南京農業大學 Nanjing Agricultural University 植物保护学院

Plant Defense Signaling Laboratory

Research focus

1. Plant–bacterium interaction
2. Plant defense and growth crosstalk

Academic staff (from left to right)

Hansong Dong: PhD/Prof
Chunling Zhang: Ph.D/Assoc Prof
Heng Xu: MSc/Assis Prof
Juying Long: PhD/Assis Prof
Congfeng Song: PhD/Prof
Dan Shen: PhD/Assis Prof

A place for young scientist growth

Since 2000, 49 and 78 students have obtained M.Sc. and Ph.D. degrees, respectively. Of them, 23 students participated in resaerch collaborations with Stanford, Cornell, and other universities outside China. Eight postdoctoral associates and three visiting fellows completed their studies.

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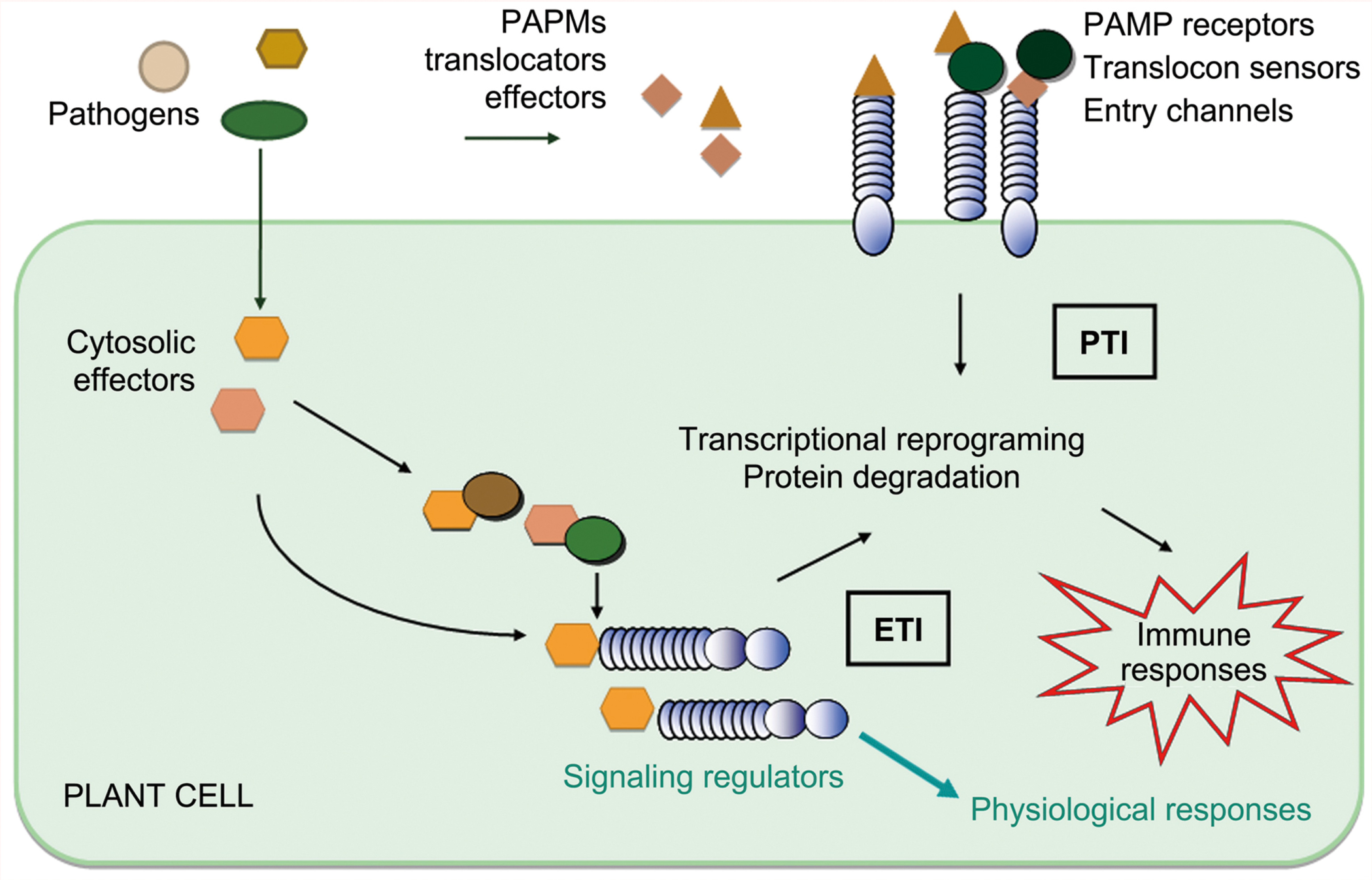
Research Summary

Plant-pathogen interactions are governed by a complex exchange of mutual signals and determinie plant resistance or susceptibility to pathogens under particular environment. We study signal perception and transduction following pathogen infection in plants. Currently, we focus on illumination that how plants perceive bacterial type III translocators, especially those from rice bacterial blight pathogen Xanthomonas oryzae pv. oryzae (Xoo), to translocate effectors and cause subsequent impacts on pathogenesis and defense responses in crosstalk, under circumstances, to the regulation of growth and development in plants (see the cartoon below).

In past five years, our group has headed and participated over 10 projects from the National Science Fund for Distinguished Young Scholars, NSFC project, Novel Transgenic Organisms Breeding Project, the national 863 program and the national 973 Plan. Long-term international cooperations have been established with several institutions inside and outside China. To data, we have published more than 180 papers in most famous academic journals, in which vast majority are indexed by SCI. Three research results were authorized by the National Invention Patent.



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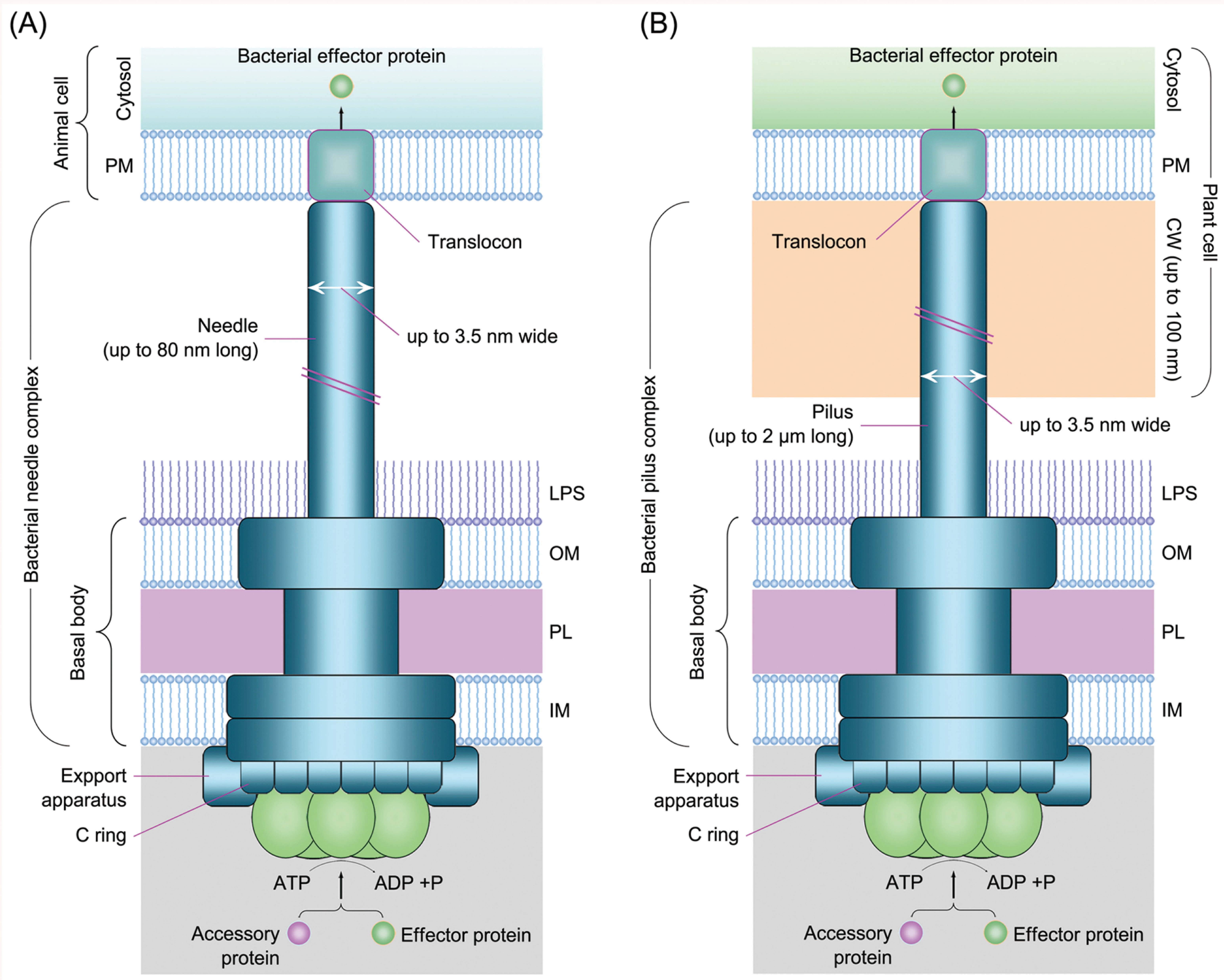
Research Activities and Scientific Claims (1)

Type III translocon and plasma membrane sensors

Many animal (Figure 1A) and plant (Figure 1B) pathogenic Gram-negative bacteria employ the type III secretion pathway to inject effector proteins and/or toxins directly into the cytosol of eukaryotic host cells. Effector translocation is fulfilled through an integral component of the pathway, the channel-like translocon assembled by contrapuntal associations of type III translocators at the top of a proteinaceous needle or pillus machinery. We have sought to characterize Xoo translocators, models of their associations into the translocon, translocator sensors potentially present in the target plasma membrane (PM), and presumable interactions between the translocators and their sensors in relation to the translocon assembly.



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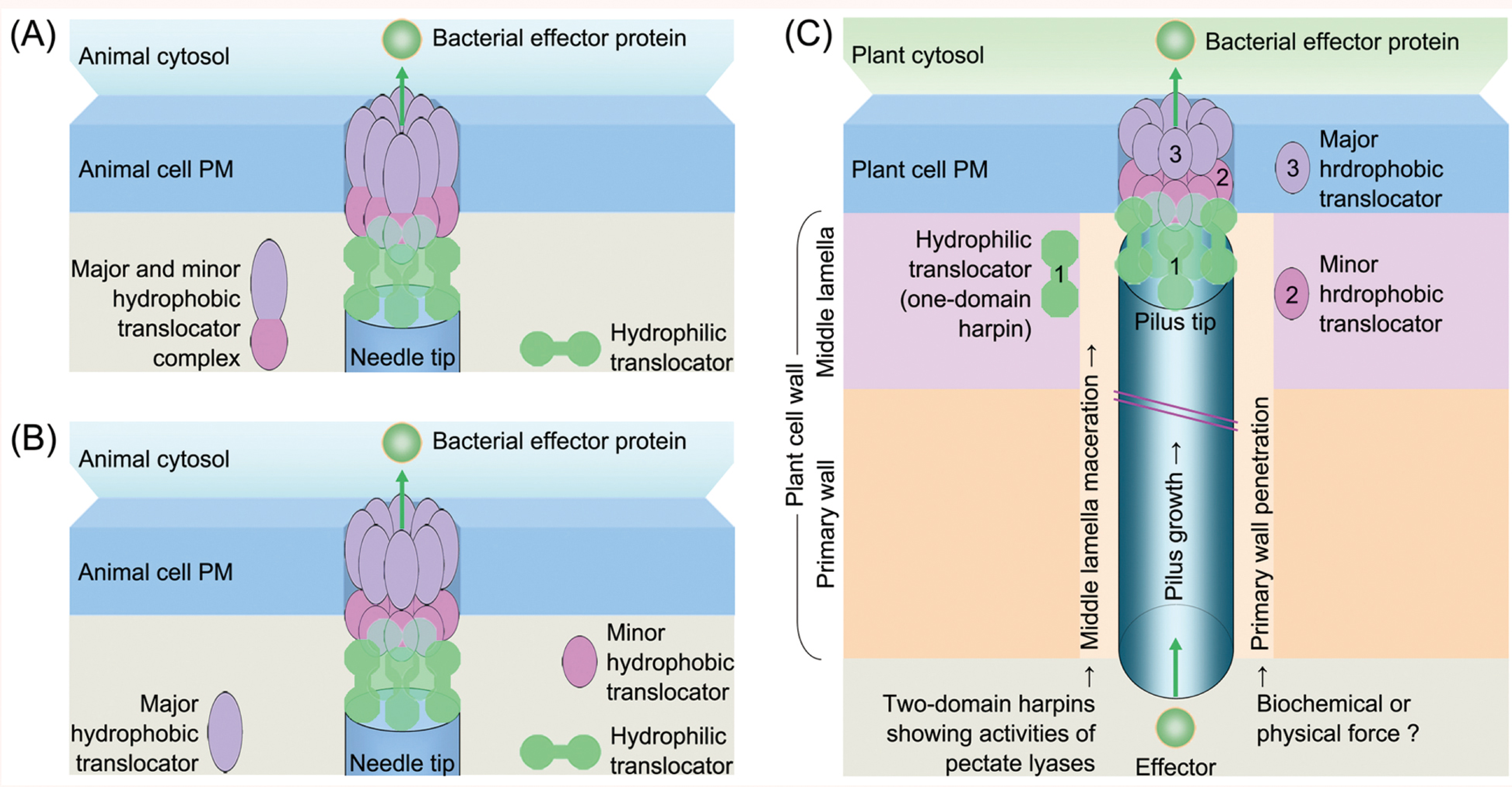
Research Activities and Scientific Claims (2)

Biophysical architecture of plant–bacterium interface

Every species of animal pathogenic bacteria possesses one hydrophilic and two hydrophobic translocators, each to form homogenous oligomers before participating in the translocon assembly. Scientists have proposed two distinct models of the type III translocon assembly by animal pathogens. One conceives a heterooligomer of two hydrophobic translocators, spontaneously contacting the hydrophilic counterpart (Figure 2A). The other is called “three–tiered ring” model: two hydrophobic translocators exist in oligomeric form, with the major partner inserting stably into the target PM, whereas the minor translocator situated at the needle tip serves as the link with the hydrophilic counterpart (Figure 2B). Although most biochemical results point to the second model, the possibility of translocon assembly as a heterooligomer can not be ruled out at present. We propose the third model of translocon assembly by plant pathogens and examine it in the rice–Xoo interaction system (Figure 2C).



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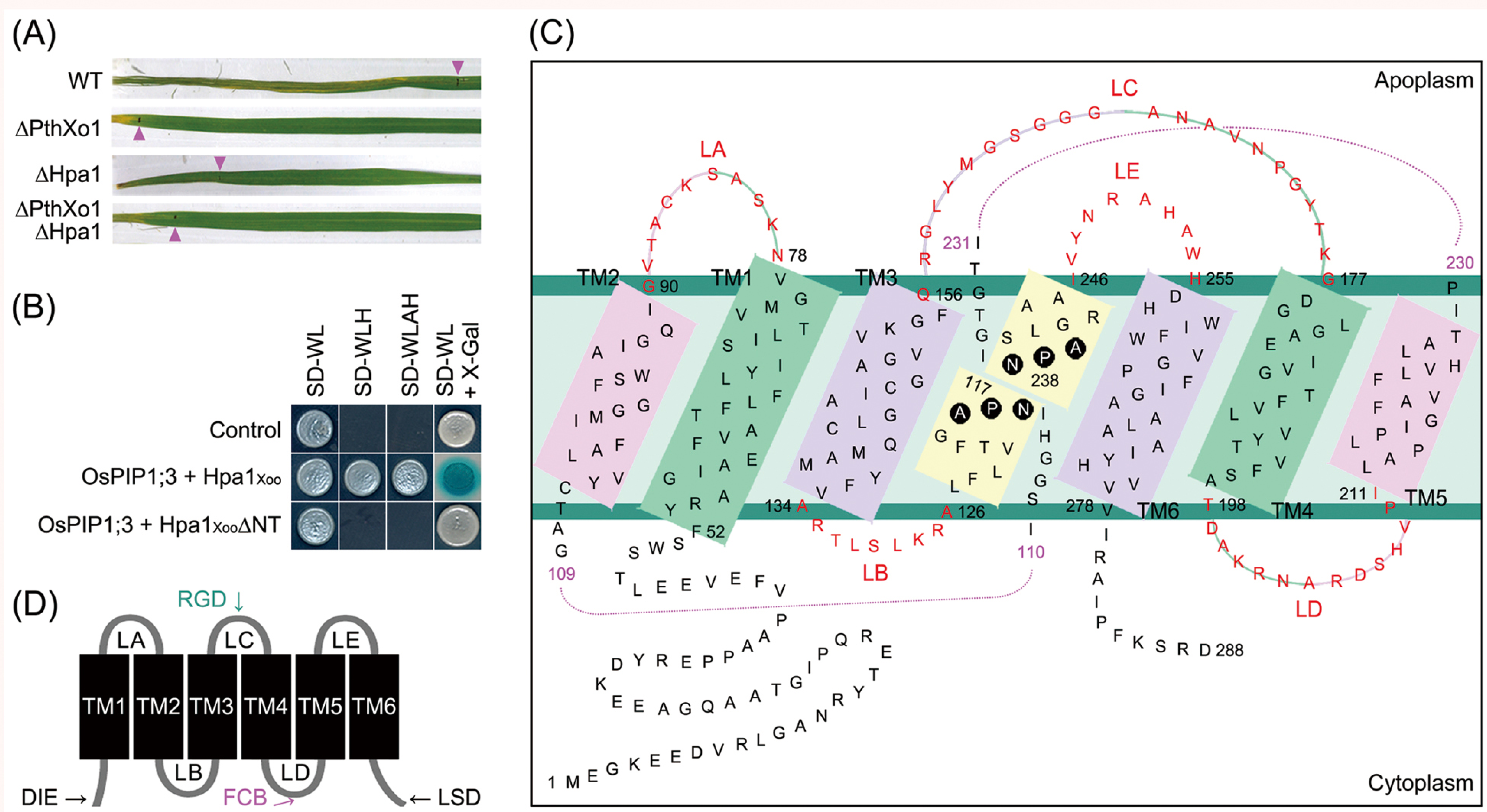
Research Activities and Scientific Claims (3)

Pathological consequences of ligand signal perception

Bacterial blight severities on leaves of susceptible rice variety Nipponbare are different after inoculation with Xoo strain POX99A and its mutants, showing the critical effect of Hpa1 on virulence determined mainly by TAL effector PthXo1 (Figure 3A). An assay with a split ubiquitin-based yeast two-hybrid system was performed on the combination of OsPIP1;3 with Hpa1 or its mutant Hpa1 NT (Figure 3B). The topological structure of OsPIP1;3 was analyzed according to a previously established model, showing TM-to-loop turning points as coded (Figure 3C). Protein-interacting motifs or regions have been found in different aquaporins: DIE, maize (Zea mays) ZmPIP2 diacidic DIE motif (4 6 Asp-Ile-Glu); FCB, filensin- and calmodulin-interacting region in lens AQP0; LSD, human AQP1 and AQP4 regions binding to the light-sensing protein Killer Red; and RGD, integrin-binding RGD motif (Arg-Gly-Asp) in renal AQP2 (Figure 3D). Identification of interacting motifs in PIP1s is in underway and will lead to biophysical characterization of the interaction.



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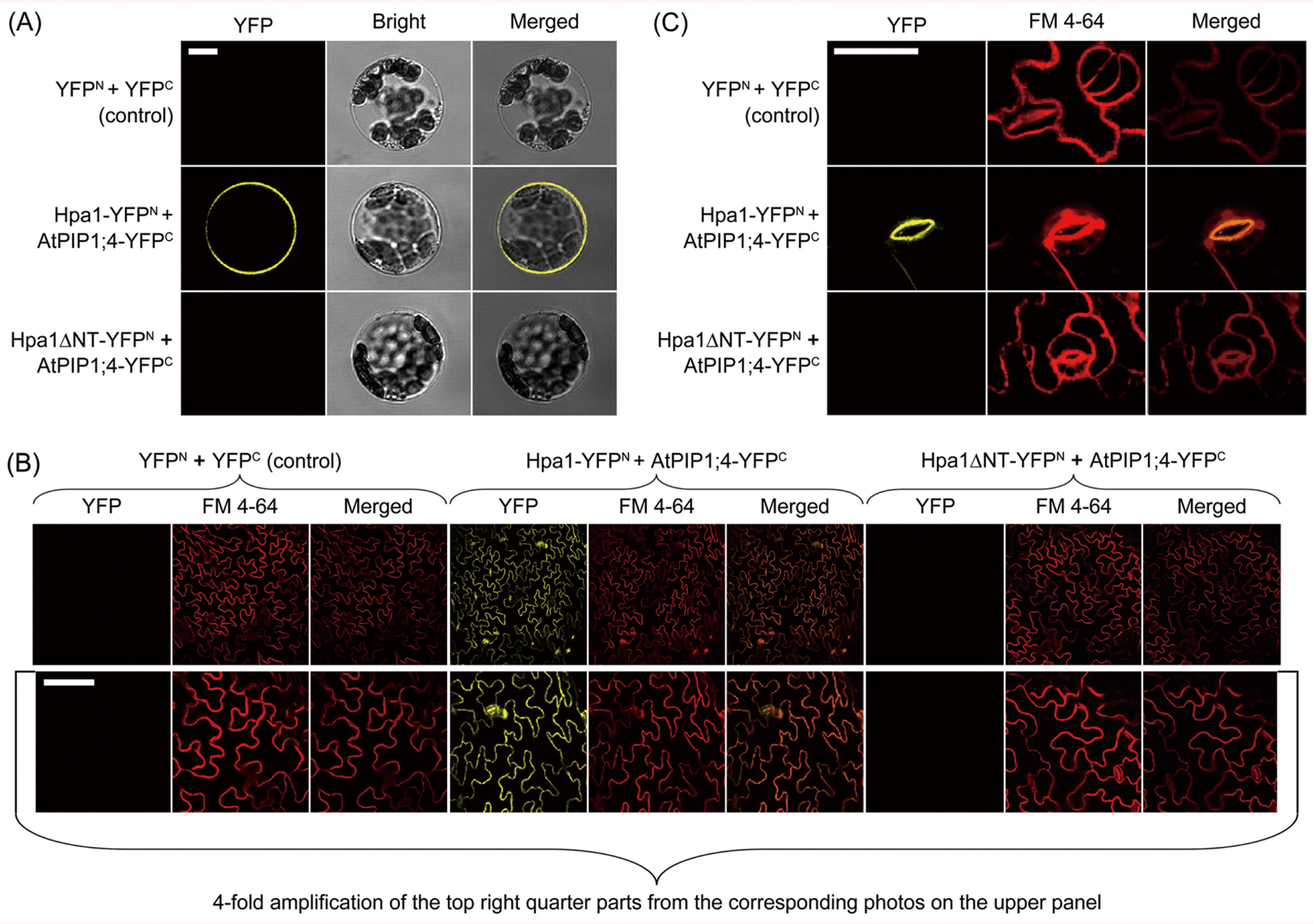
Research Activities and Scientific Claims (4)

Physiological consequences of ligand signal perception

A recently found function of aquaporins is to regulate physiological responses through interacting with non-aquaporin proteins. We have shown that Arabidopsis AtPIP1;4 facilitates the CO2 permeability of PM in response to Hpa1. AtPIP1;4 directly interacts with Hpa1 at PMs of protoplasts (Figure 4A) and leaf epidermal cells (Figure 4BC) of the plant. Our evidence suggeste that this aquaporin indeed is a facilitator of CO2 transport into mesophyll cells. This role of AtPIP1;4 is increased upon interacting with Hpa1 at the PM, and as a result, leaf photosynthesis rates are increased and the plant growth is enhanced in comparison with the normal process in the absence of Hpa1 and its interaction with AtPIP1;4. Our findings suggest a previously unappreciated mechanism that governs the functional regulation of aquaporins in plants.



Research Activities and Scientific Claims (5)

Plant growth and defense crosstalk by nucleocytomic trafficking

Sophisticated nucleocytoplasmic trafficking is an important feature for fine-tuning signaling pathways in eukaryotic organisms. Importin (IMP) and nucleoporin (Nup) proteins are essential for the exchange of macromolecules across the nuclear envelope. Plants can use these proteins to dominate phytohormone signaling pathways that regulate defense responses to pathogens. The most important one of plant defensive pathways involves salicylic acid (SA) signal transduction. SA signaling activates the ankyrin-containing protein NRP1 to regulate systemic acquired resistance (SAR), and often antagonizes ethylene or jasmonic acid (JA) signaling. In Arabidopsis, at least 7 IMP and 7 Nup genes are involved in nucleocytoplasmic trafficking of SA signaling components associated with SAR. Bioinformatics and experimental data show that these IMPs and Nups contain cis-acting elements that are inducible not only by SA but also by ethylene and JA (Figure 5). This conforms to the antagonism between SA and ethylene or JA in plant defense responses, suggesting that the competition or cooperation in nucleocytoplasmic trafficking contributes to crosstalk of defense pathways in plants.

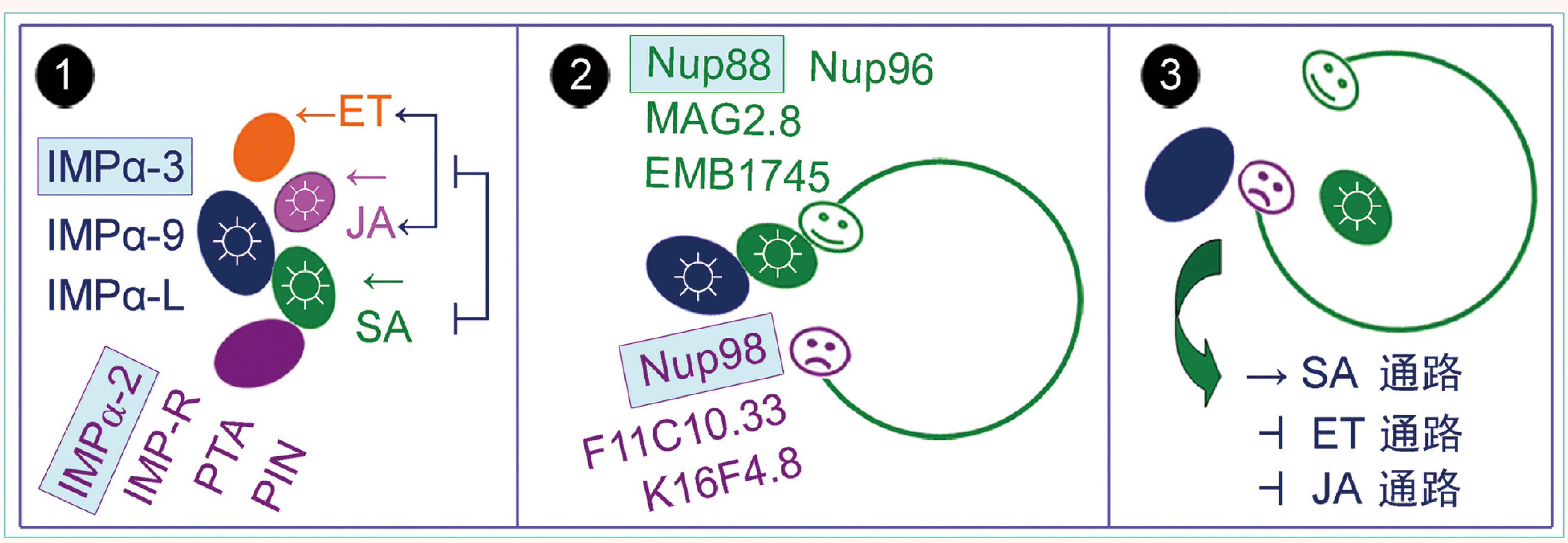


Figure 5. Nucleocytoplasmic trafficking regulators in salicylic acid (SA), ethylene (ET), and jasmonic acid (JA) signaling pathways

Biger ellipse, nucleoporin; smaller ellipse, the hormone signaling regulators; the sun symble , excecute function; →, positive regulation; , cooperation; ⊢ or ⊣ , negative regulation; green circle, nucleus; green smalling face, positive regulatory role; purple sad face, negative regulatory role; regulatory stesps: ① cargo lading in the cytosol; ② temporary anchoring to nulear pore; ③ release of regulators within nuclues to directly or indirectly regulate defenses or growth.

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竹林新纪 Culture Complex

玉树高阳好呵护

淑子双娇正春风

清青眉宇刹那芳华 沧苍心思宛驻春秋

追随佩索阿的幽思
黄昏变成黑夜之前 步伐比时间和空间更老
走过历史的烟柳与河 走过绿树苔层青山荒域
走过冬天走到夏季 时间风干记忆刻录沧桑
真情像海洋宽阔 过滤灵魂指示万里长空一朝风月
洋溢八极 一瓣心香

洛霞拂染云彩好

凌风借力梓泽清