrical signals such as action potentials (APs) are one of the fastest long distance signalling mechanisms in plants. Plant APs display similar characteristics to those in animals (albeit with slower kinetics), fulfilling the all-or-none law, having a self-amplifying character, travelling with constant velocity and magnitude, and being followed by a refractory period. As in animals, the plant AP is likely to depend on voltage-gated ion channels. Nonetheless, although a basic picture of ion movements during an AP has been proposed, little is known about the molecular identity of the mechanisms underlying these signals. We aim to identify and characterise the ion channels involved in the initiation, generation and propagation of APs in plants. Using extracellular electrodes inserted into the vascular tissue of Arabidopsis leaves, we measured the electrical response in K+ channel mutants after the imposition of an electrical stimulus. We have identified two K+-selective channels that participate in plant APs: the weakly-rectifying channel AKT2 and the outward-rectifying, depolarisation-activated GORK. AKT2 appears to be involved in triggering an AP, a role that depends on its phosphorylation status, whilst GORK has a role in shaping the signal, controlling its amplitude and duration. To try to understand how these channels influence AP generation and propagation, we developed a single-cell mathematical model. To mimic the mutant plants, we introduced the appropriate modified channel parameters into the model and from this, were able to replicate our experimental results. To obtain insights into AP propagation, we have expanded this single-cell model to a multicellular model by connecting individual cells with simplified plasmodesmata. This model predicts the variable amplitudes and other properties coherent with what we found in planta. This more complex model will be used to make further predictions about the transport systems underlying the mechanisms of excitability in plants, thus increasing our understanding of AP initiation and propagation in plants.

Session: 8.2
Abstract Number: 3032
Title: Surface Sum Action Potentials (APs) and Electro-Physiograms (EPGs) as a Basis for Systems Biological Analysis of Plant Behavior
Author: Lehner, Lars
Co-Authors: Wagner, Edgar

The plant is conceived as a hydraulic-electrochemical signal transducer from the cellular to the organismic level. Rhythms in leave movements (LM) and stem extension rates (SER) reflect integral hydraulic controls which might be at the basis of plant behavior.
The quantitative data on LM and SER will be illustrated by video clips from time laps photography of rhythmic plant behavior.
Plant behavior in response to environmental queues will be discussed with respect to basic research and applications in horti-, agri-, viti- and silvi-culture.

Session: 8.3
Abstract Number: 3027
Title: Quantifying effects of soil water content, vapor pressure deficit and electrode position on electrical potentials in Juglans regia and Vitis vinifera using multivariate statistical methods
Author: Gil, Pilar
Co-Authors: Saavedra, Jorge; Navarro, Rosa; Schaffer, Bruce

Changes in internal electrical potentials (EP) in response to environmental variables such as soil water content and light intensity have been observed in some fruit crop species. These relationships are difficult to statistically quantify due to simultaneous and interacting influences of two or more environmental variables on EP. Experiments were conducted to quantify the effects of soil water content and atmospheric vapor pressure deficit (VPD) on EP in Juglans regia (walnut trees) and Vitis vinifera (grapevines). For each species, plants in containers in a Faraday cage in a greenhouse were subjected to two irrigation treatments over a 3-day period. Juglans regia treatments were: no irrigation (T1), or irrigation 3 times per day in morning, mid-day, and evening (T2). Vitis vinifera treatments were: irrigation once per day in morning (T1), or twice per day in morning and afternoon (T2). For each species, there were 3 plants (replications) per treatment. Electrical potentials were measured at 1-min intervals at 3 places along the stem: immediately above the root zone, in the center of the trunk, and in the middle of the canopy. Electrical potential differences (ΔEP) between each set of electrodes were determined from EP measurements. Soil moisture was continuously monitored by frequency domain reflectometry (FDR) probes. Vapor pressure deficit in the greenhouse which fluctuated naturally throughout the day was continuously monitored. Data were analyzed by principal component analysis (PCA) and PCA with orthogonal signal correction (OSC-PCA) to assess the relationship between soil water content, VPD, electrode location on the stem, and the response variables (EP and ΔEP). OSC-PCA was a powerful tool for quantifying the relationships between EP and ΔEP and soil moisture content, VPD and location of electrodes on the stem. For Juglans regia , 87% of the total variation in EP and ΔEP could be explained by a combination of the independent variables, with electrode position accounting for most of the variation. However, soil moisture was a secondary factor, separating EP and ΔEP values into two distinct groups based on irrigation treatment. For Vitis vinifera , 63% of the variation in EP and ΔEP could be explained by a combination of the independent variables, with electrode position again accounting for most of the variation. Soil moisture was as a secondary factor separating EP and ΔEP values into two distinct groups based on irrigation treatment. The results indicate that OSC-PCA is a useful tool for distinguishing simultaneous influences of two or more external factors on plant electrical potentials. Also, in Juglans regia and Vitis vinifera , EP and ΔEP were strongly influenced by the position of the electrodes on the stem. Thus, electrode position must be considered when quantifying the effects of soil moisture or VPD on EP or ΔEP.

Session: 8.4
Abstract Number: 3006
Title: A new plant water stress sensor based on the electrophysiology behaviour of fruit bearing trees
Author: Gurovich, Luis
Co-Authors: Rios, Liliana

Development and evaluation of a water stress sensor, based on the electrophysiological behavior of fruit bearing woody plants, is presented. Real time electric potentials measured in tree trunks for different irrigation schedules, inducing variable water stress condition, are discussed in relation to soil water content and micro – atmospheric evaporative demand, determined continuously by conventional sensors. Also, plant stress is assessed by means of stomata conductance and photosynthesis rate instruments, and correlated to tree electric potential measurements
Systematic and differentiable patterns of electric potentials for water stressed and no stressed trees in 4 fruit species are presented. Early detection and recovery dynamics of water stress conditions can also be monitored with these sensors, which enable continuous and no destructive measurements for efficient irrigation scheduling throughout spring and summer seasons.
Our results also indicate that the dynamic steady– state of water availability assessment by plants, seems to be a very fast physiological process, on which back and forth information transmission between roots and shoots, leaves and stomata takes place almost continually, in the form of action and variation electric potentials, thus enabling the plant to optimize its water economy.

Session: 8.5
Abstract Number: 3050
Title: Action potentials in the root apex are dependent on gravity
Author: Masi, Elisa
Co-Authors: Ciszak, Marzena; Comparini, Diego; Monetti, Emanuela; Pandolfi, Camilla; Azzarello, Elisa; Mugnai, Sergio; Baluska, Frantisek

Gravitropism plays an important role in all living organisms since they have evolved and adapted their life in a condition of constant earth's gravity field of 1 g. In complex organisms, the response to general gravistimulation involves the modulation of the bioelectricity properties of cells, cell membrane, membrane proteins and membrane potentials.
In animal cells, the properties of action potentials (APs) have been found to be gravity dependent (Rüegg et al. 2000; Meissner and Hanke 2005; Hanke et al. 1998 and 2006). In higher plants, evidences that reorientation induces transient electrical activity have been reported (Bose 1907; Brauner 1927; Clark 1937; Schrank 1947; Tanada and Vinten-Johansen 1980; Shigematsu et al. 1994). Concerning the root system, membrane hyperpolarization has been detected in the columella cells (Sievers et al. 1995) and in the elongation zone (Ishikawa and Evans 1990) of the gravistimulated plants. It is worth noting that, in all these investigations, the gravistimulation consisted in changes in the orientation of the plants. Are there similar responses when analysing the effect of variations in the magnitude of gravity? Fast chemical responses to microgravity stress, involving oxygen and nitric oxide fluxes, have been reported in plants exposed to microgravity during parabolic flight experiments (Mugnai et al. 2008). Masi et al. (2008) used for the first time a multi electrode array (MEA) system to monitor the electrical activity of root cells during parabolic flight: they observed fast electrical signals (APs) produced during the whole flight, whose frequency of firing seemed to be influenced by the gravity condition.
In this study, made comparing the effect of microgravity and hypergravity treatments on the electrical activity of plant roots recorded in parabolic flight and in large diameter centrifuge experiments, we aims to understand better how AP's properties are gravity dependent.
All the experiments were performed on primary root apices of maize (Zea mays L.) (see Masi et al. 2008 and Masi et al. 2009 for Materials and Methods). The experiments were conducted during the 46th ESA parabolic flight campaign performed at Novespace in Bordeaux (France) for microgravity investigations and in the Large Diameter Centrifuge (LCD) at the ESA-Estec division (Noordwijk, NE) where two different increased gravity (2 g and 5 g) where tested. Data obtained on ground (1 g) where used as controls. Spikes waveforms and timestamps were obtained with a threshold based method and processed for spike rate analysis, cross-correlation of firing events, and shape analysis; finally, some signals propagating from one region to the other were extracted and used for the computation of the speed of propagation.
Results demonstrated that gravity affected frequency, duration and propagation rate of fast eelectrical signals (APs). The implications of such results will be discussed.

Session: 8.6
Abstract Number: 3035
Title: Mechanosensitive Channels and Plant Signaling
Author: Frachisse, Jean Marie
Co-Authors: Girault, Tiffanie; Tran, Daniel

Plants are constantly subjected to mechanical stimulations from their surrounding environment. These solicitations may vary in length, frequency and intensity depending on their origin. They are relayed in natural condition by a large scale of mechanical stimuli from the slight touch produced by an insect to damages produced by a storm. In all these situations, forces applied to the plant will produce deformations of the tissues. These deformations are transduced into internal signals and thus will induce an adaptive growth response called thigmomorphogenesis. In plant, the molecular nature of protein mediating mechanoperception is still elusive. Mechanosensitive ion channels belonging to MSL (Mechanosensitive Small-conductance Like) family represent strong candidates to be involved in mechanoperception and cell signalling. MSL proteins have been recently characterized in Arabidopsis in our laboratory [1] [2]. These proteins provide a mechanosensitive channels activity, anion selective, elicited by plasma membrane stretching. Using the GUS reporter gene, we have shown that MSL4, MSL5, MSL6, MSL9 and MSL10 have a wide range of expression from root to rosette leaves and interestingly, for two members, the expression is enhanced by wounding. Based on approaches combining q-PCR, patch clamp and extracellular potential recording, we have evaluated the putative role of MSL in local and transmitted response to mechanical stimulation.
Data concerning the function of MSL channels and new insight associated to biophysical properties of these channels will be presented and discussed.
[1] Haswell, E. et al. (2008). Curr. Biol., 18: 730-734
[2] Peyronnet, R., et al. (2008) .Plant Signaling & Behavior, 3: 726-729.
Acknowledgment: This study is supported by a grant (SENZO) of the French ANR

Session: 9.1
Title: Learning from the plant kingdom
Author: Mancuso, Stefano

The Plant Kingdom represents an amazing source of inspiration. The aim of the session is to present and discuss the importance of investigating plants for learning from their structure and behaviour, and for mimicking their features to develop new technologies and systems. Despite their amazing abilities plants have rarely been a source of inspiration for fields as robotics and artificial intelligence, doubtless because of misconceptions on their capabilities and their radically different functional principles as compared to other living organisms. Mimicking plants requires deep investigation of new materials, mechanisms, sensors, actuators, and control schemes and can lead to breakthrough advances of technologies. In this session, we wish to contribute to the discussion on the development of biomimetic solutions inspired by plants looking at the importance of integrating knowledge coming from different fields as biology, engineering, chemistry, computer science, and physics to conceive and develop advanced systems, with the objectives of providing an authoritative overview of solutions inspired by plants.

Session: 9.2
Abstract Number: 3062
Title: Plantoid: A new robot inspired by plant roots
Author: Mazzolai, Barbara
Co-Authors: Sadeghi, Ali; Tonazzini, Alice; Popova, Liyana

The understanding of anatomy, physiology, and behaviour of the plant root apparatus can open a plethora of new solutions in ICT and robotic fields. Plant roots are excellent soil diggers and represent a great source of inspiration for a new kind of robots able to explore soil [1]. We are interested in particular plant-root characteristics, such as capacity of directional growth and exploration in response to external stimuli (tropisms) with high plasticity and morphological adaptation to the environment; growth from the tip of the root by adding cells and production of lateral hairs, which reduces friction and pressure needed penetrate the soil; osmotic actuation principle, used for plant cells elongation and omnidirectional steering; sensory capabilities with respect to a wide amount of different physical and chemical quantities; just to mention some of them. We are developing a robotic system, named Plantoid, that takes inspiration from these interesting strategies of plant roots for soil penetration.
This work presents a mechanism in which the effect of growth from the tip, sloughing cells in the apical root region, and the role of lateral hairs in the root anchoring task was obtained by releasing a 3D soft skin with lateral hairs that is positioned between the body of the robotic root and soil [2]. This skin traverses from an internal hole of the robotic root to its external surface. The soil-side of the released skin remains in contact with the soil and provides anchorage due to the presence of hairs, in order to avoid the backward movement, while its other side behaves like a tunnel. Instead of pushing the body of the robotic root in the granular medium, the mechanism slips in the tunnel created by the skin. In order to add exploration and obstacle avoidance capabilities, a flexible root structure was designed and developed. Root cells work as soft hydraulic actuators. They expand during water uptake. Because of their radially reinforced walls, the expansion is not isotropic and determines cell elongation in the axial direction. Symmetrical growth of cells at the sides of the root provides a straight penetration, whereas differential cell growth causes a bending movement. With a similar simplified structure, we developed a soft bending mechanism which consists of several chambers embedded in a matrix made by silicone rubber [3]. Each chamber was individually reinforced in the radial direction. Due to this feature, these cell-like chambers could easily be arranged in different forms, e.g. tubular structure. By applying a fluidic pressure, chambers elongate in the axial direction and their differential elongation provides the whole system bending. In order to separately control each chamber, several miniaturised valves, based on electro rheological (ER) fluid, were embedded in the structure. ER fluids change fast phase when a voltage is applied [4]. The valves were integrated in the hydraulic circuit of the fluidic actuator and their working principle and role in bending the artificial root were tested in both air and soil. This flexibility can also help the robotic system to passively follow low resistance paths in soil.
[1] B. Mazzolai, A. Mondini, P. Corradi, C. Laschi, V. Mattoli, E. Sinibaldi and P. Dario, A Miniaturized Mechatronic System Inspired by Plant Roots, IEEE Transaction on Mechatronics, 16(2):201-212 (2011)
[2] A. Sadeghi, A. Tonazzini, L. Popova, B. Mazzolai, Robotic Mechanism for Soil Penetration Inspired by Plant Roots, 2013 IEEE ICRA, Karlsruhe, May 6 - 10, 2013
[3] A. Tonazzini, A. Sadeghi, L. Popova, B. Mazzolai, Plant Root Strategies for Robotic Soil Penetration Living Machines 2013, Natural History Museum, 29 July-2August, London, UK
[4] A. Sadeghi, L. Beccai, B. Mazzolai, IEEE/RSJ Int. Conf. on Intelligents Robots and Systems, October 7-12, 2012 Vilamoura, Algarve, Portugal

Session: 9.3
Abstract Number: 3041
Title: On the mechanisms of the self-burial seed dispersal of Erodium cicutarium
Author: Pandolfi, Camilla
Co-Authors: Comparini, Diego; Popova, Liyana; Mazzolai, Barbara; Mancuso, Stefano

Erodium cicutarium L. plants are characterized by two coupled seed dispersal methods: explosive dispersal and self-burial. As the fruits dry, the stresses developed in the structure cause the sudden separation of the seeds that fly away from the plant, and once on the ground, penetrate the soil thanks to a self-burial strategy, which increases the chance of a safe germination. Both these movements are possible thanks to hygroscopic tissues that generate passive movements via changes in the hydration of the cell walls.
The seeds are able to penetrate the soil thanks to a dedicated dispersal unit, the awn, a long tail that responds to variations in the external humidity and changes its configuration accordingly. In fact the awn is helical when dry and linear when wet. The day-night cycle of external humidity results in a coiling and uncoiling motor action, that, combined with other accessory structures, moves the seed across the surface and into the ground.
The present study aims at getting a deeper insight into the self-burial strategy of Erodium cicutarium in order to implement this ability into mechanical structures that relying on changes in the external parameters (such as light, temperatures or humidity) can achieve passively the same goal. The self-burial behaviour will be discussed in light of its potential application for biomimetic technologies such as penetrators for subsurface investigation.

Session: 9.4
Abstract Number: 3053
Title: Plant learning and intentionality: Some research questions and directions
Author: Affifi, Ramsey

Some biosemioticians maintain that semiotic activity can be distinguished from physical activity through the fact that the organism under question can “make a mistake”. That artificial sweeteners can fool sugar-seeking bacteria is stated as a common example (Stjernfelt, 2007;). However, there are some objects (having what some philosophers call “derived intentionality”) that can also “make mistakes”: for example, a keyhole can sometimes be “tricked” by a skeleton key. Such phenomena have intentionality because they are a part of larger intentional systems (in this case, humans, who have a desire to lock things up). Dennett (1989) noted that organisms can also be considered as having “derived intentionality” where the design principle is coordinated by evolution through natural selection. Such systems are capable of improvement over time in the same way that better and better locks are continuously designed to thwart thieves: natural selection perpetually selects for changes in the breadth of a given “sign”, especially in cases where another organism stands to benefit from misidentification. In other cases, a given sign can be broadened in meaning. An interesting question concerning plant studies is whether semiotic changes are solely due to evolution by natural selection. If so, then their intentionality is merely the sort of derived intentionality that we find in locks and keys. However, there is the emerging possibility that plant plasticity includes learning (itself an evolved capacity), such that the breadth of a given sign shifts through the organism’s interactions with its environment. Different types of sign changes could occur, and differentiating them would outline research directions and experiments that could give a better sense of the semiotic capacities and limitations of plants.
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Stjernfelt, F. (2007). Diagrammatology: An investigation on the borderlines of phenomenology, ontology, and semiotics . Dordrecht, The Netherlands: Springer.

Session: 9.5
Abstract Number: 2858
Title: Animal-like learning in Mimosa pudica
Author: Gagliano, Monica

Scientists have wondered for some time whether plants, like animals, can truly learn from the past and adjust their future behavior appropriately. We adopted the same approach used in studies of animal learning and memory and put the sensitive plant Mimosa to the test. We found that plants too can learn even rapidly when circumstances demand it, but most importantly they remember what has been learnt for several weeks (at the very least). These findings demonstrate that memory is not property special to organisms with a nervous system, inviting us to re-examine the fundamental mechanisms shaping behavior across living systems.

Session: 9.6
Abstract Number: 3069
Title: The Plant Intelligence Project
Author: L'Abbe, Sonnet

The Plant Intelligence Project is the collective public art event put on recently by students in a second-year creative writing class. After learning of the ways the plant behaviour metaphor helps to describe new knowledge about plant life, students applied the modernist and contemporary writing approaches they were studying to the question of how language influences how we understand the natural world and our relationship to it. Poet and eco-criticism author Sonnet L'Abbé will discuss how her research interests in critical plant studies led her to develop this interdisciplinary pedagogy, as well as how she herself has taken up the plant behaviour metaphor in her own professional creative practice.

Session: 10.1
Abstract Number: 3028
Title: Multiple ways to detect and respond to competing neighbors in dense stands.
Author: Pierik, Ronald

Growth at high plant densities is dominated by competition for limiting resources. To improve light interception shade-intolerant plants display a major developmental adjustment called the shade avoidance syndrome (SAS) which positions the leaves in higher, better lit zones of dense vegetations though enhanced shoot elongation. SAS is triggered through phytochrome-based signaling of far-red-enriched light reflected by surrounding vegetation. We show here that several other cues exist in dense stands and that these are exploited to respond adequately to neighboring vegetation. At the physiological level, phytochrome-mediated shade avoidance responses rely largely on regulation of DELLA protein turnover through gibberellins and on auxin biosynthesis and transport. Partly similar physiological interactions occur in response to reduced blue light fluence rates that occur in intense shade during competition for light. We show here that phytochrome-mediated shade avoidance is further enhanced by blue light depletion and will discuss possible mechanisms through which this interaction can occur. In addition to these interacting light signals, we recently showed that plants can detect neighbors through touching leaf tips as well as volatile organic compounds emitted by plants. The functional relevance of this multitude of plant neighbor detection signals will be discussed in the context of interactions between plants and other organisms, including competing plants, insects and pathogens.

Session: 10.2
Abstract Number: 3071
Title: Plant Environmental Stress Resistance: Roles for Touch and Time
Author: Chehab, E. Wassim
Co-Authors: Goodspeed, Danielle; Min-Venditti, Amelia; Covington, Michael F.; Yao, Chen; Henderson, Zachary; Kim, Se; Braam, Janet

Plants cannot change location to escape stressful environments. Therefore, plants evolved to use stimulus response behaviors and the circadian clock to enhance their resistance to such conditions. When mechanically stimulated by touch, most plants display gradual touch-induced morphological alterations, called thigmomorphogenesis. Thigmomorphogenesis may be adaptive; trees subjected to wind develop less elongated and thicker trunks and thus are less likely damaged by powerful wind gusts. Despite the widespread relevance of thigmomorphogenesis, the regulation that underlies plant mechanostimulus-induced morphological responses remains largely unknown. Furthermore, whether thigmomorphogenesis confers additional advantage is not fully understood. We have identified that jasmonate (JA) phytohormone is both required for and promotes the salient characteristics of thigmomorphogenesis in Arabidopsis. Furthermore, we found that repetitive mechanostimulation enhances Arabidopsis pest resistance against cabbage loopers (Trichoplusia ni) and fungal infection in a JA-dependent manner. We have also discovered that the circadian clock provides selective advantage to plants through anticipation of and enhanced defense against herbivory and fungal infection. Cabbage loopers have a clock-regulated, rhythmic feeding behavior and plants entrained in light-dark cycles in phase with entrainment of loopers suffer only moderate tissue loss due to herbivory. In contrast, plants entrained out of phase relative to the loopers are highly susceptible to attack, with dramatic loss of tissue mass. Both the circadian clock and jasmonates are required for this in-phase plant resistance to herbivory. We find that jasmonates accumulate in a circadian rhythmic pattern, suggesting that plants prepare in advance of peak insect feeding behavior and thereby have enhanced insect resistance. We also find that salicylate, a hormone involved in biotrophic defense, accumulates in opposite circadian phase to jasmonates. Clock-regulated defense also impacts fungal resistance; the time of infection with Botrytis cinerea fungal spores strongly impacts fungal lesion spread. Our results demonstrate that environmental mechano-stimulation and the plant circadian clock play important roles in the plant defenses against insect herbivory and fungal infections, and thereby provide a strong physiological advantage. This material is based upon work supported by the National Science Foundation under Grant No. MCB 0817976 Grant, a Rice University Institute of Biosciences and Bioengineering Medical Innovations Award to JB and a Bill and Melinda Gates Foundation Award to JB and EWC.

Session: 10.3
Abstract Number: 3072
Title: Take It or Leave It: Cellular Signaling Pathways Linking Salinity Stress to Root Growth
Author: Testerink, Christa

Plants are constantly exposed to different types of stress and have developed mechanisms that not only sense their environment but also protect them from biotic and abiotic stresses. Depending on the type and intensity of the stress, plants have the capability to "deal with" the stress by initiating signal transduction pathways that lead to the activation or expression of genes involved in tolerance. Alternatively, when stress cannot be overcome, plants can modify their growth in order to avoid or "run away" from the stress source. Although both plant growth and the mechanisms of stress tolerance have been well characterized, the link between these two processes is poorly understood.
To deal with drought or high salinity of the soil, plants can adjust and optimize their root system architecture (RSA), to avoid local high salt concentrations (Galvan-Ampudia and Testerink 2011) We study the intracellular signalling pathways linking salinity to root development and direction of root growth. Phosphatidic acid (PA) is a lipid second messenger involved in an array of processes occurring during a plant's life cycle, and is induced upon salinity stress (Testerink and Munnik 2011). Previously, we have isolated and identified several proteins that directly interact with the lipid second messenger phosphatidic acid (PA). Functional characterization of two PA-binding SNF1-related protein kinases (SnRK2s) has revealed that they are involved in maintaining root growth and branching under salinity stress (McLoughlin et al. 2012).
In another study, we set up an approach to specifically isolate and identify putative proteins from Arabidopsis roots that interact with PA and are recruited to membranes in response to salt. Proteins identified are involved in the regulation of potassium homeostasis, metabolism and clathrin recruitment, amongst other functions (McLoughlin et al. 2013). In accordance, phospholipase D-generated PA was found to be essential for clathrin-mediated endocytosis as an immediate response to salinity. I will discuss implications of this pathway for directional growth of roots away from high salinity, which involves redistribution of auxin, and occurs through clathrin-mediated internalization of the auxin efflux carrier PIN2 (Galvan-Ampudia et al., unpublished).
To discover new components in the signaling pathways that link salt stress perception to the regulation of root growth, we are also studying natural variation in salt-induced changes in RSA, as a means to identify novel genes involved in the response. The Arabidopsis HapMap diversity collection of 360 different accessions collected from all over the world was screened and we are currently performing genome-wide association studies (GWAS) to identify the causal loci underlying the different responses.
Galvan-Ampudia, C.S. and Testerink, C. (2011) Salt stress signals shape the plant root. Curr. Opin. Plant Biol., 14, 296-302.
McLoughlin, F., Arisz, S.A., Dekker, H.L., Kramer, G., de Koster, C.G., Haring, M.A., Munnik, T. and Testerink, C. (2013) Identification of novel candidate phosphatidic acid binding proteins involved in the salt stress response of Arabidopsis thaliana roots. Biochem. J. In press.
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Testerink, C. and Munnik, T. (2011) Molecular, cellular, and physiological responses to phosphatidic acid formation in plants. J. Exp. Bot., 62, 2349-2361.

Session: 10.4
Abstract Number: 3070
Title: Cytokinin and Plant-Organism Associations
Author: Emery, Neil

The cytokinins (CKs) are a complex group of classic plant hormones that have dramatic impact on plant processes such as meristem activity, nutrient acquisition, senescence, branching, inter-organ source-sink relationships, flowering, seed development, and root growth. Although they are still treated as classic phytohormones, it has become increasingly apparent that they are, by no means, uniquely associated with plants. They are known to be synthesized by algae, bacteria, fungi, insects, nematodes, fish and even humans. In fact, all organisms tested in my lab have contained CKs. Some distinct inter-organism impacts reveal a role for CK in parasitic, pathogenic and mutualistic associations with plants. These observations may represent only a subset of functions indicative of a greater role for CK among kingdoms. Indeed CK are ancient molecules which pre-date plants and they are known to pass among organisms and flow through the environment in many different ways. I will present studies from my lab on pathogenic (ie tumor inducing) and mutualistic (nodule inducing) interactions with fungi, bacteria and insects. Results will be discussed within the context of CK and control of organs within plants, and plant-organism associations.

Session: 10.5
Abstract Number: 3009
Title: Downy Oak: Rendering ecophysiological processes in plants audible
Author: Maeder, Marcus
Co-Authors: Zweifel, Roman

In our research project trees: Rendering Ecophysiological Processes Audible , we are working on the acoustic recording, analysis and representation of ecophysiological processes in plants and studying the acoustic and aesthetic requirements for making them perceptible. Measurements of acoustic emissions in plants are only interpretable in relation to climatic and physiological dynamics such as microclimatic conditions, sap flow, and changes in trunk radius and water potentials within the plants—all measurement data that is not auditory per se. Therefore, our work involves sonifying ecophysiological data, on one hand, and analysing the acoustic emissions mathematically on the other. How can phenomena that are beyond our normal perception be made directly observable, creating new experiences and opening a new window on the processes of nature? The sound installation trees: Downy Oak , exhibited at swissnex in San Francisco in summer 2012, is a first approach to a spatial audio sonification and research system. Our experiments show that immediate and intuitive access to measurement data through sounds and their spatial positioning is very promising in terms of new forms of data display as well as generative art works.

Session: 10.6
Abstract Number: 3047
Title: Plant perception of insect herbivores includes leaf vibrations caused by chewing.
Author: Appel, Heidi

Plant defenses against insects are elicited by a range of signals differing in their intensity, transmission distance, and speed. These include calcium signals and ROS caused by wounding and components of herbivore oral secretions deposited while feeding. These local signals are distributed or propagated systemically by the release of volatiles or the transport of signals through the vascular stream which can cause defense induction directly or prime the plant for a stronger response when a second attack occurs. Here we report a new type of signal that elicits plant defense– the vibrations caused by insect feeding. Arabidopsis thaliana (L.) rosettes pre-treated with the vibrations caused by caterpillar feeding had 20% higher levels of glucosinolate and phenolic defenses when subsequently attacked by attacked by Pieris rapae caterpillars than did untreated plants and plants treated with the vibrations caused by wind. These results demonstrate that plants can respond to herbivore-generated vibrations in an ecologically meaningful way. Although the way in which plants perceive mechanical vibrations is not well understood, a vibration signaling pathway would complement the known signaling pathways that rely on airborne volatiles or phloem-borne signals. As such, vibration may represent another long distance signaling mechanism in plants responsible for systemic induction by herbivory.

Session: 11.1
Abstract Number: 2869
Title: Role of PDH45 in crop improvement under adverse conditions of salinity stress
Author: Tuteja, Narendra

Various environmental stresses, including climate change and global warming, are the major concerns especially with regard to crop productivity in relation to the increasing global population. These stresses ultimately lead to reduction in crop yield and threaten food security. Therefore, there is an urgent need to develop stress-tolerant crop plants which have negligible loss in productivity even under stress. Since stresses affect the cellular gene expression machinery, therefore, molecules involved in nucleic acid metabolism including duplex unwinding enzymes (helicases) are likely to be the target. Most helicases are members of DEAD-box protein super-family and play essential roles in basic cellular processes such as replication, repair, recombination, transcription, ribosome biogenesis and translation initiation. There are now few reports on the up-regulation of DEAD-box helicases in response to abiotic stresses. Earlier, we have reported the isolation of a pea DNA helicase 45 (PDH45) that exhibits striking homology with the eukaryotic translation initiation factor eIF-4A (Plant J). Here, the focus is on the functional validation of PDH45 in model plant and in different crops. The PDH45 mRNA is induced in pea seedlings in response to high salt, and its overexpression driven by a constitutive cauliflower mosaic virus-35S promoter in tobacco plants confers salinity tolerance, thus suggesting a previously undescribed pathway for manipulating stress tolerance in crop plants. The T0 transgenic plants showed high levels of PDH45 protein in normal and stress conditions, as compared with WT plants. The T0 transgenics also showed tolerance to high salinity as tested by a leaf disk senescence assay. The T1 transgenics tobacco plants were able to grow to maturity and set normal viable seeds under continuous salinity stress without any reduction in plant yield in terms of seed weight. Measurement of Na+ ions in different parts of the plant showed higher accumulation in the old leaves and negligible accumulation in seeds of T1 transgenic lines as compared with the wild type plants. The exact mechanism of helicase-mediated salt tolerance is not yet understood. After observing the proof of concept in model plants, the PDH45 has been used to transform the bacteria and the different varieties of rice plants. The results show that PDH45 also provide the salt tolerance in bacteria and rice. The T1 transgenic rice plants exhibited higher glutathione (GSH) and ascorbate (AsA) contents under salt stress. The activities of antioxidant enzymes viz. superoxide dismutase (SOD), ascorbate peroxidase (APX), guaicol peroxidase (GPX) and glutathione reductase (GR) were significantly higher in transgenics; suggesting existence of efficient antioxidant defense system to cope up with salinity induced-oxidative damages. Furthermore, the T2 transgenic rice plants were also able to grow, flower, and set viable seeds under continuous salinity stress of 200 mM NaCl. Furthermore, the transgenic plants were found to have no negative impact on the properties and microbial communities of rhizosphere soil. This study provides insights into the mechanism of PDH45 mediated salinity stress tolerance by controlling the generation of stress induced reactive oxygen species (ROS) and also by protecting the photosynthetic machinery through strengthened antioxidant system.

Session: 11.2
Abstract Number: 3059
Title: Understanding of the salt tolerance mechanisms during seed germination in sunflower
Author: Bhatla, Satish C.

Sunflower seedlings subjected to salt stress exhibit a decrease in extension growth of hypocotyl, non-expansion of cotyledons, loss of root. turgidity and root proliferation in a salt concentration-dependent manner. With increasing salinity, sodium ions tend to accumulate in roots. Physiological production of NO seems to play a role in the initiation of seed germination. Oilseed germination, in contrast to other seeds, accompanies triacylglyceride (TAG) mobilization from seedling cotyledons, thus offering a biochemically interesting system for investigating the various biochemical signaling events during this developmental process. A possible correlation between endogenous nitric oxide (NO) expression in seedling roots and oil bodies, NaCl-induced changes in seedling growth, Na+ /K+ ratio and oil body mobilization pattern has been demonstrated. Present findings thus provide new information on the NO-modulated NaCl stress tolerance through delayed proteolytic degradation of principal oil body membrane proteins (oleosins). Higher NO production in the 2-day-old control seedlings reflects a significant role of NO during early stages of seedling growth. A transient increase in NO production, primarily contributed by nitric oxide synthase (NOS), is evident at 4-day stage in sunflower seedlings subjected to 120 mM NaCl. From the two observations, i.e. transient increase in NO accumulation at 4-day stage and a reduction in the rate of increase in Na+ /K+ ratio at 4-days stage, it is inferred that NO regulates Na+ accumulation probably by affecting the associated transporter proteins. Greater retention of the three oleosin isoforms with increasing NaCl stress is observed in sunflower seedlings, indicating their role in oil body longevity. A transient increase in the expression of NO signal in NaCl-treated root tips is indicative of the possible role of NO in altering the activity of specific transporter proteins. Using a new methodology, the present work demonstrates ouabain (OU)-sensitive ATPase activity in the roots of sunflower seedlings subjected to salt stress (120 mM NaCl). Salt stress for 48h leads to a significant induction of OU-sensitive ATPase activity in the meristematic region of the seedling roots. Based on the proteomic approach followed by LC MS analysis, several adaptation strategies have been identified in sunflower seedlings under salt stress. Greater impact of NaCl stress is evident on the enzymes of primary metabolism (18%), reactive oxygen species scavenging proteins (18%), followed by chaperones (14%), proteolysis (9%), cytoskeleton/structural proteins (9%) and proteins related to desiccation tolerance (9%). Laccase activity modulation is likely to exert its effect on shortening of seedling roots by enhanced lignification of cell. Tyrosine nitration is believed to change protein function by gain or no effect; inhibition and prevention or stimulation of phosphorylation. Present work indicates a gradient of tyrosine nitrated proteins from the tip to the upper part of the root and also from the periphery to the deep seated cells, more so in the root tip region. Since these zones of the root are in direct contact with salt containing nutrient, a correlation between salt stress and tyrosine nitration of proteins is anticipated. Major differences in tyrosine nitration are evident in proteins having a molecular mass less than 25 kDa. Thus, a total of 8 major differences in tyrosine nitration of proteins can be detected in the cytosolic proteins of roots in response to salt stress. Of these, most proteins show enhanced labeling in the presence of salt. Western blot analysis of anti-nitrotyrosine labeled proteins in the total soluble protein from the seedling cotyledons and oil body membrane proteins has revealed prominent differences in response to salt stress.

Session: 11.3
Abstract Number: 3016
Title: REDOX RESPONSIVE TRANSCRIPTION FACTOR1 amplifies the formation of reactive oxygen species in Arabidopsis thaliana shoots and roots
Author: Oelmüller, Ralf
Co-Authors: Matsuo, Mitsuhiro; Johnson, Joy Michal; Godfrey, Rinesh; Obokata, Junichi; Böhmer, Frank-D.

Redox Responsive Transcription Factor1 (RRTF1) in Arabidopsis thaliana is rapidly and transiently upregulated by stress and redox signals. Inactivation of RRTF1 restricts and overexpression promotes reactive oxygen species (ROS) production in response to biotic and abiotic stress. oe lines are impaired in root and shoot development, light sensitive and susceptible to Alternaria brassicae infection. These symptoms are diminished by the beneficial root endophyte Piriformospora indica which reduces ROS accumulation locally in roots and systemically in shoots. Approximately 800 stress- redox-, ROS regulated-, ROS scavenging-, defense-, cell death- and senescence-related genes are regulated by RRTF1, and those genes which are upregulated in all oe tissues are ROS marker genes. Many differentially expressed genes respond to an RRTF1-mediated change in the cellular ROS homeostasis. RRTF1 is co-regulated with the phylogenetically related RAP2.6, but elevated RAP2.6 levels do not promote ROS formation. RRTF1 mediates systemic ROS production in distal non-stressed leaves. We conclude that the highly conserved RRTF1 rapidly, transiently and systemically amplifies ROS formation in response to ROS and ROS producing abiotic and biotic stress signals. Necrotrophs stimulate RRTF1 expression, while (hemi-)biotrophs and P. indica which do not induce ROS production in the host, do not affect or repress RRTF1 expression.

Session: 11.4
Abstract Number: 2868
Title: Pyramiding of the PDH45 gene with EPSPS for developing salt and herbicide tolerant plants
Author: Garg, Bharti

Various biotic and abiotic stresses are responsible for the reduction in the crop yield which further leads to food insecurity. Therefore, there is an urgent need to develop multi-stress tolerant crop plants which can enhance the food production even under stress conditions. Salinity stress and weeds are the most serious biological constraint in cultivation of many crops, therefore, the development of salinity and herbicide tolerant plants could be one of the useful approaches for enhancing the crop production. Plants have a well coordinated network of various regulatory genes known to play a role in tolerance to these stresses. Among them, the PDH45 (pea DNA helicase 45) and the EPSPS (5-enolpyruvylshikimate-3-phosphate synthase) were previously reported for their role in providing salt and herbicide tolerance, respectively. Therefore, considerable interest has been focussed on tobacco transgenic plants with dual characteristics by harbouring PDH45 and EPSPS. The results showed that the transgenic tobacco plants overexpressing PDH45 and PDH45+EPSPS were more tolerant to salt stress. The mechanism of salt stress tolerance was identified as regulatory uptake of Na+ ions by PDH45 and double construct as compared to control plants, as monitored by Corona dye. Salt stress affects the ROS homeostasis and is also known to affect the biochemical status of the plant. Therefore, comparative analysis of salt stress on biochemical status, ROS machinery and antioxidant system was carried out. Collectively, these results proved that overexpressing lines with PDH45+EPSPS and PDH45 were highly tolerant to salt stress in comparison to the transgenics of EPSPS and control (WT and empty vector) lines. Furthermore, amongstthe identified salt tolerant lines, PDH45 + EPSPS wasalso resistant to glyphosate. In conclusion the double construct of PDH45 and EPSPS may serve as a useful biotechnological tool for the improvement of stress and herbicide tolerance in different varieties of plant.

Session: 11.5
Abstract Number: 3020
Title: Regulation of Trichome Development by Single-repeat R3 MYB Transcription Factors
Author: Wang, Shucai

MYB transcription factors (MYBs) control multiple aspects of plant growth and development. Among a large family of MYBs, single-repeat R3 MYB transcription factors (R3 MYBs) are small proteins (~100 amino acids) that consist of a single MYB DNA-binding domain. R3 MYBs are best characterized for their regulatory roles in trichome development. In the model plant Arabidopsis, trichome initiation is promoted by an R2R3 MYB-type transcription factor GLABRA1 (GL1) , a bHLH transcription factor GLABRA3 (GL3) or ENHANCER OF GLABRA3 (EGL3), a WD 40 -repeat protein TRANSPARENT TESTA GLABRA1 (TTG1) , and a homeodomain protein GLABRA2 (GL2) . R3 MYBs inhibit t richome formation by competing with GL1 for binding GL3 or EGL3, thus limiting the activity of the activator complex formed by TTG1, GL1 and GL3 or EGL3. Available evidence suggests that similar types of transcription factors control trichome formation in other plant species. Recent studies also revealed that R3 MYBs may use distinct mechanisms to regulate trichome formation, and that the expression of R3 MYB genes is not solely controlled by the activator complex. Here, we provide a comprehensive review on the role of R3 MYBs in regulating trichome development.

Session: 11.6
Abstract Number: 3063
Title: Identification of N-Acylethanolamines Binding Protein in Arabidopsis thaliana
Author: Tripathy, Swati
Co-Authors: Wong, Justin; Chapman, Kent D.

N - Acylethanolamines are bioactive fatty acid derivatives that are produced from the membrane phospholipid, N-acylphosphatidylethanolamine (NAPE), in both animal and plant systems. NAE signaling is terminated by fatty acid amidohydrolase (FAAH), and in animal tissues, the regulated formation and inactivation of NAE is part of the endocannabinoid pathway that regulates many physiological and behavioral processes. Among the commonly occurring NAEs in plants, N-lauroyl- (NAE 12:0) and N-myristoyl- (NAE 14:0) ethanolamines were two species, found to increase several fold during pathogen-derived elicitor treatment to likely participate in signaling of defense gene activation. Understanding the action of NAEs in plants has expanded substantially with identification and manipulation of Arabidopsis FAAH, especially with respect to NAE 12:0 as a negative regulator of seedling growth. While the physiological actions of NAES in plants are unfolding, their cellular targets of action have yet to be identified. In animal systems, selected NAEs bind to cannabinoid and vanilloid receptors to mediate cellular signal transduction. Here, we have identified a putative binding protein for NAEs in Arabidopsis thaliana (At1g26440) using mammalian cannabinoid and vanniloid receptors as templates for motif elicitation. The recombinant protein was expressed in Saccharomyces cerevisceae, and it exhibited saturable, high affinity (Kd, 6.0 nM) binding to [3H]NAE 14:0 that was comparable to the binding activity measured in Arabidopsis leaf microsomes (Kd, 14.8 nM). T-DNA insertional mutants of this Arabidopsis locus (SALK_044810, SAIL_856_D03) did not show biding activity towards [3H]NAE 14:0, and were insensitive to growth inhibition by NAE12:0. We propose that At1g26440 represents an endogenous NAE binding protein in Arabidopsis and is a potential mediator of NAE regulated signaling.

Session: 11.7
Abstract Number: 3044
Title: How does maternal abiotic stress affect offspring reproductive traits?
Author: (H.S) Seshadri, Arathi
Co-Authors: Smith, Tyler

Plants are experiencing unprecedented environmental variations and these variations may not always follow a consistent pattern. Plant reproductive strategies provide crucial insights into the effects of abiotic stress. But the conditions experienced by maternal plants may be significantly different from those experienced by their offspring, thus limiting the potential for evolutionary change. Reproductive traits of Collinsia heterophylla , a mixed-mated, hermaphroditic, annual were studied in stressed maternal plants and in their offspring grown under no stress. Our results indicate that among a suite of responses, stressed maternal plants had highly reduced herkogamy allowing for augmented selfing success. While this trait was inherited in the offspring, reproductive success was significantly limited, possibly due to compromised pollen behavior, both under stress, and inbreeding. We propose that, reproduction by selfing may be a favored strategy under environmental stress, but the potential for a mixed-mated species to become predominantly selfing, may be limited by interactive effects of stress and inbreeding depression.

Session: 11.8
Abstract Number: 3015
Title: Self/non-self discrimination in pea (Pisum sativum) cv. Mikado
Author: Macedo, Francynês
Co-Authors: Oliveira, Ricardo; Olinda, Ricardo

In order to determine if the pea plants cv. Mikado are capable of self/non-self discrimination, a system of "split-root" containing two treatments: self (pots with two roots of the same plant) and non-self (pots with two roots of different plants), was used for eleven day seedlings, whose pots were grouped in triplets. The experiment was kept in growth chamber under controlled environmental conditions. After 18 days the shoot and root growth was evaluated. Considering the average values of each triplet, there was no significant difference in shoot growth between treatments. Concerning root growth, except for the diameter, the other variables differed significantly, and self treatment plants had values of dry weight, surface area and total length of 36.71%, 27.84 % and 23.18%, respectively, higher than the non-self treatment plants. However, when we observe the behavior of plants in each triplet, the plants of the non-self treatment had different shoot and root sizes. Furthermore, the roots of the same plant grew differently depending on the identity of neighbor roots implying self/non-self discrimination, and in self treatment, there was no difference in size between the plants in a triplet.

Session: 11.9
Abstract Number: 3013
Title: Sexual selection inside a fertilised egg?
Author: Gorelick, Root

Many things happen inside an egg cell between when sperm cells enter and two haploid nuclei fuse to form a zygote. The egg cell becomes a microcosm in which haploid nuclei can engage in sexual selection and/or conflict because there are multiple haploid egg nuclei (usually two, but sometimes four) and multiple haploid sperm nuclei (usually two sperm per pollen tube in seed plants). Not only may haploid nuclei actively choose one another, but they may control ejection or digestion of other haploid nuclei ('polar bodies'). Two haploid egg nuclei from the same meiotic division may even choose to fuse with one another instead of with a sperm nucleus or, more rarely, two haploid sperm nuclei may fuse with one another ejecting all haploid egg nuclei as polar bodies (Cupressus dupreziana?). Such dynamics inside a fertilised egg cell may provide a hitherto unrecognized form of cryptic sexual selection/conflict, which could possibly occur in plants, especially if multiple sperm enter an egg.

POSTER PRESENTATIONS (abstracts organized by author's last name)

Abstract Number: 3019
Title: Analysis of MAP kinase pathways and the expression of DNA repairing genes during wheat response to pathogen attacks
Author: Albaraky, Ashwaq
Co-Authors: Xing, Tim

Plants are exposed to abiotic stresses such as drought, high or low temperature, and to biotic stresses such as insect attack or pathogen infection. Plants have developed specific mechanisms to detect external signals with proper physiological responses in order to survive under these challenges. Protein phosphorylation is involved in plant response to pathogen attacks. One of the principle phosphorylation pathways that are used by plants in biotic and abiotic stress responses is mitogen-activated protein (MAP) kinase pathway, which consists of MAPKKK, MAPKK, and MAPK. The following work will be presented: cell death mechanisms, FLR gene expression, RAD50 and RAD51 gene expression. β-glucanase and glutamine synthetase have been studied when Fusarium head blight resistance and susceptible cultivars were challenged by fungal toxin Fumonisin B1 or salicylic acid.

Abstract Number: 3017
Title: A putative Lambda class Glutathione-S-transferase gene in the wild soybean interacts with polyphenolic metabolites which promote plant growth and enhance survival under salinity stress
Author: Chan, Ching
Co-Authors: Lam, Hon-Ming

Reactive oxygen species (ROS) are highly reactive and toxic molecules which cause damage to cytosolic protein, lipid, carbohydrate and DNA. Various abiotic stresses could lead to the overproduction of ROS, predominately in the chloroplast and mitochondria. Leaf chlorosis, which is the first step in senescence-associated programmed cell death, is clearly visible three days post salt treatment in cultivated soybean (sensitive line), characterized by chlorophyll loss and disruption of membrane integrity. Meanwhile, such process is delayed in wild soybean (tolerant line). By comparative genomic approach using a unique soybean recombinant inbreed population, a salt stress related gene cluster was identified. Expression of most genes in the cluster was up-regulated under salt stress. Among which a putative glutathione-S -transferase (GST) gene was highly up-regulated specifically in wild soybean. Phylogenetic analysis revealed that the putative GST belongs to Lambda class which is understudied compared to the auxin responsive Tau class and xenobiotics conjugating Phi class GST. We therefore named this gene GmGSTL1 . Overexpression of GmGSTL1 in tobacco BY-2 cell line and Arabidopsis thaliana significantly reduced salinity induced ROS accumulation and enhanced cell/plant survival under salt stress. Two candidate flavonoids from leaf extract were found to bind to the GmGSTL1 protein. Making use of a knock-out mutant of a close homologue of GmGSTL1 in A. thaliana , we showed that application of the candidate flavonoids could delay salinity induced leaf chlorosis. Similar functional protection was also observed in wild type plant and overexpressors under high salt conditions. Given that dietary polyphenols, including phenolic acids, phenolic diterpenes, flavonoids and volatile oils are well-known effective antioxidants due to their strong H-donating activity, GmGSTL1 might serve to maintain the pool of active flavonoid under salinity stress. Therefore, the up-regulation of GmGSTL1 under salinity stress in wild soybean might account, at least partially, to protect the cellular functions, and hence delayed onset of leaf senescence. [This work is supported by the Hong Kong RGC Collaborative Research Fund (CUHK3/CRF/11G), and funding from the Lo Kwee-Seong Biomedical Research Fund and Lee Hysan Foundation.]

Abstract Number: 3057
Title: Apyrases and extracellular ATP play a role in Arabidopsis stomatal opening and closing
Author: Clark, Greg
Co-Authors: Darwin, Cameron; Mehta, Viraj; Jackobs, Faith; Perry, Tyler; Hougaard, Katia; Roux, Stanley

Extracellular ATP regulates the growth of a variety of plant tissues. In Arabidopsis leaves both the opening and closing of stomata release ATP from guard cells, and lower concentrations of applied ATP induce stomatal opening, while higher concentrations induce closure. The induced opening and closing of stomates are both blocked by two different mammalian purinoceptor antagonists, PPADS and RB2. These antagonists also partially block ABA-induced stomatal closure and light-induced stomatal opening. Application of ATPγS can induce changes in stomatal aperture at 10-fold lower concentrations than ATP, presumably because applied ATP is hydrolyzed by ectoapyrases. Two closely related apyrases in Arabidopsis, AtAPY1 and AtAPY2, are both expressed in guard cells. Different levels of apyrase chemical inhibitors can induce stomatal opening or closing. Treatment with apyrase enzyme blocks ABA-induced stomatal closure and partially blocks light-induced stomatal opening. Taken together these data suggest that the swelling and shrinking of guard cells induced by various stimuli may result in the release of ATP that help regulate stomatal apertures.

Abstract Number: 3034
Title: MSLs MECHANOSENSITIVE AND CLCs ANION CHANNELS IN LEGUME ROOT HAIR: ROLE IN SYMBIOSIS
Author: Frachisse, Jean Marie
Co-Authors: Tran, Daniel; Guichard, Marjorie; Alloul, Lydia; Girault, Tiffanie; Filleur, Sophie

The root hair plays crucial roles in water and nutrient uptake, and thus in plant development. In legumes, it also plays a central role in the establishment of the nitrogen-fixing symbiotic interaction with rhizobia, which has a crucial importance for sustainable agriculture as it largely contributes to limitation of nitrogen fertilizers. In this study we have addressed the MSL and CLC channels families which might be involved in key processes of symbiosis in the model legume Medicago truncatula . Mechanosensitive ion channels belonging to MSL (Mechanosensitive Small-conductance Like) family represent strong candidates to participate in mechanoperception and thus in processes leading to cell signalling in Arabidopsis (Haswell et al., Current Biol., 2008). In Medicago, the bacterial infection initiated by bacterial adhesion to root hairs will lead to hair curling that entraps the bacteria.The hypothesis of the involvement of physical sensors at the surface of the root hair during early symbiotic interaction is worth considering. CLC genes encode a nitrate and chloride channel/transporter family that we contributed to identify and characterize in Arabidopsis (Barbier-Brygoo et al., Annual Rev. Plant Biol., 2011). Amongst the seven isoforms, AtClCa is involved in nitrogen storage through its ability to accumulate nitrate in the vacuole. Considering the ability of plant legume to establish symbiosis in order to assimilate atmospherical nitrogen when nitrate concentrations are low in soils, the root nitrate channel/transporter equipment of Medicago is worth analyzing. In this context we have identified 13 members related to MSL channels and 8 members related to CLC channels/transporter from in silico analysis of Medicago genome. Amongst the 13 MSL members, 8 strong putative candidates were divided into two clades, as observed in Arabidopsis. The expression analysis of one clade by semi-quantitative PCR, revealed that these candidates are present in root hair and other root tissues. Preliminary results showed that transient expression in a silenced-system provides a channel activity dependant on membrane tension for one MSL. Among the 8 CLC members, 4 putative candidates which distribute into two clades as observed in Arabidopsis were selected. The expression analysis by semi-quantitative PCR indicates that two CLC are strongly expressed in root hair while two other CLC are found both in root hair and other root tissues. Further investigations are in progress in order to get a functional characterization of these root hair channels and to obtain an integrated view of their role in early symbiosis.
Acknowledgment: This study is supported by a grant (CAROLS) of the French ANR

Abstract Number: 3038
Title: Transgenic barley with modified cytokinin level
Author: Husickova, Alexandra
Co-Authors: Pospisilova, Hana; Jiskrova, Eva; Mrizova, Katarina; Jezilova, Eliska; Klimesova, Jana; Galuzska, Petr; Frebort, Ivo

World crop production is negatively affected by variety of biotic and abiotic stresses. Cytokinins are important signaling molecules in plant cells and tissues where they control cell division, affect apical dominance, leaf senescence, grain filling and other important processes. Genetic manipulation of cytokinin level may influence many physiological processes, besides others the stress tolerance, root formation and grain yield. A molecular approach was used to modulate cytokinin levels in barley to produce transgenic plants with decreased cytokinin content. Growing these plants hydroponically we observed significantly lower decrease in relative water content (RWC) in comparison to control barley plants after one day of stress conditions. Further, after 6 days of revitalization, the photosynthetic parameter Φ PSII (quantum efficiency of photosystem II in the light-adapted state) of the transgenic plants recovered to higher values in comparison to control plants. Surprisingly, lumen acidification of the transgenic plants had changed kinetics as well. The most probable mechanism of the enhanced stress resistance in the transgenic barley plants is reduced inhibition of root formation by cytokinins.

Abstract Number: 3030
Title: Extracellular ATP as Signaling Molecule in Root Apex Transition Zone
Author: Kagenishi, Tomoko
Co-Authors: Yokawa, Ken; Baluska, Frantisek

It is well known that ATP is an ubiquitous energy source for living organisms. In mammalian cells, ATP is known to be released often out of cells and it then behaves as a signaling molecule. Also in plant, recent studies demonstrated that extracellular ATP (eATP) is involved in regulating plant growth and adaptation to stress (Tanaka et al. 2010, Dark et al. 2011). In root apices, several regions were defined based on their cellular, anatomical and physiological functions (Baluška et al. 2010). 'Transition zone' of the root-apex plays many important roles for determining root behaviors such as growth, tropisms via polar auxin transport, endocytosis and vesicle trafficking (Baluška et al. 2010). Transition zone is known to have high activity of ATP release induced by touch stress (Weerasinghe et al. 2009) as well as wounding and osmotic stress (Dark et al. 2011). Transition zone may have important a role of ATP signaling. The aim of this study is to investigate the mechanisms of eATP signaling in roots of Arabidopsis. We have found that endocytosis and endocytic vesicle recycling in the transition zone is inhibited by 1 mM eATP. In this presentation, possible roles of eATP signalling in roots, and in their responses to environmental stimuli, will be discussed. References Baluška et al. Trends Plant Sci. 15: 402-408 (2010) Demidchik et al. Plant J. 58: 903-913 (2009) Dark et al. Plant Signal. Behav. 6: 1855-1857 (2011) Tanaka et al. Trends Cell Biol. 20: 601-608 (2010) Weerasinghe et al. FEBS Lett 583: 2521-2526 (2009)

Abstract Number: 3060
Title: The Leucine-Rich Repeat Receptor-Like Kinase MUSTACHES Regulates Bilateral Symmetry In Stomata
Author: Keerthisinghe, Sandra

Stomata are specialized epidermal structures that regulate shoot gas exchange and water loss. Eudicot stomata consist of two kidney-shaped guard cells (GCs) surrounding a pore. Stomata form through a dedicated cell lineage wherein a stem cell undergoes an asymmetric division which is followed by a symmetric division. This division initiates the development of a mirror-like bilateral symmetry in overall GC shape, including that of the pore, and of radial microtubule (MT) arrays. This symmetry is critical for the valve-like function of stomata.
MUSTACHES (MUS) encodes a Leucine-Rich Repeat Receptor-Like Kinase (LRR-RLK) which acts to enforce bilateral symmetry after the symmetric division generates the GCs. Loss of MUS function disrupts GC symmetry and morphogenesis. Defects include abnormal pore formation, loss of symmetry in MT arrays and disruptions in the direction of MT growth. Many cellular processes related to bilateral symmetry occur close to the center of the stoma. However, translational GFP fusions indicate that MUS is localized peripherally in developing and mature GCs. Thus, MUS likely enforces stomatal symmetry by acting from the GC periphery.

Abstract Number: 3036
Title: Glutamate effect on electrophysiological characteristics of characeaen cell membrane
Author: Lapeikaite, Indre
Co-Authors: Kisnieriene, Vilma; Sakalauskas, Vidmantas; Sevriukova, Olga

Glutamate as neurotransmitter and one of the main substance in amino acid metabolism and component of a pool of dissolved organic nitrogen in soil is one of the most abundant amino acid in living organisms. There are evidences that glutamate act as signaling molecule in intracellular and long distance communication within plants modifying variety of physiological processes including root development and plant reaction to stress. It is suggested that plant homologs of mammalian ionotropic glutamate receptors (iGluR) acts as non-selective cation channels permeable to calcium which is substantial to signal transduction. Glutamate can induce cytosolic Ca2+ concentration increment therefore affect action potential (AP) generation in various species of plants. Till now glutamate effect on characeaen cells membrane electrophysiological characteristics was not investigated. Using microelectrode measurements ant voltage-clamp method we investigated effect of various concentrations of L-glutamic acid solutions to cell membrane resting potential; AP threshold, repolarization duration, maximum repolarization velocity and Cl- efflux. Results show, that exogenous glutamate depending on its concentration (0,1-5 mM) reduce action potential threshold, repolarization velocity, thus elongates length of action potential repolarization phase (33, 2±5, 51 %.), increase maximum Cl- current value during electrically stimulated action potential. In some cases 5 mM glutamate elicits membrane potential depolarization and series of spontaneous action potentials generation. These results support concept that glutamate take place in plant electrical communication.

Abstract Number: 3037
Title: A simultaneous enhancement of source- and sink-capacities results in increased potato tuber yield
Author: Ludewig, Frank
Co-Authors: Jonik, Claudia; Wöstefeld, Nicole; Zhang, Lizhi; Flügge, Ulf-Ingo

Potato plants overexpressing a pea glucose 6-phosphate/phosphate translocator (GPT) or an Arabidopsis adenylate translocator (NTT) in tubers show no effect on tuber starch yield. In contrast, plants simultaneously overexpressing both genes exhibited moderately enhanced tuber yield, starch content and total tuber starch content per plant, demonstrating starch synthesis within amyloplasts to be co-limited by the import of energy and carbon skeletons. To analyze whether a simultaneous enhancement of source- and sink-capacities is suitable to further improve tuber starch yield, source capacity was additionally altered in the above-mentioned double transgenic plants using a leaf-specific antisense repression of ADP-glucose pyrophosphorylase. Analyses of the resulting triple transformants proved this strategy promising for the increased formation of starch in tubers which becomes apparent in strongly enhanced tuber yield, starch content and total tuber starch content per plant.

Abstract Number: 3011
Title: Oxidative Stress Responses in Galdieria sulphuraria - A Prospective Plant Neurobiological Model for the Study of Functional Proteomics
Author: Okpodu, Camellia

Plant neurobiology is a field of increasing interest. New techniques and methods have been developed to better understand how plants are able to respond to environmental stress with considerable plasticity. In animals and humans the concept of neurobiology is coordinated with behavior, however in bacterial and plants, coordinate outcomes are associated with special gene/protein circuits which change relative to the environmental conditions. Galdieria sulphuraria is an unicellular red algae found in volcanic areas where there are sulfuric hot springs. Galdieria sulphuraria can grow in complete darkness on a wide variety of organic substrates, including sorbitol, glycerol and mannitol. The high adaptability of Galdieria sulphuraria to extreme environments (i.e., elevated temperature and extreme pH's) which causes oxidative stress makes it a model organism in which to study the regulation of both the reactive oxygen scavenging mechanism as well as the antioxidant ascorbate-glutathione scavenging system. In this presentation we propose that Galdieria sulphuraria's antioxidant scavenging pathway is a prospective model biological circuit that can be used to examine both short- and long-distant electrical signals in eukaryotic organisms. (Supported in part by NSF-HRD15940624929; NSU GMEB Funds – 9114400555; NASA - NNC04GB58G)

Abstract Number: 3040
Title: Physiology of acclimation to salinity stress
Author: Pandolfi, Camilla
Co-Authors: Mancuso, Stefano; Shabala, Sergey

Acclimation to environmental changes can occur in plants thanks to internal adjustments within tissues and cells, enabling plant metabolism to proceed under these somewhat altered conditions. In a contrast to adaptation that occurs in plant phylogeny, acclimation occurs during plant ontogeny and describes enhanced stress tolerance of a particular individual plant. In the context of salinity, it was widely reported that many plant species increased the ability to tolerate salt stress after being exposed to low level of stress for a certain period of time. The beneficial effects of acclimation included both agronomical (e.g. improved survival rate; higher growth rate; less biomass reduction) and physiological (lower Na+ accumulation in the shoot; better osmotic adjustment) characteristics. However, the physiological mechanisms beyond this acquired resistance to salinity remain largely a matter of conjecture.
In present contribution we will present the results of different sets of experiments in two glycophyte plants: Pisum sativum and Zea mais. Three specific questions on the salt-acclimation process will be answered: (1) which of the two major components – specific ion toxicity or osmotic stress – has a bigger role in plant acclimation to salinity, (2) whether the acclimation affects take place in plant root or shoot tissues, and (3) which are the major ionic mechanisms that are triggered by salt acclimation.

Abstract Number: 3042
Title: Morphologic and aerodynamic considerations of the hairy parachute of the seeds of Tragopogon pratensis
Author: Pandolfi, Camilla
Co-Authors: Casseau, Vincent; Izzo, Dario

1. Tragopogon pratensis is a small herbaceous plant that uses wind as dispersal vector for its seeds. The seeds are attached to stalked parachutes, which increase the aerodynamic drag force on the seeds. This decreases their rate of descent, and hence increases the total distance travelled. The relatively large parachute of Tragopogon pratensis is an example on how nature scaled up a structure, maintaining a very high aerodynamic performance.
2. The present contribution describes some of the features evolved by the plant to increase its dispersal capacity by maximizing the drag force, controlling its release and influencing the dispersal distance.
3. We prove that the porosity of the textile that the plant creates is a very appropriate solution to achieve a lightweight structure that allows a low terminal velocity, a stable flight and a very efficient parachute for the velocity at which it is operating.

Abstract Number: 3043
Title: Thigmotropic behavior of climbing plants and and a bio-inspired tactile based grasping device
Author: Pandolfi, Camilla
Co-Authors: Mimmo, Tanja; Vidoni, Renato

Climbing plants are cable to grasp objects by extending themselves and then use the objects as support by coiling around them. The goal is to achieve maximum vertical height for rich sun exposure while avoiding the energy expenditure of developing a supporting trunk.
Unlike the examples of grasping in the animal kingdom, climbing plants do not rely on vision to attain the support, but drive their tendrils using only the contact sense. Using this basic sensory-motoric loop without centralized sensing and control, plants can blindly rely on organs that will coil around supports, providing a successful grasping method. In this contribution, some preliminary results on the behavior of the tendrils of Passiflora caerulea will be presented, with the goal of extrapolating the main dynamic concepts and translating them in engineering language and dynamics rules. Then a robotic approach is exploited to describe and simulate a bio-inspired robotic tendril from a kinematic point of view.

Abstract Number: 3061
Title: Pb and Cd change chloroplast distribution pattern in Lemna trisulca L. mesophyll cells
Author: Samardakiewicz, Slawomir
Co-Authors: Suski, Szymon; Gzyl, Jaroslaw; Gabrys, Halina

Chloroplast distributions in Lemna trisulca L. cells treated with Pb2+ and Cd2+ ions were analysed under confocal microscope. X-ray microanalysis (EDS INCA Energy TEM) was used to co-localize lead and chloroplasts.
In dark-adapted control fronds chloroplasts were uniformly distributed along all cell walls (dark position). In the fronds treated with lead for 24h nearly all chloroplasts were accumulated at the anticlinal walls. Only few chloroplasts remained near periclinal walls. A similar arrangement of chloroplasts is observed also in control plants in response to strong light (avoidance response). This arrangement ensures minimization of the amount of energy absorbed by chloroplasts, thereby protecting the photosynthetic apparatus from excess energy. Thus, the redistribution of chloroplasts in the dark after lead treatment may reduce the risk of their photodamage after the plant exposure to strong light. Using TEM X-ray microanalysis we showed that intracellular chloroplast arrangement was independent of the location of Pb deposits.
This work was supported by the National Science Centre (Grant No. NN303 806640).

Abstract Number: 3065
Title: High throughput gene testing strategies to improve yield at Monsanto Company
Author: Somaiah, Rajani Monnanda

Plant yield is a multigenic trait. Diverse gene testing strategies are used in the crop and model plant pipeline at Monsanto Company to improve Agronomic traits and yield. An overview of gene function categories, gene source organism and phenotype discovery process adopted in-house for improving plant performance and yield will be outlined in the poster.

Abstract Number: 3029
Title: Differences of cytokinin action in detached leaves senescing under dark- and light- conditions
Author: Spundova, Martina
Co-Authors: Husickova, Alexandra; Melkovicova, Helena; Provalilova, Jozefina; Trojanova, Zuzana

In our work, a light-dependence of the effect of cytokinin meta-topolin (mT; N6-(meta-hydroxybenzyl)adenine) was studied in barley (Hordeum vulgare L.) leaves during 12 d after their detachment. Five “light“ regimes (dark, D; periodic light 70 µmol m -2 s -1 , P70; continual light 70 µmol m -2 s -1 , C70; periodic light 370 µmol m -2 s -1 , P370; continual light 370 µmol m -2 s -1 , C370) and three mT concentration (10 -5 M, 10 -4 M, 3•10 -4 M) were used. The chlorophyll content and maximal efficiency of photosystem II photochemistry (F V /F M) were used to evaluate an extent of senescence. In control leaves (without mT) the rate of decrease in both chlorophyll content and F V /F M fell in order: D, C370, P370, C70, and P70. In dark senescing leaves, mT had the expected positive effect (i. e. slowed down a decrease in chlorophyll content and F V /F M) in all concentrations used. However, the positive effect of mT decreased with increasing light dose, and at C370 leaves even changed to negative ones (i. e. mT accelerated the decreases in both parameters). This trend was more pronounced with increasing mT concentrations. The accelerating effect of mT on senescence under light conditions was associated with an increased de-epoxidation of xanthophylls and stimulation of cell-wall invertase activity. These changes indicate an over-excitation of photosynthetic apparatus and feed-back inhibition of photosynthesis due to mT action.

Abstract Number: 2864
Title: Functional and structural characterization of PiCyP A like protein from Piriformospora indica and its role in salt stress tolerance in E.coli and Tobacco
Author: Trivedi, Dipesh
Co-Authors: Bhatt, Harshesh; Pal, Ravikant; Bhavesh, Neel Sarovar; Tuteja, Narendra

Piriformospora indica, a plant-root-colonizing basidiomycete fungus, was discovered in the Indian Thar desert and has been shown to provide strong growth-promoting activity during its symbiosis with a broad spectrum of plants. The fungus interacts with the roots of many plant species and promotes growth, development and seed production and confers resistance to various biotic and abiotic stresses. We have found around 30 genes upregulated in P.indica under high salinity stress. Cyclophilins found to be upregulated are widely distributed both in eukaryotes and prokaryotes and have a primary role as peptidyl-prolyl cis–trans isomerases (PPIases). In this study we have provided a direct evidence for a novel function of the Cyp A gene of P. indica in high salinity (NaCl) stress tolerance in bacteria (E. coli). In order to study the role of the fungus gene (Cyp A) in salinity stress tolerance in plant, we have also raised Cyp A overexpressing tobacco transgenic plants. This study also provides an evidence for the role of P. indica Cyp A gene in salinity stress signalling. Further we have also analysed these transgenic by biochemical assays. We reported sequence-specific 1H, 13C and 15N resonance assignments for this Cyclophilin A like protein from P. indica by NMR spectroscopy. Structural analysis were also done by X-ray crystallography. In X-ray crystallography, crystals diffracted at 1.9 Å resolution and structure solution was carried out using Molecular Replacement method.

Abstract Number: 2918
Title: Mechanism of Free-coiling in Cucumber Tendrils
Author: Van Volkenburgh, Elizabeth
Co-Authors: Eberle, Annike; Stripinis, Christopher M.; Sholles, Sara; Guilbert, Brittany; Taya, Minoru

Plant tendrils form elegant helix structures that extend from the vines of pumpkins, cucumbers, and passion flowers. While many plant tendrils form primary (contact) coils, few plants go on to form secondary, phone cord-like, (free) coils that draw stems closer to the support. The goal of this work is to determine the biomechanical basis for free-coiling in cucumber. Anatomical investigation revealed dorsiventral specialization, with a “Bianconi” plate of suberized cells wrapping around the ventral side. This plate did not fully form until after free-coiling was completed. Detailed marking experiments showed that the dorsal side of the tendril grew more in the free-coiled region (30-75% from base) than in the straight (basal) or contact coiled region; the ventral side did not grow, or shrank slightly in the coiled region. Epidermal cell size before and after coiling reflected these differences in growth. Parenchyma cells increased in cross-sectional area on the dorsal, but not the ventral side within the coil. Endogenously applied auxin stimulated growth of the dorsal, but not ventral sides of excised pre-coil sections. A modified finite element model of a tendril predicted helical coiling even when no asymmetric perturbation was applied. It is not clear where the asymmetry lies that causes the helix to form.

Abstract Number: 2919
Title: Physiological basis for drought tolerance behaviours in Phaseolus vulgaris
Author: Van Volkenburgh, Elizabeth
Co-Authors: Banan, Darshi; Cantillo Polo, Johanna

In collaboration with an international bean breeding program directed by Dr. Steve Beebe at CIAT (International Center for Tropical Agriculture, Colombia) we are investigating the physiological control of leaf expansion, leaf positioning, and pod development in Phaseolus vulgaris. These behaviors are being assessed in lines of P. vulgaris obtained from CIAT: parental lines ALB91 and INB841, drought-sensitive lines DOR500 and TC75, and drought-tolerant lines NCB226 and SER118. In greenhouse experiments water deficit treatment is caused by raised capillary mats; results replicate the drought phenotypes reported for these lines in field trials. All lines show reduced stomatal conductance, transpiration, leaf water and solute potentials under water-deficit conditions. Among lines and for both treatments, pod weight is correlated with the rate of leaf expansion, with NCB226 highest and TC75 lowest. We hypothesize that pod and leaf growth rate are regulated by auxin, although this is a controversial view for leaf expansion. Assessment of leaf movement acuity is performed on excised leaves exposed to unidirectional blue light; we expect to find a correlation between acuity and leaf expansion rate. The mechanism of auxin-regulation of leaf expansion and pulvinus movement will be pursued, along with the possibility that auxin integrates the water stress response.

Abstract Number: 3049
Title: Membrane-binding properties of unique plant protein DREPP
Author: Vosolsobe, Stanislav
Co-Authors: Petrasek, Jan; Schwarzerova, Katerina

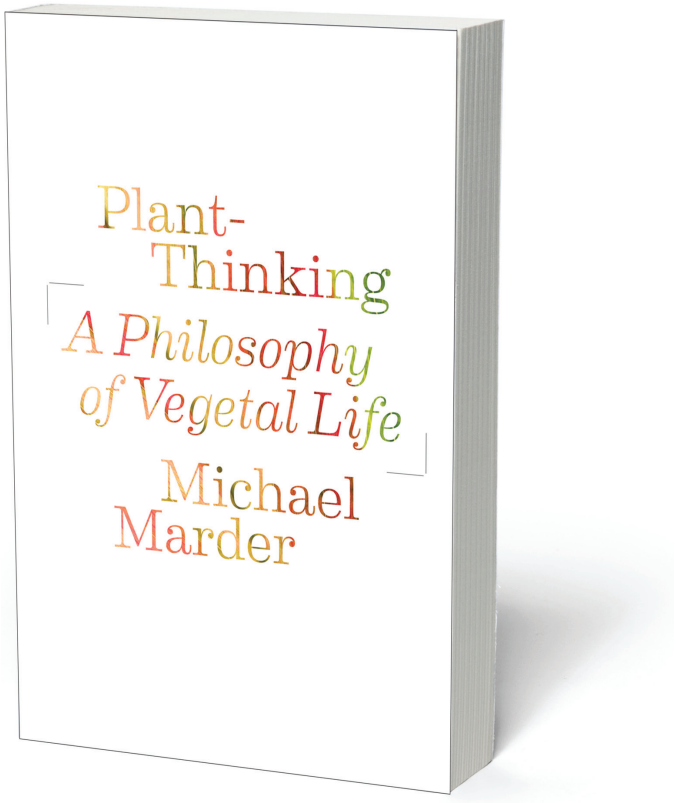
DREPP - Developmentally regulated plasma membrane polypeptide - is a family of higher-plant specific plasma-membrane associated Ca2 + -binding proteins with microtubule and actin destabilising activity (syn. PCaP1/2 or MDP25/MAP18 in Arabidopsis thaliana).
At DREPPs are associated with membrane via myristoyl anchor in the N-terminus. Nevertheless, our analysis showed that the myristoylation site is not conserved in many other plant species. For example, two of the four DREPP paralogues in tobacco (DREPP3 and 4) carry natural mutations in myristoylation site, whereas all of them are localized to the plasma membrane. To uncover the mechanism of plasma membrane association of DREPPs, we used site-directed mutagenesis combined with protein trimming, and expressed GFP-fused proteins in tobacco cells. We showed that in contrast to At DREPPs whose interaction with plasma membrane relies exclusively on myristoyl anchor, tobacco DREPPs are associated with plasma membrane through different mechanisms. Moreover, even DREPPs within tobacco family differ in their ability to associate with plasma membrane. Whereas Nt DREPP2 is associated with plasma membrane via myristoyl and newly identified palmitoylation site, Nt DREPP4 associates with plasma membrane only through putative electrostatic interaction between short Lys-rich N-terminal domain and PtdIns P s.
Our results demonstrated high flexibility of membrane binding mechanisms of plant proteins that developed distinct mechanisms for membrane association even within a family of closely related proteins.
This work was supported by grant No. P501/12/1176 of the Grant Agency of the Czech Republic.

Plant-Thinking

A Philosophy of Vegetal Life

Michael Marder

Foreword by Gianni Vattimo and Santiago Zabala



The margins of philosophy are populated by non-human, non-animal living beings, including plants. While contemporary philosophers tend to refrain from raising ontological and ethical concerns with vegetal life, Michael Marder puts this life at the forefront of the current deconstruction of metaphysics. He identifies the existential features of plant behavior and the vegetal heritage of human thought so as to affirm the potential of vegetation to resist the logic of totalization and to exceed the narrow confines of instrumentality. Reconstructing the life of plants "after metaphysics," Marder focuses on their unique temporality, freedom, and material knowledge or wisdom. In his formulation, "plant-thinking" is the non-cognitive, non-ideational, and non-imagistic mode of thinking proper to plants, as much as the process of bringing human thought itself back to its roots and rendering it plantlike.

"Marder argues that recent advances in animal ethics, for all their virtues, are often blind to the blinkered instrumentality of our understanding of plants. Re-thinking that relation opens the vegetal world to a thinking encounter few thought possible (or necessary), one that puts plants in a wholly different light yet also offers new resources for dismantling our deeply rooted metaphysical legacy. This is a remarkable book—original, daring, and timely."

—David Wood, Vanderbilt University

MICHAEL MARDER is IKERBASQUE Research Professor of Philosophy at the University of the Basque Country, Vitoria-Gasteiz. He is the author of *The Event of the Thing: Derrida's Post-Deconstructive Realism* and *Groundless Existence: The Political Ontology of Carl Schmitt*, and, with Patricia Vieira, he is the coeditor of *Existential Utopia: New Perspectives on Utopian Thought*. He is also an associate editor of the journal *Telos* and a series editor of *Political Theory and Contemporary Philosophy* at Continuum Press and of *Critical Plant Studies: Philosophy, Literature, Culture* at Rodopi Press.

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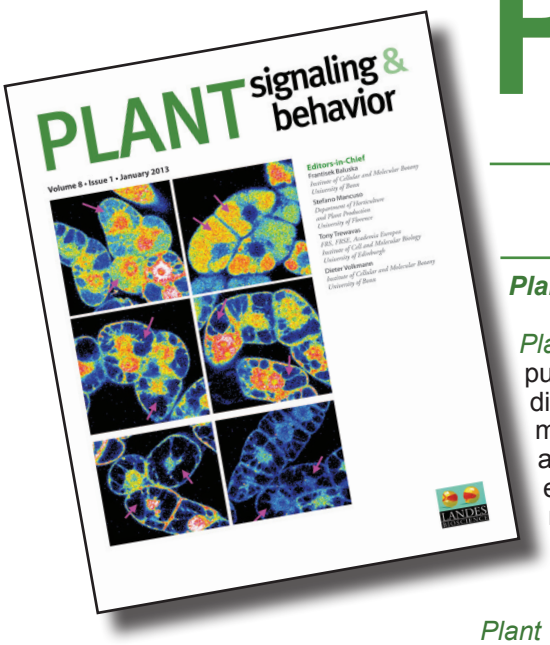

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