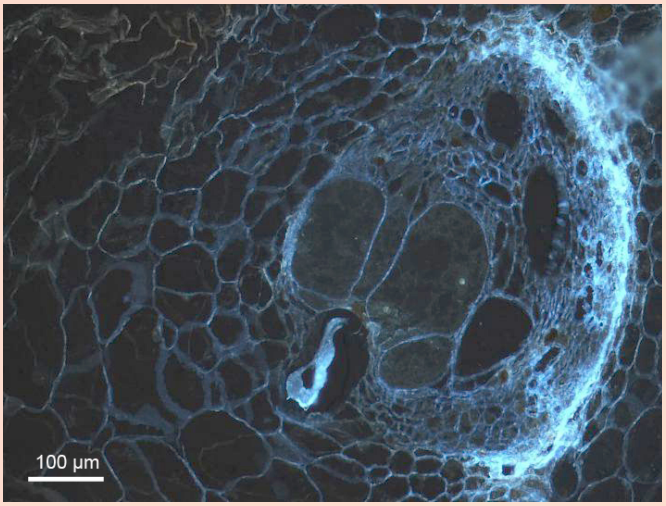
Plant Immunity in Annals of Botany



Musa-Meloidogyne interaction

Photo: Nancy Eunice Niño Castañeda and Rob Miller

Annals of Botany Special Issue on Plant Immunity

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Primary research, reviews, viewpoints, and research-in-context articles are welcomed

Guest Editors: Robert Miller, Marie-Anne Van Sluys and Thorsten Nürnberger

Plants are constantly exposed to a range of pathogens and pests, with the emergence of new virulent pathogen races responsible for considerable global crop losses every year.

Progress in research in recent decades has increased our understanding of the plant innate immune system at the molecular level, fundamental for the continued development of novel approaches for control of emerging pathogens. This special issue will be devoted to highlighting current knowledge of mechanisms involved in plant innate immunity, focusing on molecular interactions occurring between plant hosts and a variety of invading pathogens including viruses, bacteria, fungi, nematodes and insects.

The focus will cover advances in research on pathogen sensing and activation of plant immunity, with topics ranging from pathogen effector proteins, pattern recognition receptors (PRRs) for recognition of pathogen-associated molecular patterns (PAMPs) in PAMP-triggered immunity (PTI), plant NB-LRR proteins and pathogen effector recognition in Effector Triggered Immunity (ETI), RNAi in virus suppression, antiviral receptor kinases, through to plant signaling networks and downstream defence responses.

Highlighted recent publications

Ontogenetic changes in multiple plant defences

Annals of Botany **116(5):** 797-806.

doi: 10.1093/aob/mcv113

Patterns in anti-herbivore defences are not predictable because ontogenetic changes depend on plant life history, the type of defence and the growth stages being compared. Ochoa-López *et al.* examine how defensive traits of *Turnera velutina* simultaneously change across major transitions of plant development and find that ontogenetic trajectories in physical, chemical and biotic resistance are significantly different and in several cases show opposite patterns. The results suggest that defensive trajectories are a mixed result of predictions by the Optimal Defence Theory and the Growth–Differentiation Balance Hypothesis, and emphasize the importance of incorporating multiple defences and plant ontogeny into studies of plant defence evolution.

Sofía Ochoa-López, Nora Villamil, Paulina Zedillo-Avelleyra and Karina Boege. 2015.

Attack and defence in pathosystems involving *Sclerotinia* and *Brassica*

Annals of Botany **116(7):**

doi: 10.1093/aob/mcv150

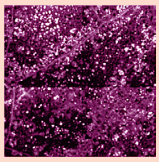
Sclerotinia stem rot damages oilseed brassicas world-wide. Host resistance is urgently needed. Uloth *et al.* show that a variety of mechanisms including hypersensitive reactions and lignification within

the stem cortex, endodermis and in tissues surrounding the lesions contribute to host resistance against *S. sclerotiorum* across three *Brassica* species. These complex interactions between pathogen and host help to explain variable expressions of resistance often observed in the field.
Margaret B Uloth, Peta L Clode, Ming Pei You and Martin J Barbetti. 2015.

Induction and suppression of plant defences (Review)

Annals of Botany **115(7):** 1015-1051.
doi:10.1093/aob/mcv054

Plants are targets for herbivory by animals that acquire nutrients and energy from their hosts in order to grow and reproduce. Hence plants are selected to evolve resistance, which, in turn, selects for herbivores that can cope with this resistance or have the means to suppress it. Kant *et al.* review the current state of knowledge about plant defences and specifically emphasize insights into herbivore adaptations that allow them to cope with these defences. In addition, they provide an ecological and evolutionary perspective on the ways in which defence resistance and defence suppression by herbivores impact community interactions, and on the conditions favouring the evolution of relevant traits.
MR Kant, W Jonckheere, B Knegt, F Lemos, J Liu, BCJ Schimmel, CA Villarroel, LMS Ataide, W Dermauw, JJ Glas, M Egas, A Janssen, T Van Leeuwen, RC Schuurink, MW Sabelis and JM Alba. 2015.



Stress-induced callose biosynthesis and pathogen responses (Viewpoint)

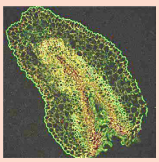
Annals of Botany **114(6):** 1349-1358.
doi:10.1093/aob/mcu120

Deposition of callose, a (1,3)-β-glucan cell wall polymer, is involved in several fundamental biological process, but despite its importance detailed knowledge about the regulation of its biosynthesis in plants is rather limited. Ellinger and Voigt summarize data from 10 years of research, focussing on callose deposition in response to pathogen attack in the model plant *Arabidopsis thaliana*. They consider that growing evidence has been found that the timing of callose deposition in the multilayered system of plant defence responses could be the key parameter for optimal effectiveness. This timing seems to be achieved through co-ordinated transport and formation of the callose synthase complex.
Dorothea Ellinger and Christian A Voigt. 2014.

Cytokinins can trigger hypersensitive-like responses

Annals of Botany **112(1):** 41-55.
doi:10.1093/aob/mct092

The mechanisms involved in plant defence against pathogens are of considerable scientific and agricultural interest. Novák *et al.* use activation of the gene ipt to produce high levels of cytokinins in tobacco, *Nicotiana tabacum*, and find that this is sufficient to trigger fast cell death without intervening chlorosis, which is characteristic of the hypersensitive response. The results are consistent with the suggestion that the molecular processes underpinning this hypersensitive-like response are orchestrated by increases in cellular hydrogen peroxide levels. The hypersensitive-like response includes inhibition of photosynthesis, increases in stress hormone levels, oxidative damage to membranes and stomatal closure. Thus, cytokinins may act as signals and/or mediate plant defences against pathogen attack.
Jan Novák, Jaroslav Pavlů, Ondřej Novák, Vladimíra Nožková-Hlaváčková, Martina Špundová, Jan Hlavinka, Šárka Koukalová, Jan Skalák, Martin Černý and Břetislav Brzobohatý. 2013.



Role of PCD in the reproductive biology of kiwifruit

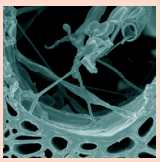
Annals of Botany **114(1):** 35-45.
doi:10.1093/aob/mcu073

Actinidia chinensis var. *deliciosa* (kiwifruit) is a functionally dioecious species with a highly successful reproductive performance that is impaired by a short effective pollination period. Ferradás *et al.* look for features of programmed cell death (PCD) in the stigamtic arms and find that in the secretory tissues cell organelles disintegrate sequentially while progressive vacuolization is detected. At the same time, chromatin condensation, nuclear deformation and DNA fragmentation and degradation are observed. These features are evident in pollinated flowers by the second day after anthesis, but only by 4 days after anthesis in non-pollinated flowers, which corresponds to the effective pollination period. The results indicate that PCD might be accelerated by pollination, suggesting its involvement during the progamic phase.
Yolanda Ferradás, Marián López, Manuel Rey, Ma Victoria González. 2014.

Brachypodium as a disease model for cereals (Review)

Annals of Botany **115(5):** 717-731.
doi:10.1093/aob/mcv010

Brachypodium distachyon (brachypodium) is emerging as a highly effective model for cereals. Fitzgerald *et al.* provide an overview of the work performed in recent years on the use of brachypodium to study cereal diseases, noting that diverse pathogens, including many of major economic significance, infect brachypodium in a similar manner as their cereal hosts. They discuss the potential of burgeoning brachypodium resources to provide new insights into the host response to infection, and summarize the extensive use of brachypodium for comparative genomic analysis to assist in the mapping of cereal resistance genes. Future prospects for brachypodium as a model to study cereal–pathogen interactions are explored.
Timothy L Fitzgerald, Jonathan J Powell, Katharina Schneebeli, M Mandy Hsia, Donald M Gardiner, Jennifer N Bragg, C Lynne McIntyre, John M Manners, Mick Ayliffe, Michelle Watt, John P Vogel, Robert J Henry and Kemal Kazan. 2015.



Wood components and Dutch elm disease tolerance

Annals of Botany **114(1):** 47-59.
doi:10.1093/aob/mcu076

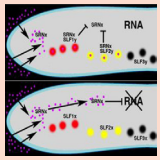
Changes occurring in the macromolecular traits of wood cell wall components of elm (*Ulmus* species) following an attack by *Ophiostoma novo-ulmi* (Dutch elm disease) are poorly understood. Ďurkovič *et al.* examine two elm hybrids with contrasting survival strategies upon infection with the current prevalent strain of the disease (ssp. *americana* × *novo-ulmi*) and find that the syringyl-to-guaiacyl ratio in lignin affects the degradability of cellulose by cellulolytic enzymes. When infected, the hybrids respond to medium-molecular weight cellulose degradation with the biosynthesis of high-molecular weight macromolecules of cellulose, resulting in an increase in values for the degree of polymerization and polydispersity. However, only guaiacyl-rich lignin in the tolerant hybrid is involved in a successful defence against the fungus.
Jaroslav Ďurkovič, František Kačík, Dušan Olčák, Veronika Kučerová and Jana Krajňáková. 2014.

Seedling defence and regeneration patterns (Viewpoint)

Annals of Botany **112(4):** 643-650.
doi:10.1093/aob/mct139

Seedling herbivory and defence play a fundamental role in the structure and composition of plant communities. However, relatively few studies focus on this early life history stage, despite growing evidence that defence and herbivory change dramatically across plant ontogeny. Barton and Hanley review why herbivory during early plant ontogeny is important and consider issues such as the development and expression of seedling defences and patterns of selection by herbivores, and how disruption of the seedling–herbivore interaction might affect normal patterns of plant community establishment.

Kasey E Barton and Mick E Hanley. 2013.



S-RNase-based self-incompatibility (Review)

Annals of Botany **108(4):** 647-658.
doi:10.1093/aob/mcr179

S-RNase-based self-incompatibility (SI) occurs in the Solanaceae, Rosaceae and Plantaginaceae, with S-RNases determining the specificity of pollen rejection in the pistil and S-locus F-box proteins fulfilling this function in pollen. McClure *et al.* introduce the genetics of SI and briefly describe the characteristics of S-RNases and pollen F-box proteins. Two alternative mechanisms have been proposed whereby compatibility is explained either as a result of degradation of non-self S-RNase or by its compartmentalization so that it does not have access to the pollen tube cytoplasm. These models are not necessarily mutually exclusive, but each makes different predictions about whether pollen compatibility or incompatibility is the default.

Bruce McClure, Felipe Cruz-Garcıa and Carlos Romero. 2011.

Ubiquitin, hormones and biotic stress in plants

Annals of Botany **99(5):** 787–822.
doi:10.1093/aob/mcl255

Plants utilize the ubiquitin/proteasome system (UPS) to alter their proteomes selectively during development. Dreher and Callis describe the ubiquitin pathway and focus on the identification of UPS components. They also highlight specific examples of, and novel evidence for, UPS involvement in plant responses to internal hormonal cues and external biotic stresses.

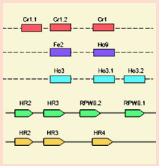
Kate Dreher and Judy Callis. 2007.

para-Aminobenzoic acid elicits induced resistance against pathogens

Annals of Botany **111(5):** 925-934.
doi:10.1093/aob/mct049

Systemic acquired resistance (SAR) triggered by avirulent pathogens and chemical inducers is a broad-spectrum immune response against pathogen attack in plants. Song *et al.* conduct field trials using pepper plants (*Capsicum annuum*) treated with *para*-aminobenzoic acid (PABA, vitamin Bx) and find that it stimulates SAR against artificially infiltrated *Xanthomonas axonopodis* pv. *vesicatoria* and naturally occurring cucumber mosaic virus. Fruit yield is increased in PABA-treated plants, indicating that PABA-mediated SAR successfully protects pepper plants from infection by bacterial and viral pathogens without significant fitness allocation costs. PABA therefore has potential as a water-soluble and safe application for crop protection under field conditions.

Geun Cheol Song, Hye Kyung Choi and Choong-Min Ryu. 2013.

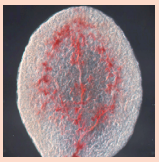


Resistance to pathogens under variable temperatures

Annals of Botany **109(4):** 833-842.
doi: 10.1093/aob/mcr320

The biotic and abiotic environment of interacting hosts and parasites may vary considerably over small spatial and temporal scales. Jorgensen examines the effects of differing temperature and soil nutrient conditions on powdey mildew infection of *Arabidopsis thaliana*, and finds that there is a strong potential for a heterogeneous environment to change the resistance capacity of *A. thaliana* genotypes, and hence the direction and magnitude of selection in the presence of the pathogen. Transcription levels of RPW8, a resistance-conferring gene, increase after infection and vary between environments, but there is no tight association between transcription and resistance levels..

Tove H Jorgensen. 2012.



Receptor-like kinases and maintenance of cell wall integrity (Review)

Annals of Botany **114(6):** 1339-1347.
doi:10.1093/aob/mcu043

Plant cell walls are exposed to a wide range of stress stimuli that have to be detected by a suitable receptor in order to induce specific reactions appropriate to the organ affected and the developmental state of the plant. Engelsdorf and Hamann review recent developments in our knowledge on plant cell wall integrity maintenance with a specific focus on possible signal elicitors and receptors. Recent evidence implicates receptor-like kinases (RLKs) in the regulatory networks associated with plant cell wall-related stress, and hence potential functions of RLKs in cell wall integrity maintenance are discussed.

Timo Engelsdorf and Thorsten Hamann. 2014.

Jasmonates: signals in stress responses and development (Review)

Annals of Botany **111(6):** 1021-1058.
doi: 10.1093/aob/mct067

Jasmonates are important regulators in plant responses to biotic and abiotic stresses as well as in development. Wasternack and Hause summarize new data from the last 5 years, with emphasis on metabolites of jasmonates, jasmonate perception and signalling, cross-talk with other plant hormones, and jasmonate signalling in response to herbivores and pathogens, in symbiotic interactions, in flower development, in root growth and in light perception. They detail recent breakthroughs in the identification of JASMONATE ZIM DOMAIN (JAZ) proteins, and consider them together with interactors such as transcription factors and co-repressors in the context of cross-talk.

C Wasternack and B Hause. 2013.