

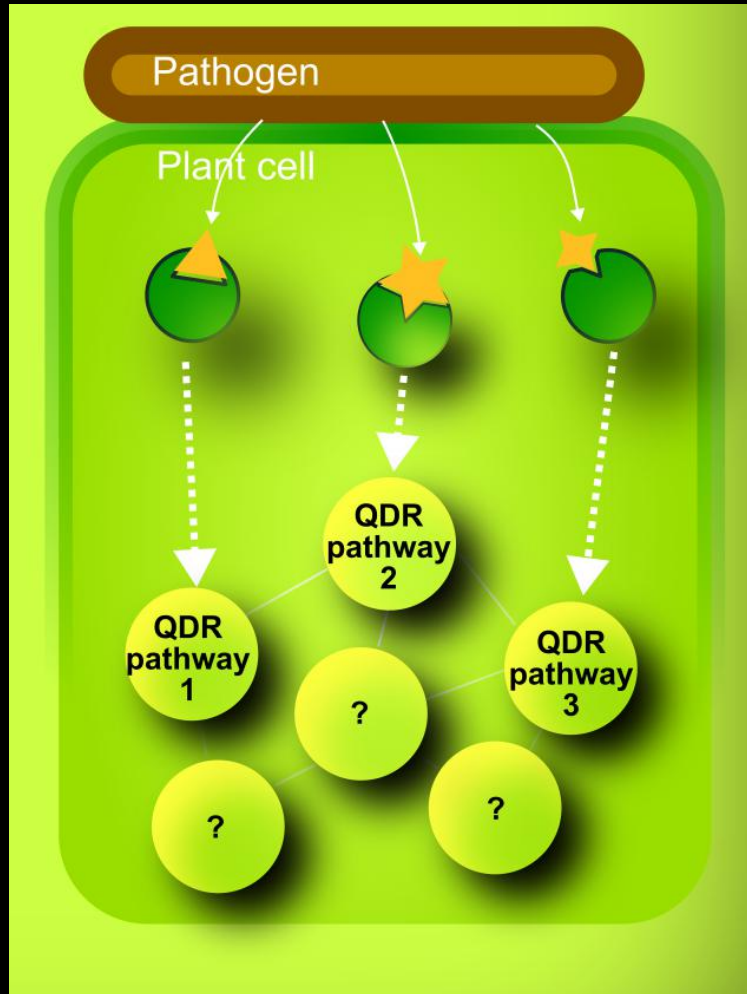
ModStatSAP.
Paris le 14 décembre 2022



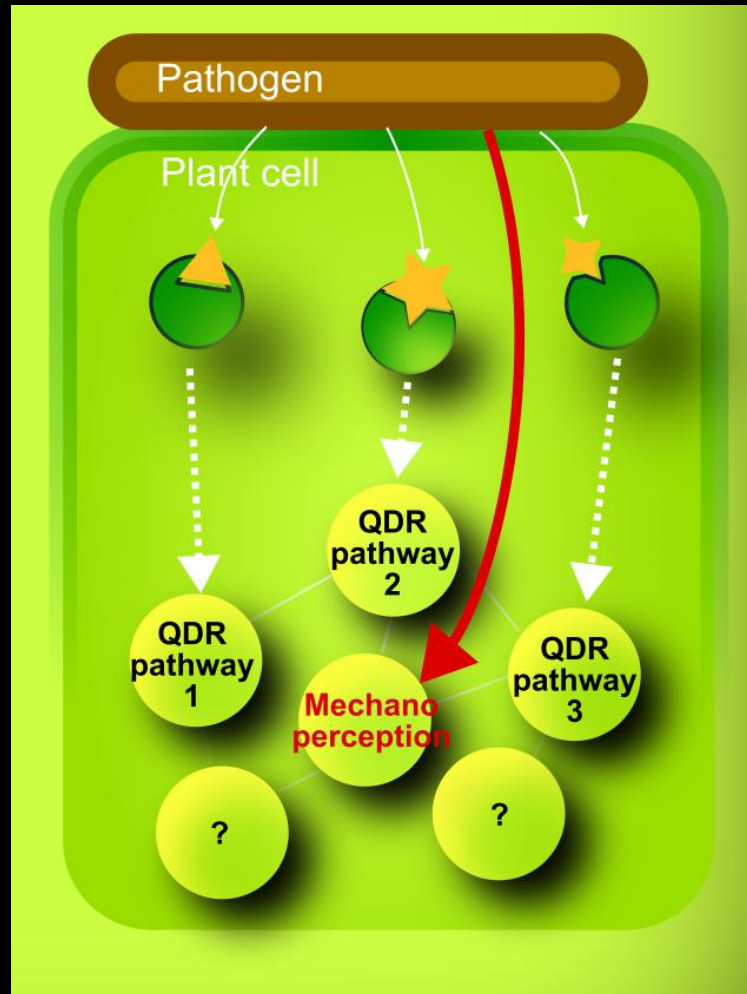
Mechano-signaling triggered immunity

Adelin Barbacci

The quantitative disease resistance



The quantitative disease resistance



Mechanical cues may be involved in the regulation of plant immune system

(strong reason)

Infection cushion

Host colonization

Type III secretion system

Biofilm formation

Geometric incompatibility

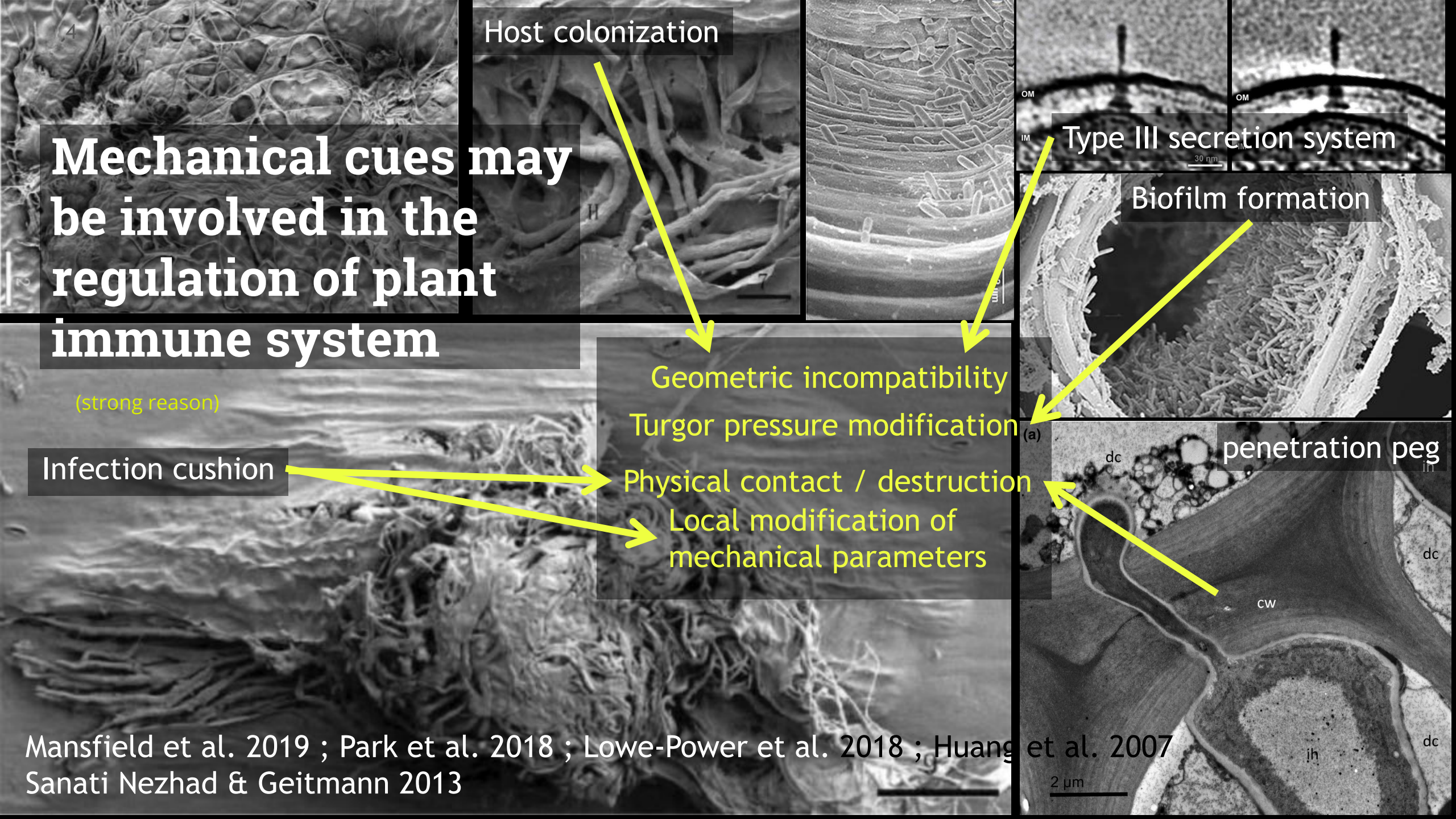
Turgor pressure modification

Physical contact / destruction

Local modification of mechanical parameters

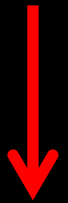
penetration peg

Mansfield et al. 2019 ; Park et al. 2018 ; Lowe-Power et al. 2018 ; Huang et al. 2007
Sanati Nezhad & Geitmann 2013



Stress and Strain mechanical cues

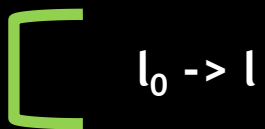
Force



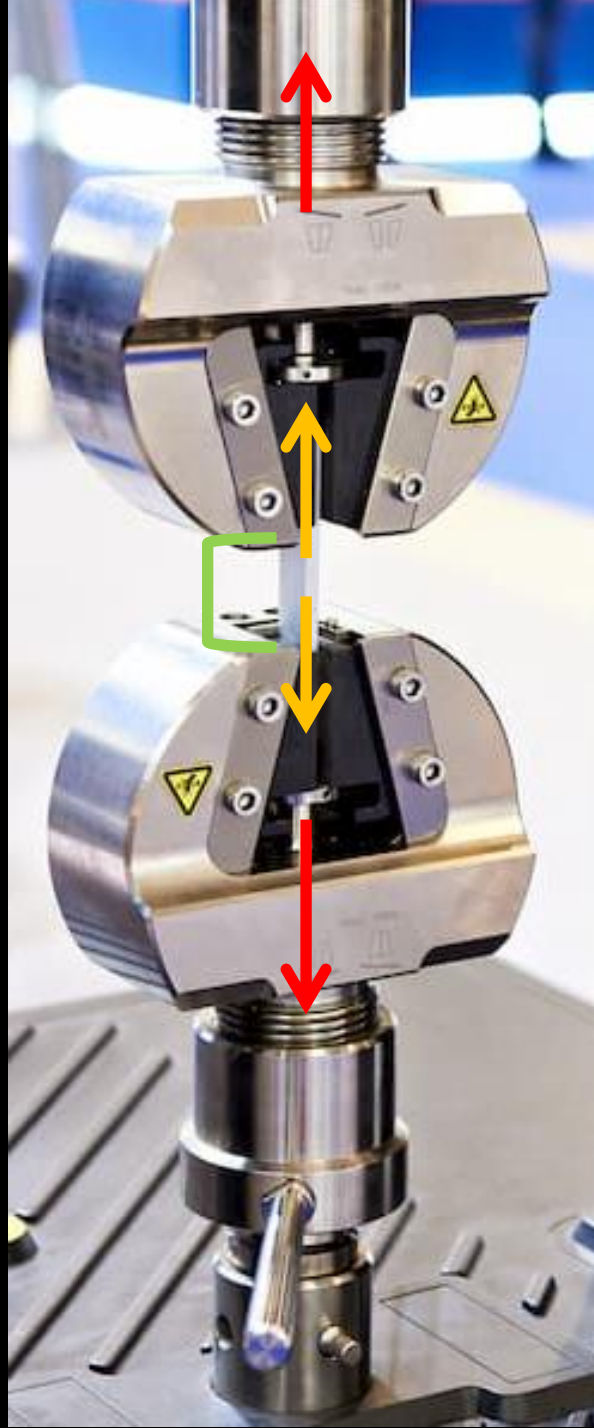
Stress
(Force in matter)



Strain
(Geometrical variation)



Direction
+
Intensity



Strain

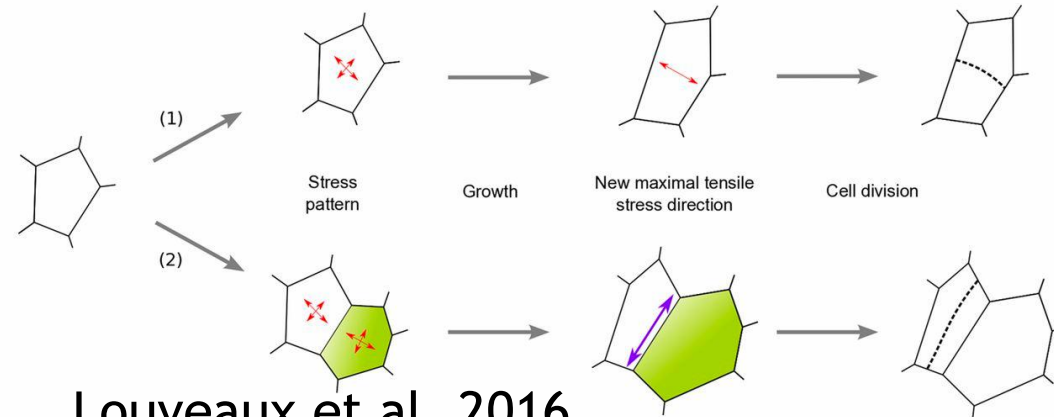
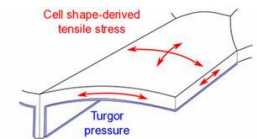


Moulija et Combes 2000

Stress

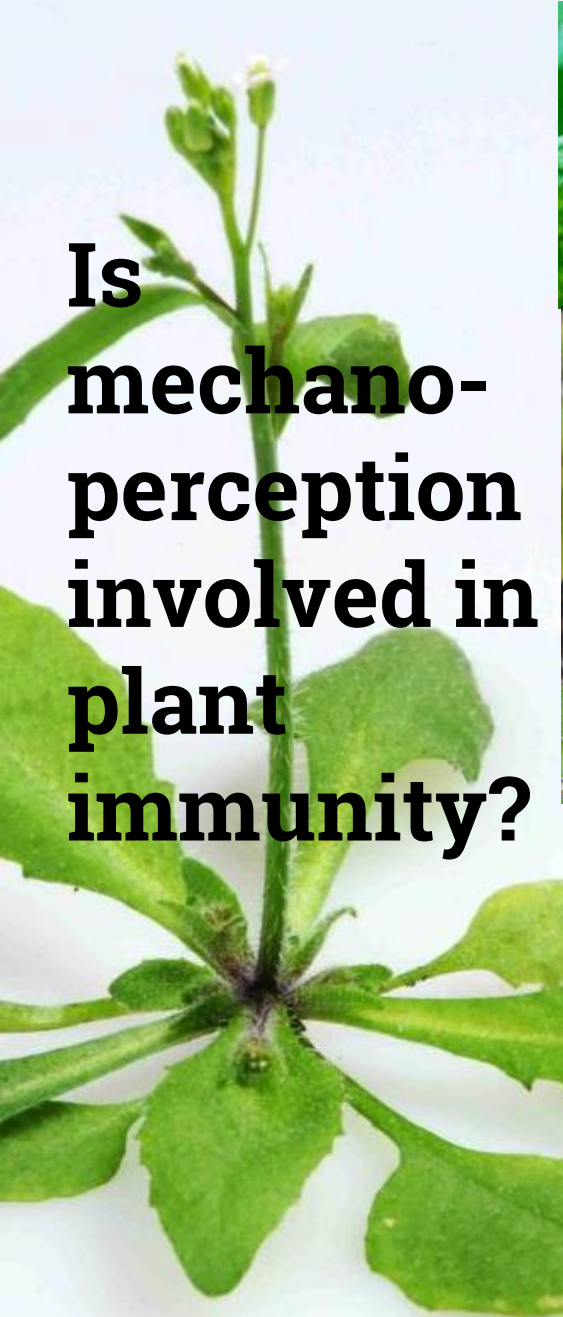
Cells divide along maximal tension

(1) Mechanical stress pattern derived from cell geometry (tissue with isotropic shape)



Louveaux et al. 2016

**Is
mechano-
perception
involved in
plant
immunity?**



necrotrophic fungus

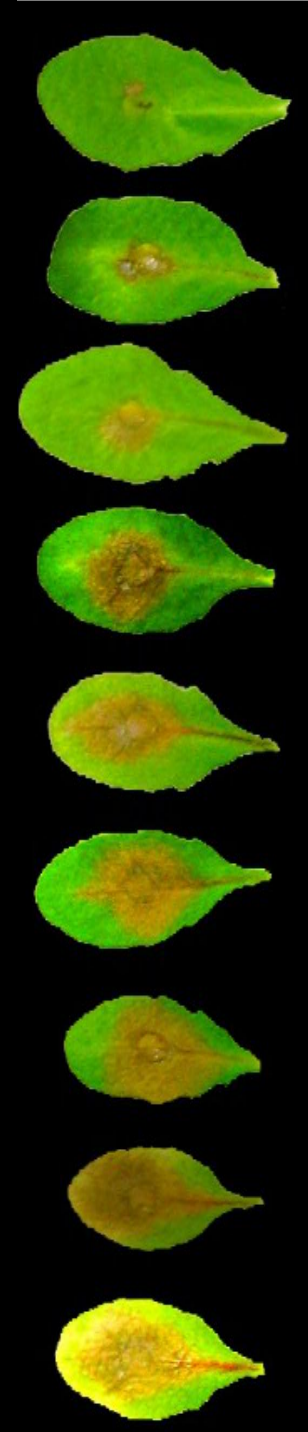
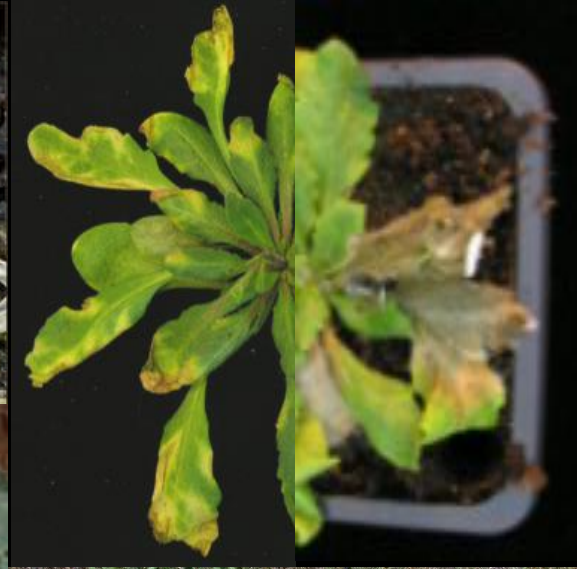
broad host range
(>400)



*Sclerotinia
sclerotiorum*



©T.A.



Arabidopsis thaliana

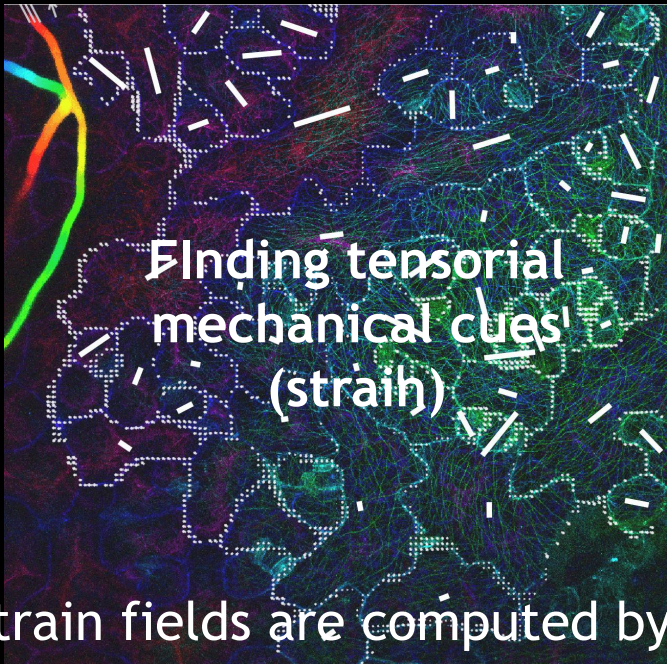


**Is mechano-
perception activated
during infection?**



Are Mechanical
cues (strain)
perceived?

Microtubules are anisotropic
probes reorganizing in the
direction of the principal stress



Finding tensorial
mechanical cues
(strain)

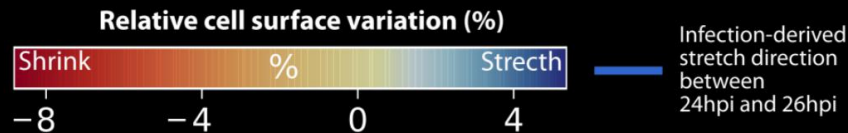
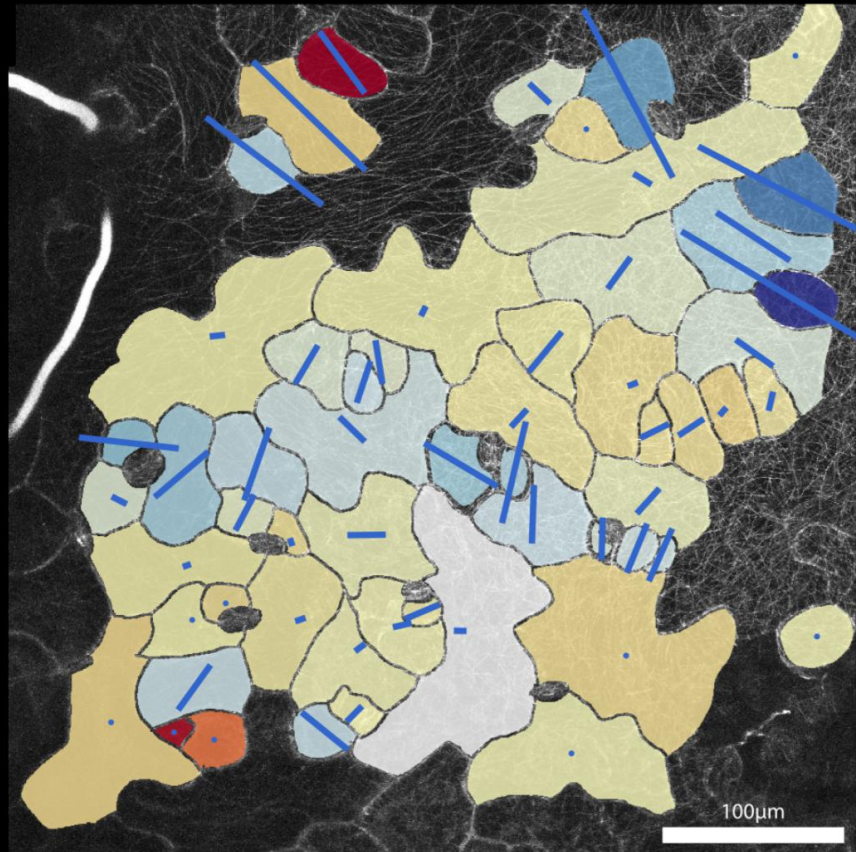
Strain fields are computed by
image analysis (ST+KLT)

Infection by a fungal pathogen partially releases tension in plant cell walls

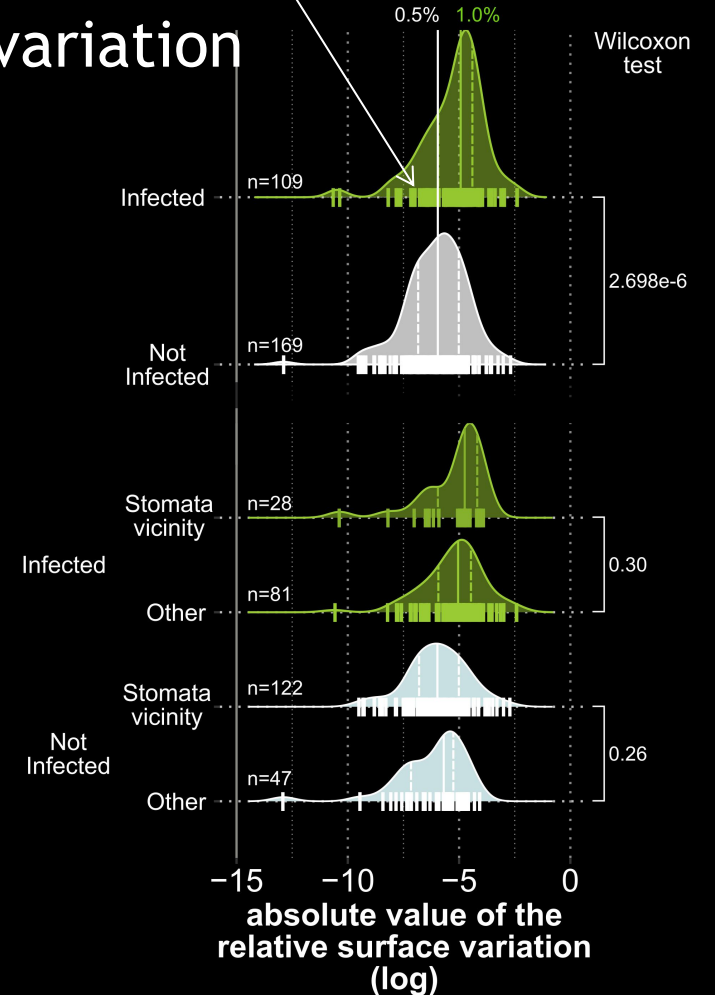
Infected: 3 plants,
109 cells

2h
(24hpi
26hpi)

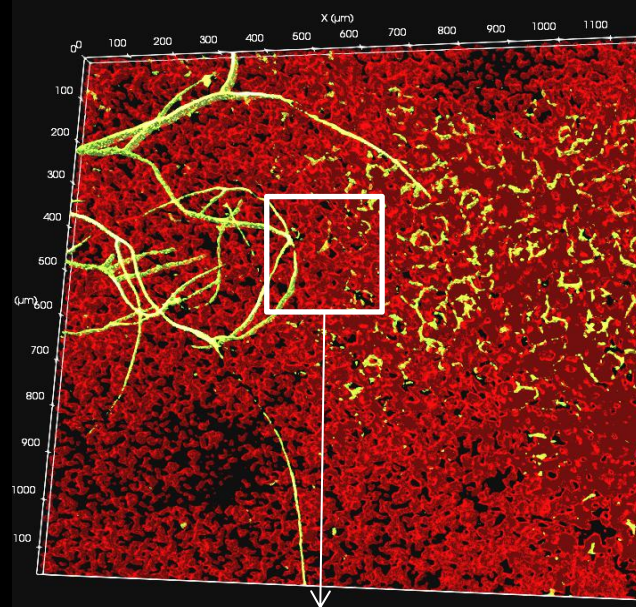
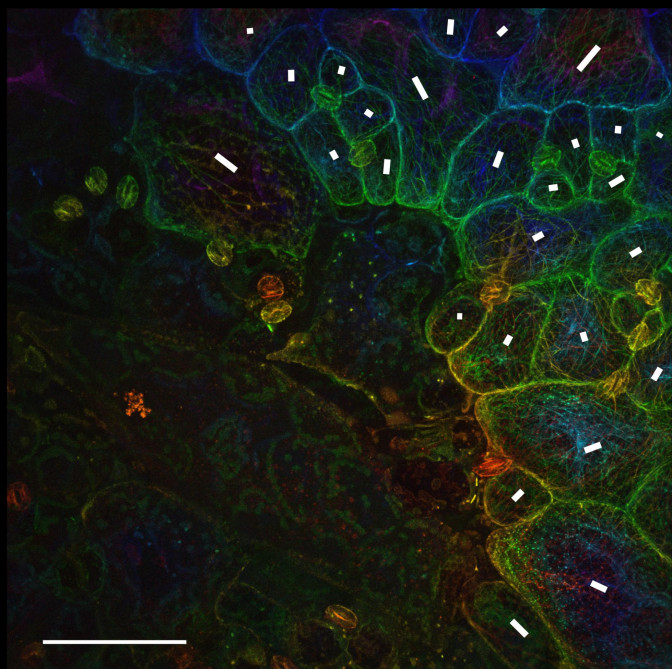
Mock: 3 plants,
169 cells



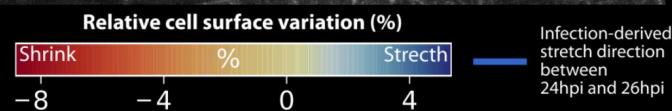
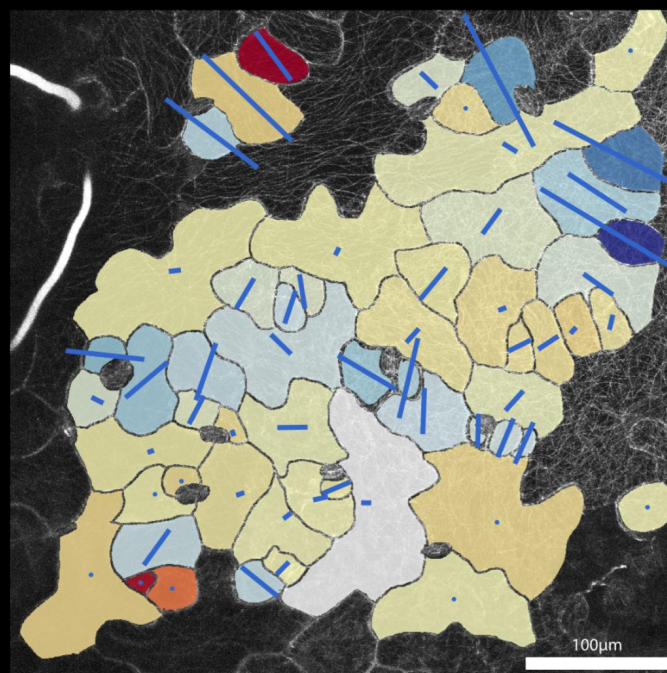
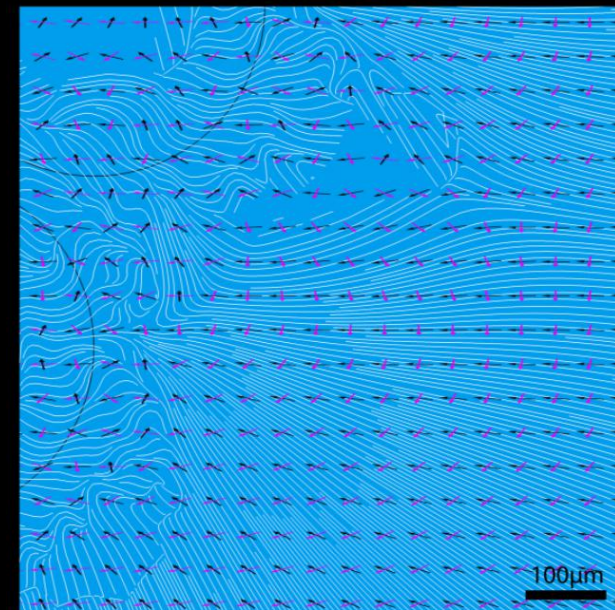
1%
surface
variation



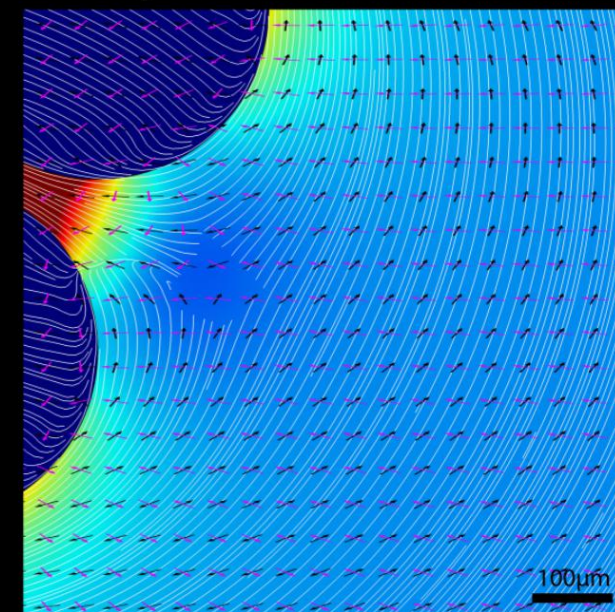
Infection by a fungal pathogen partially releases tension in plant cell walls



Low release of internal tension

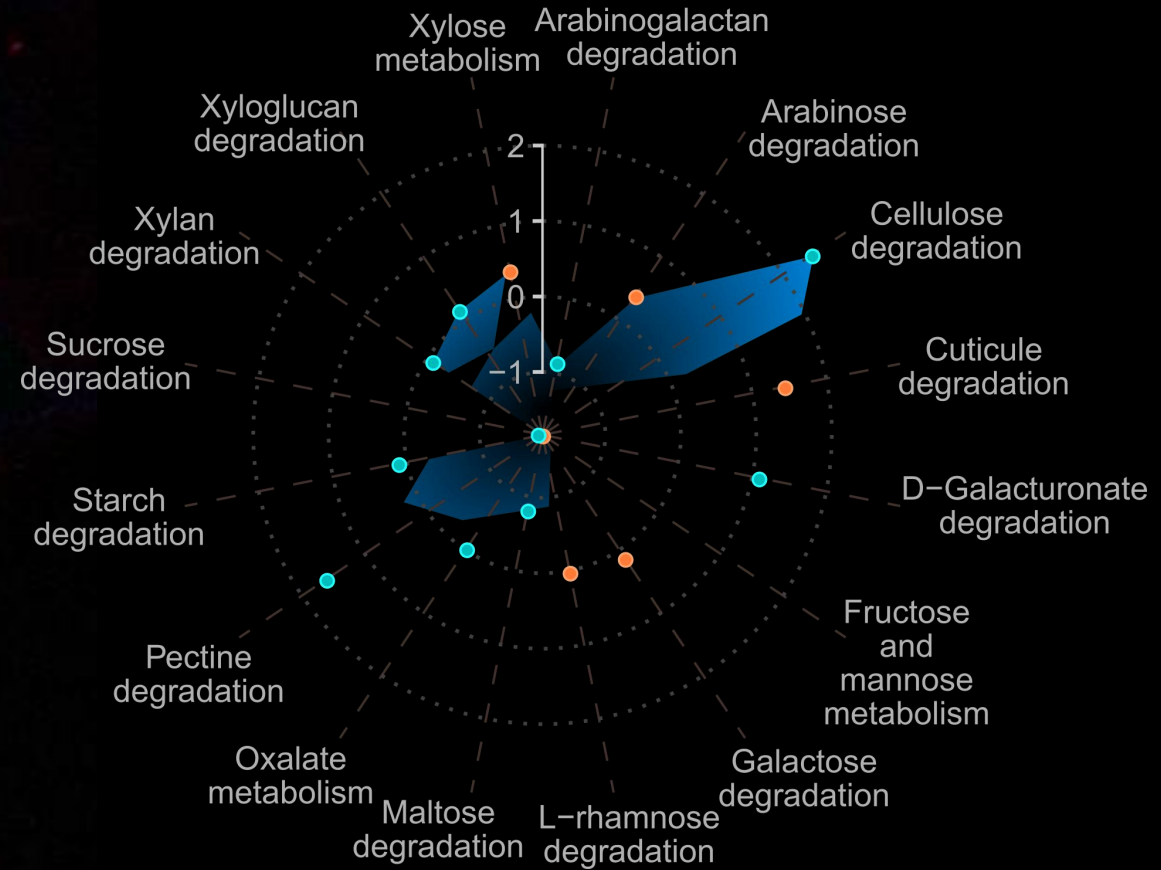


High release of internal tension



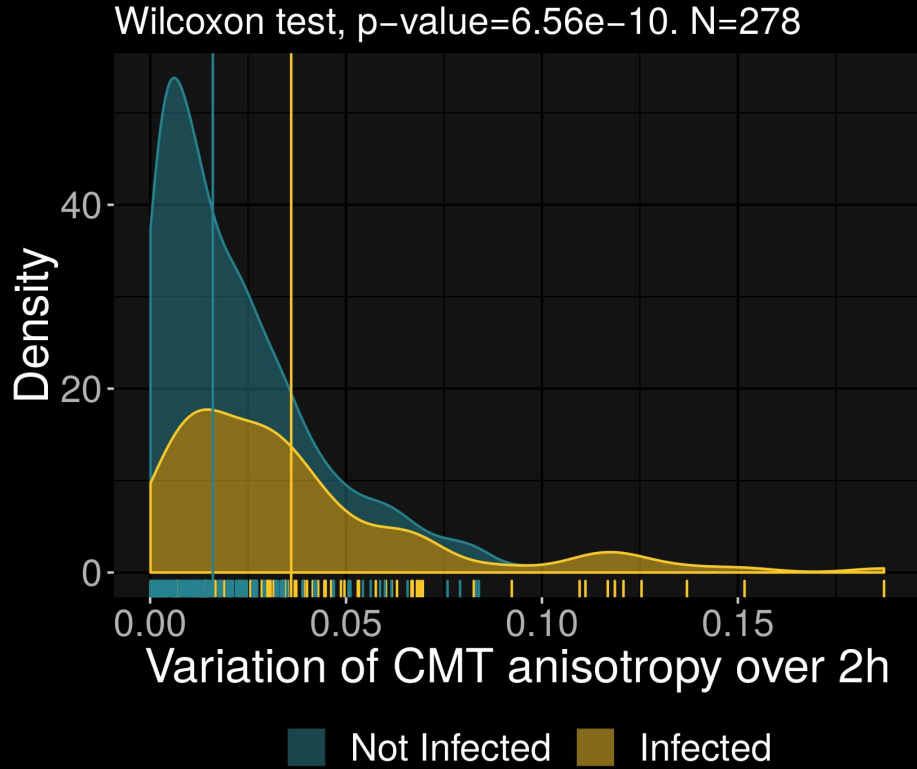
The partial releases of tension in plant cell walls is probably caused by the active fungal hydrolysis

We never observed direct physical contact between plant and fungus cells

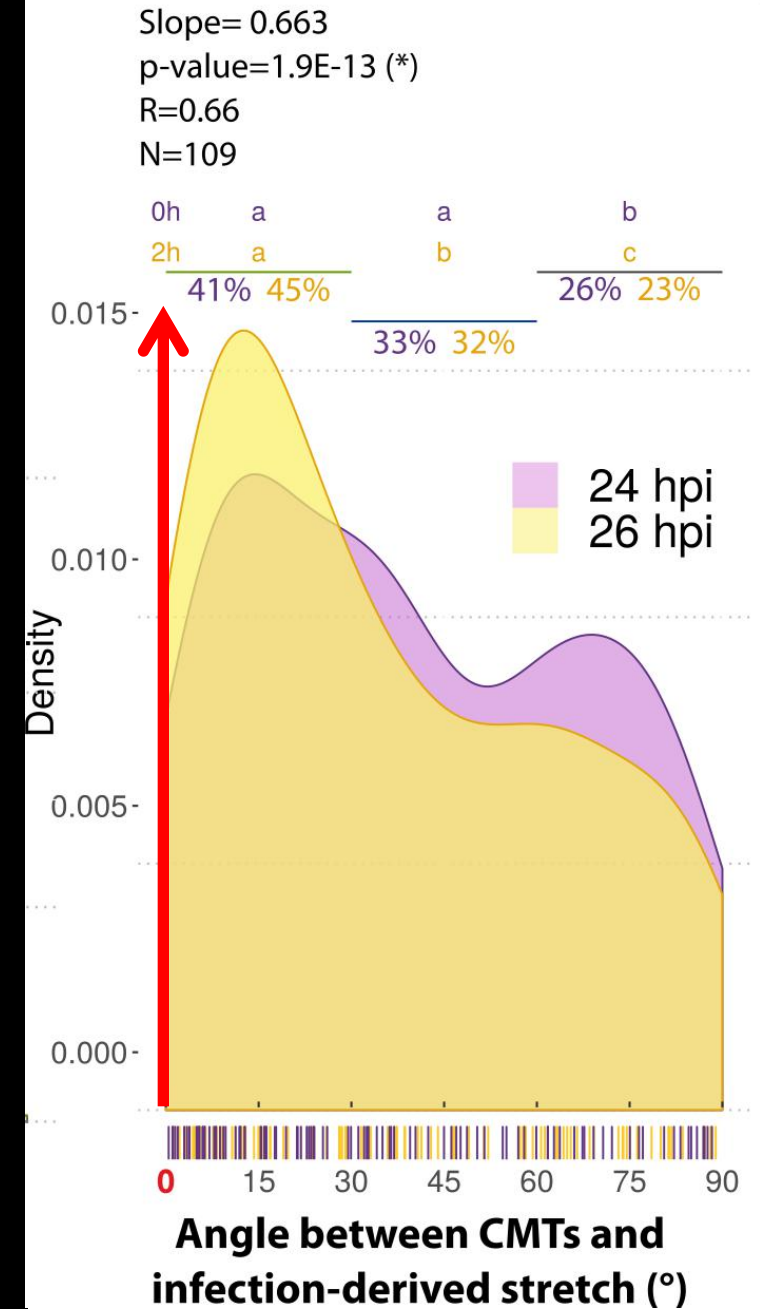


Pathogen-derived stretches guides the reorganization of CMTs.

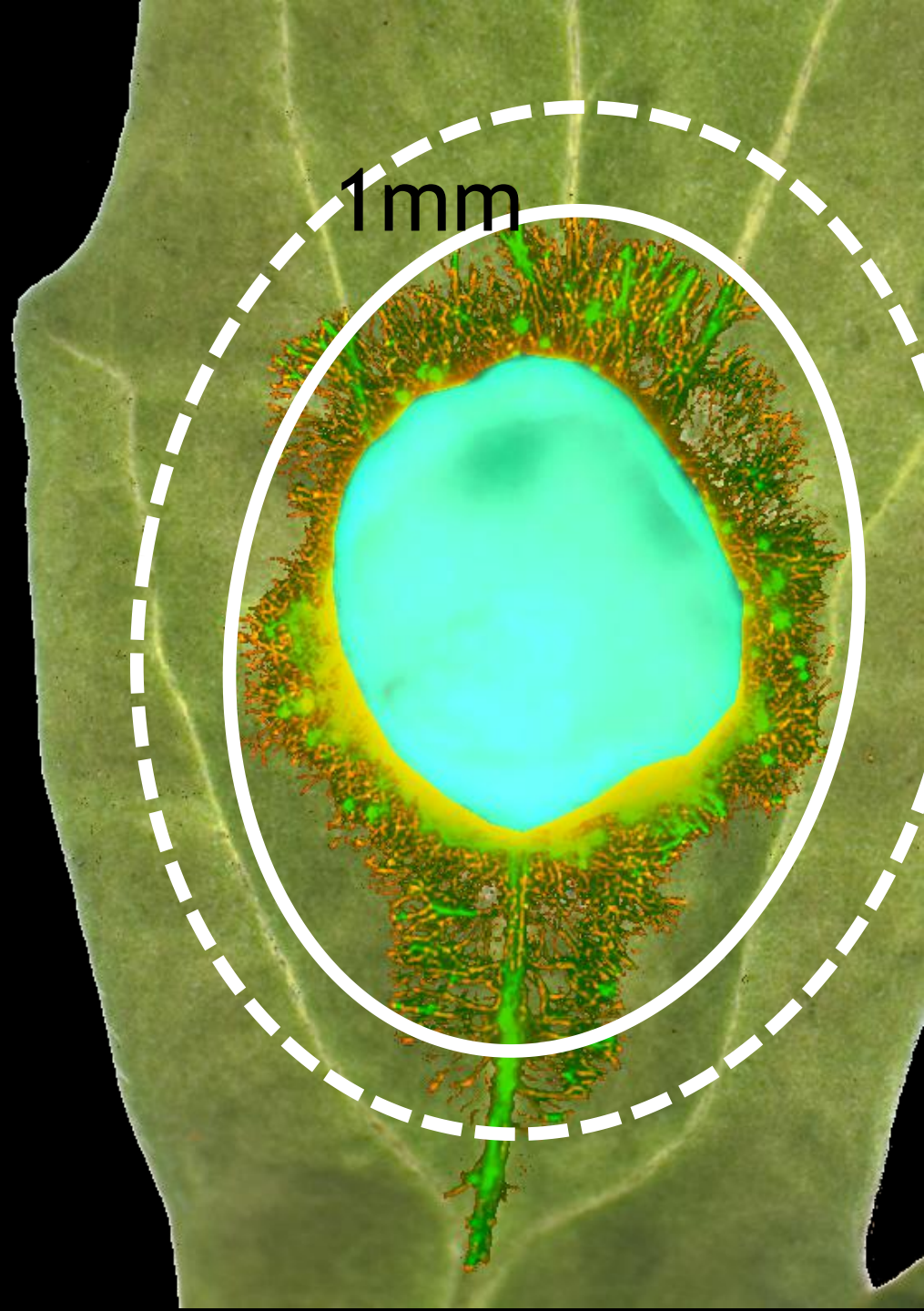
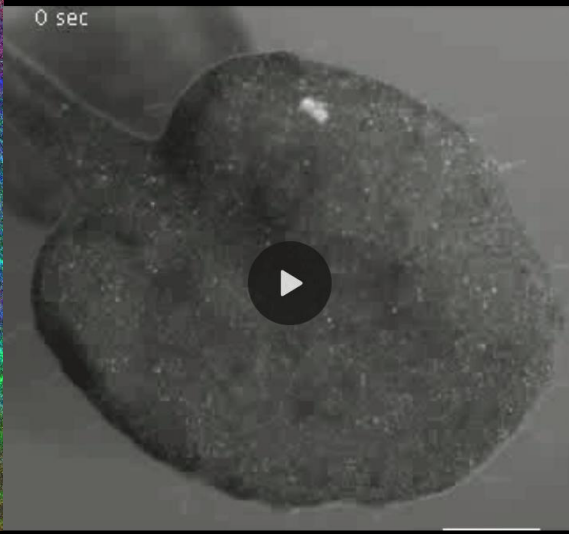
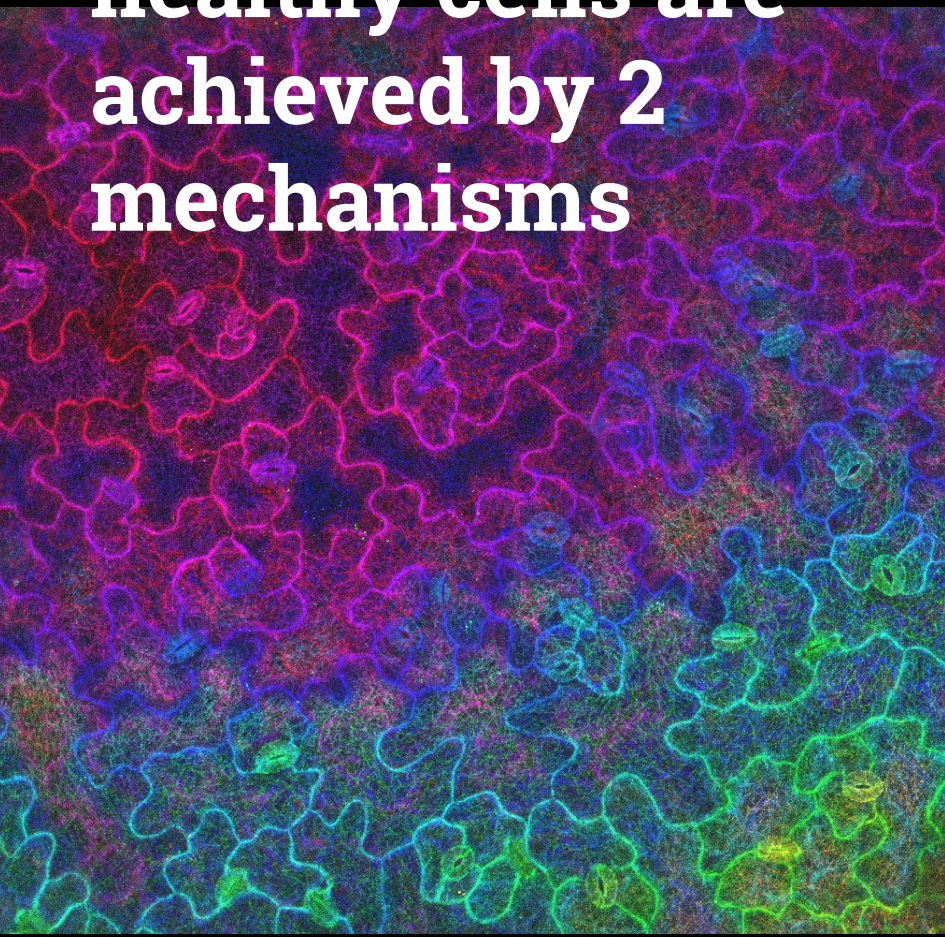
Infected: 3 plants, 109 cells
 Mock: 3 plants, 169 cells
 2h (24hpi)
 26hpi



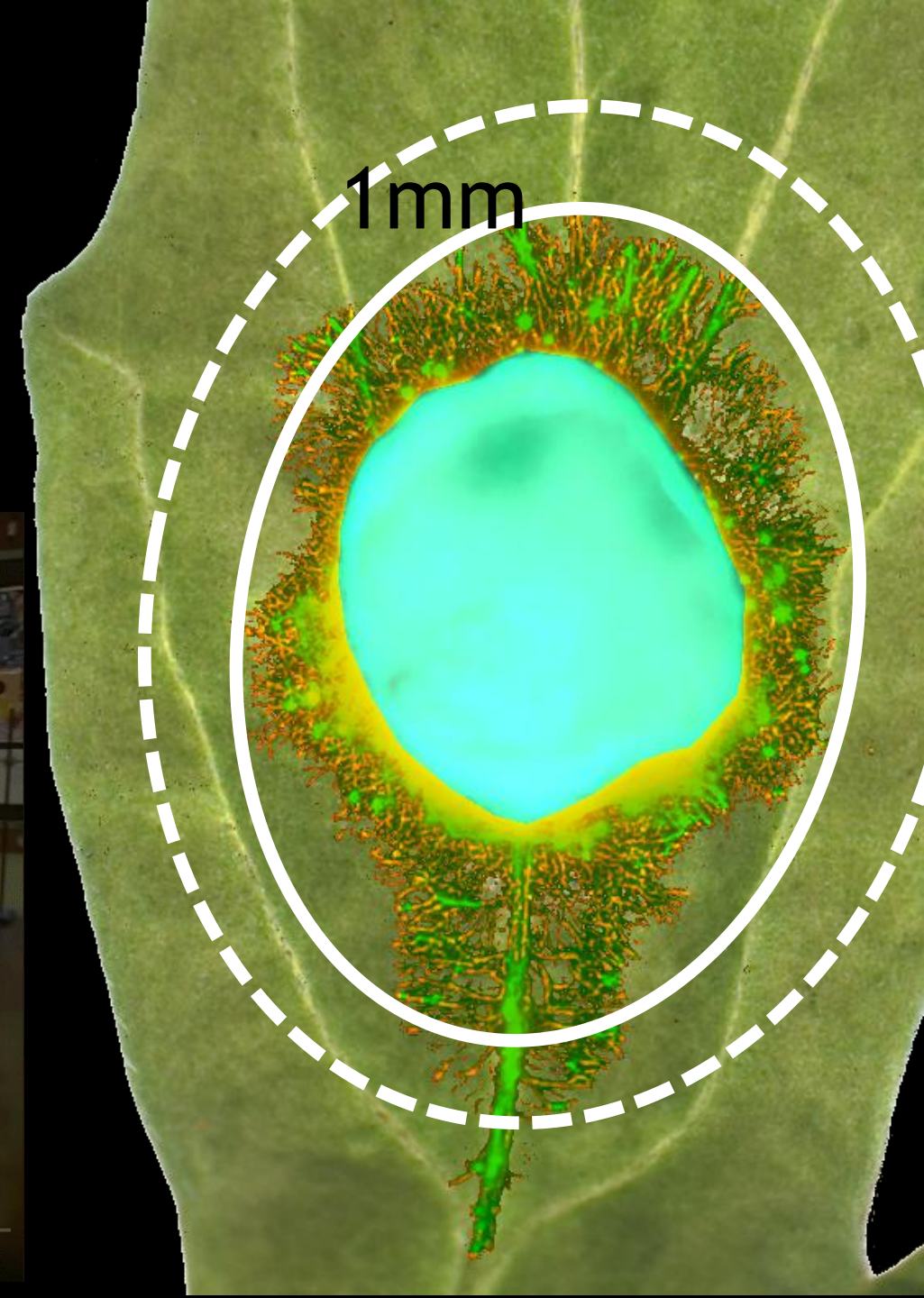
Higher CMT dynamics in infected plants



**Pathogen-derived
mechanical cues in
healthy cells are
achieved by 2
mechanisms**



**Pathogen-derived
mechanical cues in
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**Pathogen-derived
mechanical cues in
healthy cells are
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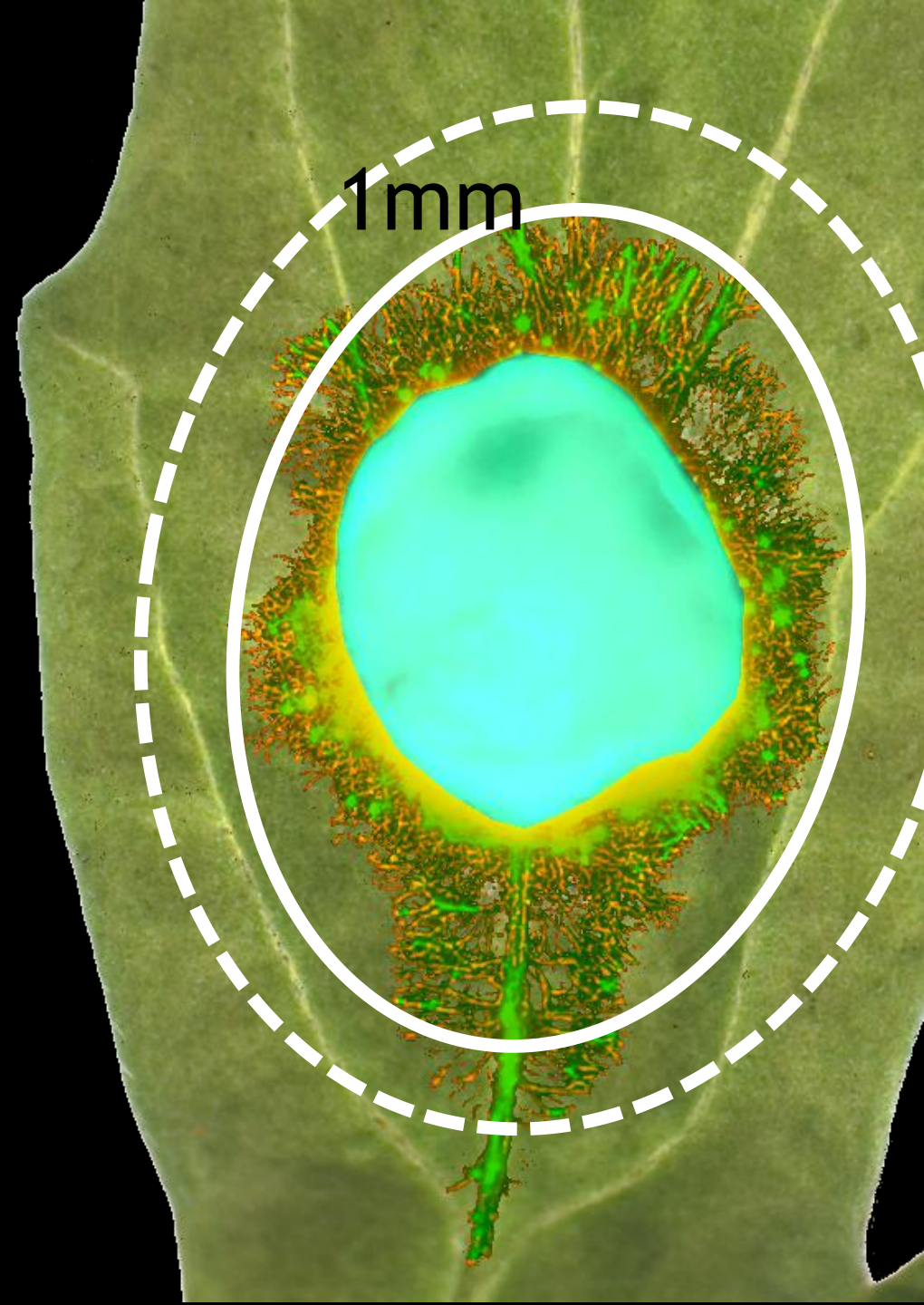
1. Enzyme & OA diffusion

$$10^5 < \tau < 10^3 \text{ s}$$

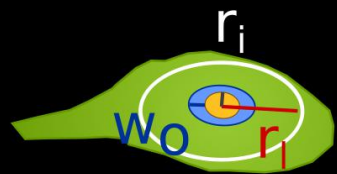
2. Reshuffling of internal stress
caused by the necrosis

$$\tau < 1 \text{ s}$$

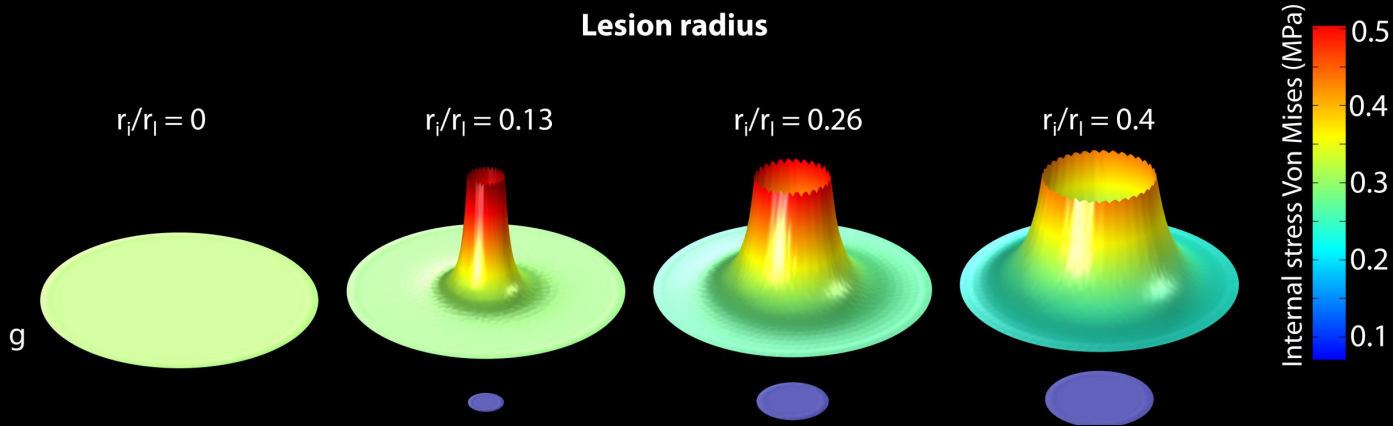
Typical growth time
 $\tau = 10^3 \text{ s} \sim \text{h}$



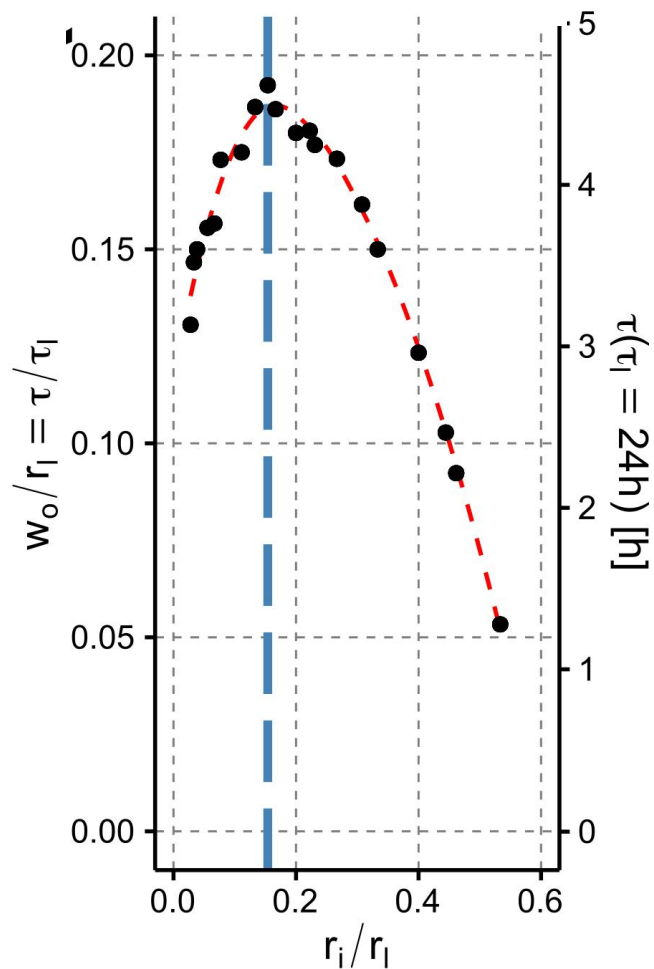
Anisotropic CMTs patterning occurs in healthy plant cells distant from the infection



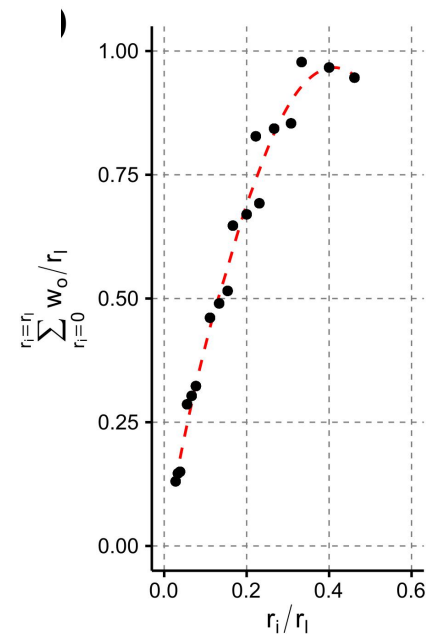
r_i : lesion radius
 r_l : leaf radius
 w_0 : width of the
 overretched ring



Fungal cell wall hydrolysis causes an over-
 stretched ring around the colony (w_0)



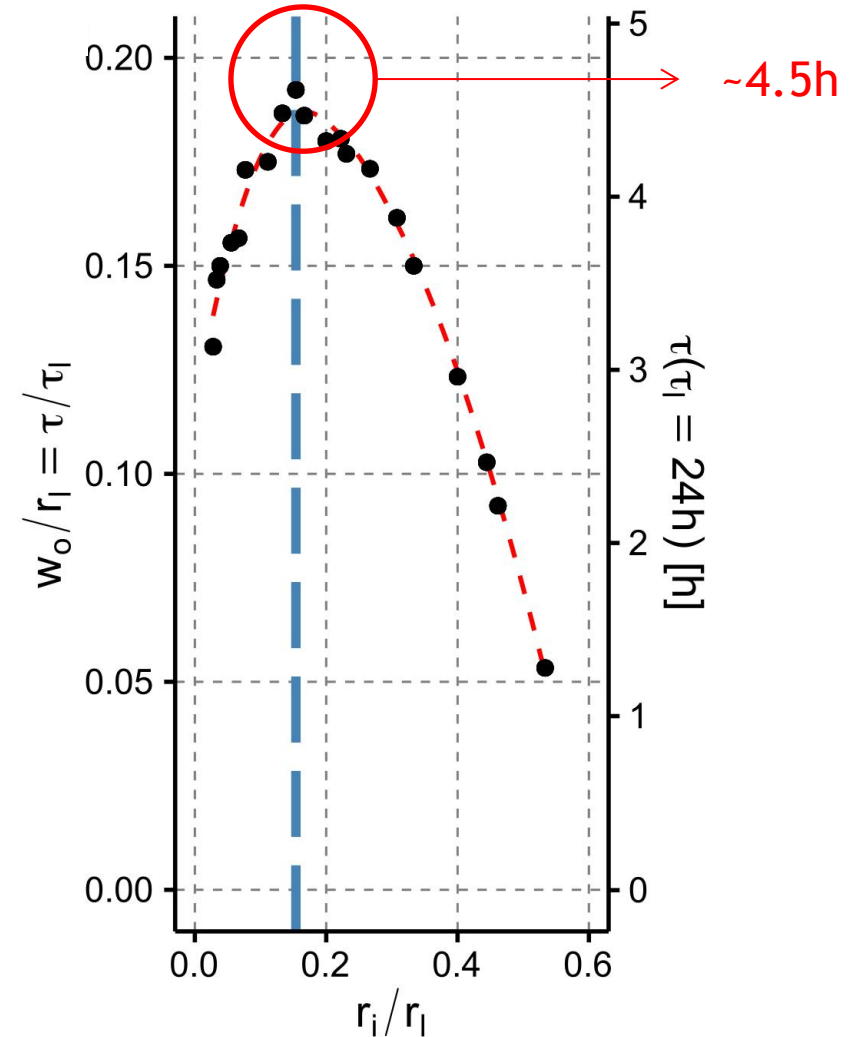
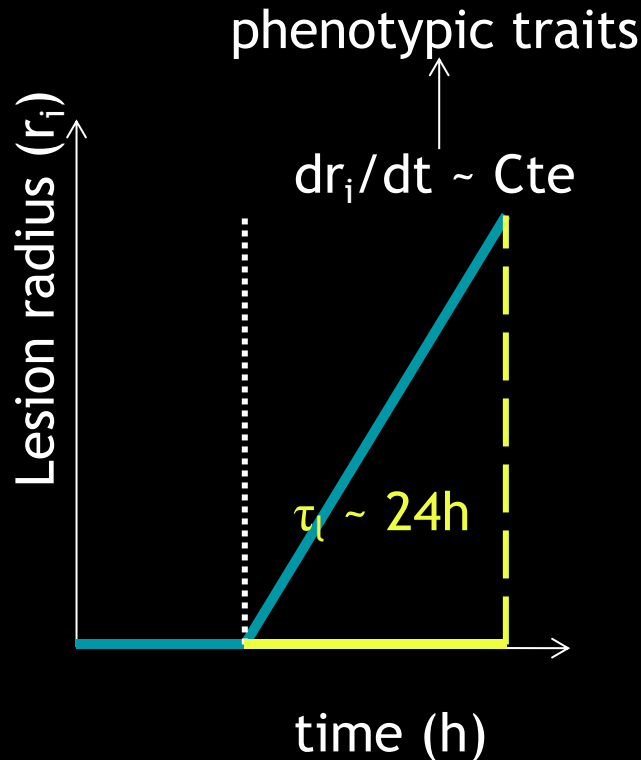
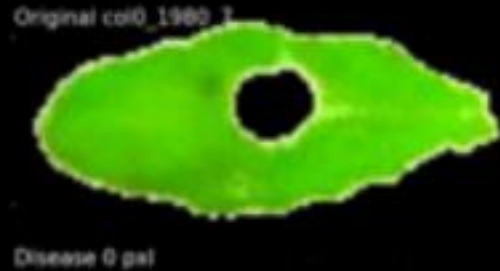
$\tau(r_l = 24h)$ [h]



Anisotropic CMTs patterning occurs in healthy plant cells distant from the infection

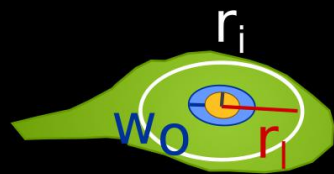


r_i : lesion radius
 r_l : leaf radius
 w_o : width of the overstretching ring



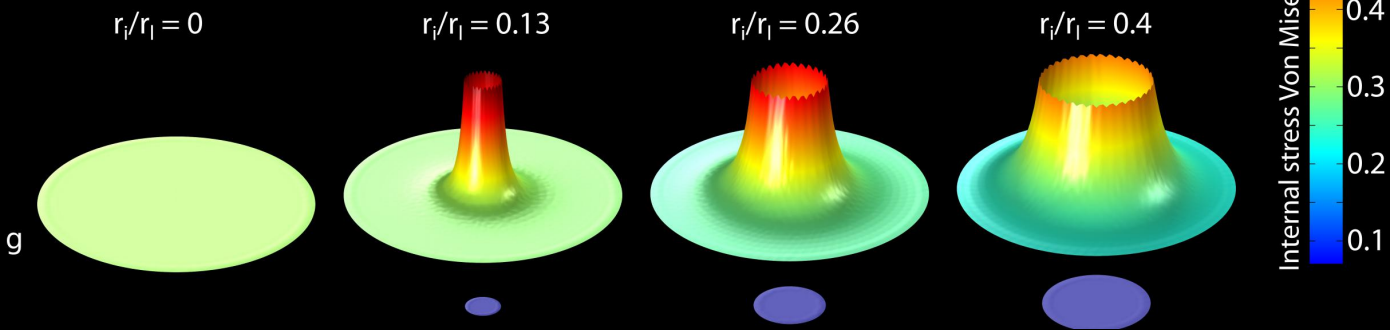
Mechanical cues (overstretched ring) inform cell several hours before the necrotroph reach the cells

Anisotropic CMTs patterning occurs in healthy plant cells distant from the infection

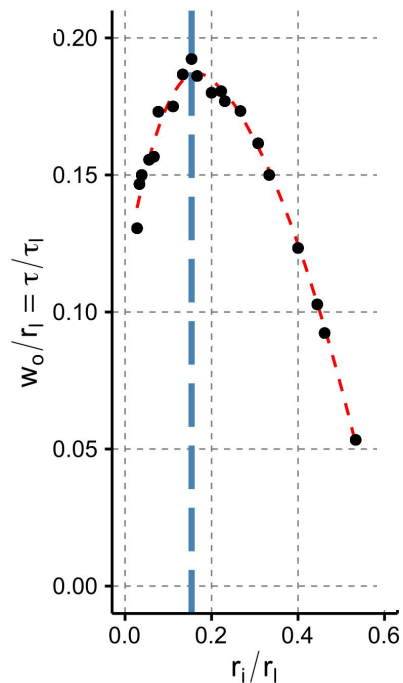


r_i : lesion radius
 r_l : leaf radius
 w_o : width of the overtretched ring

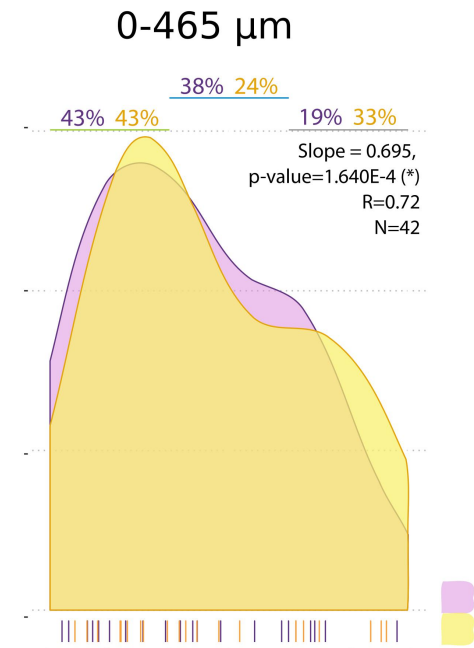
Lesion radius



Fungal cell wall hydrolysis causes an over-stretched ring around the colony (w_o)

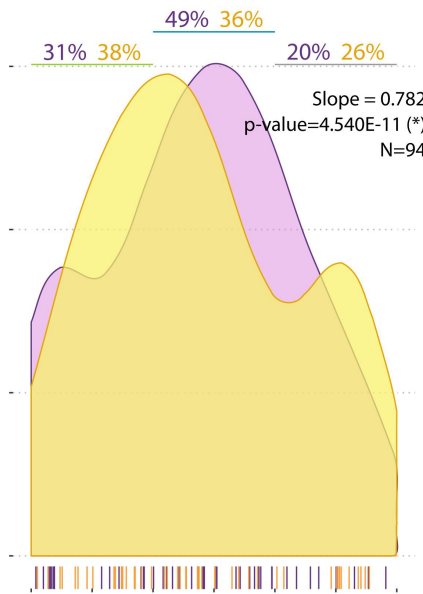
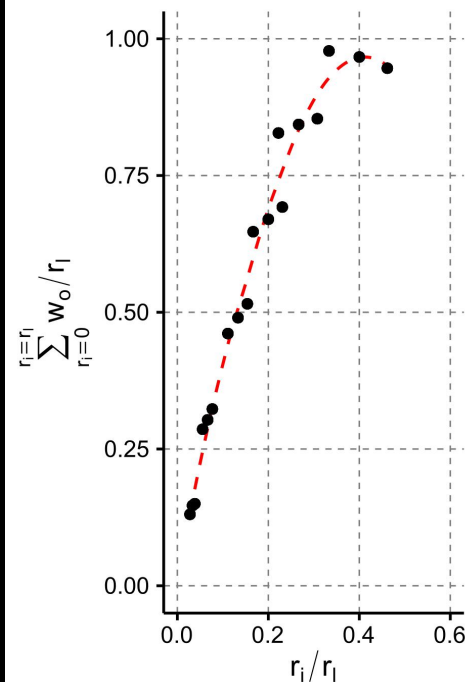


$\tau(r_l = 24h)$ [n]



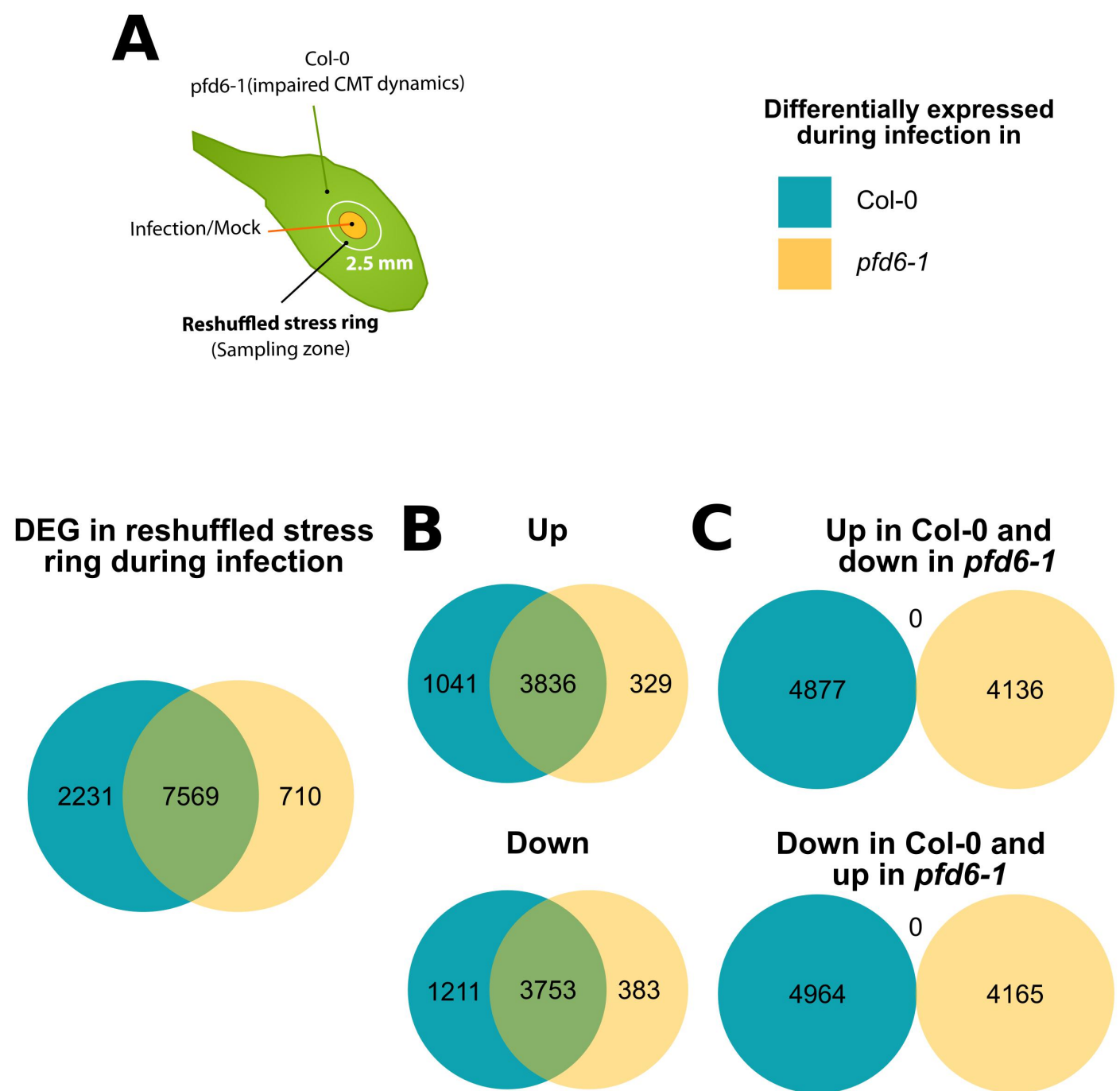
Angle between CMTs and
infection-derived stretch ($^\circ$)

2147-2612 μm

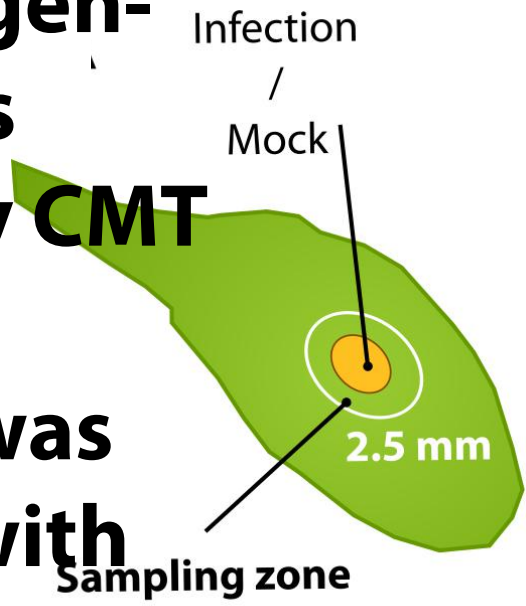


Angle between CMTs and
infection-derived stretch ($^\circ$)

Mechanoperception of pathogen-derived cues mediated by CMT anisotropic patterning was associated with the expression of disease resistance genes in distal cells

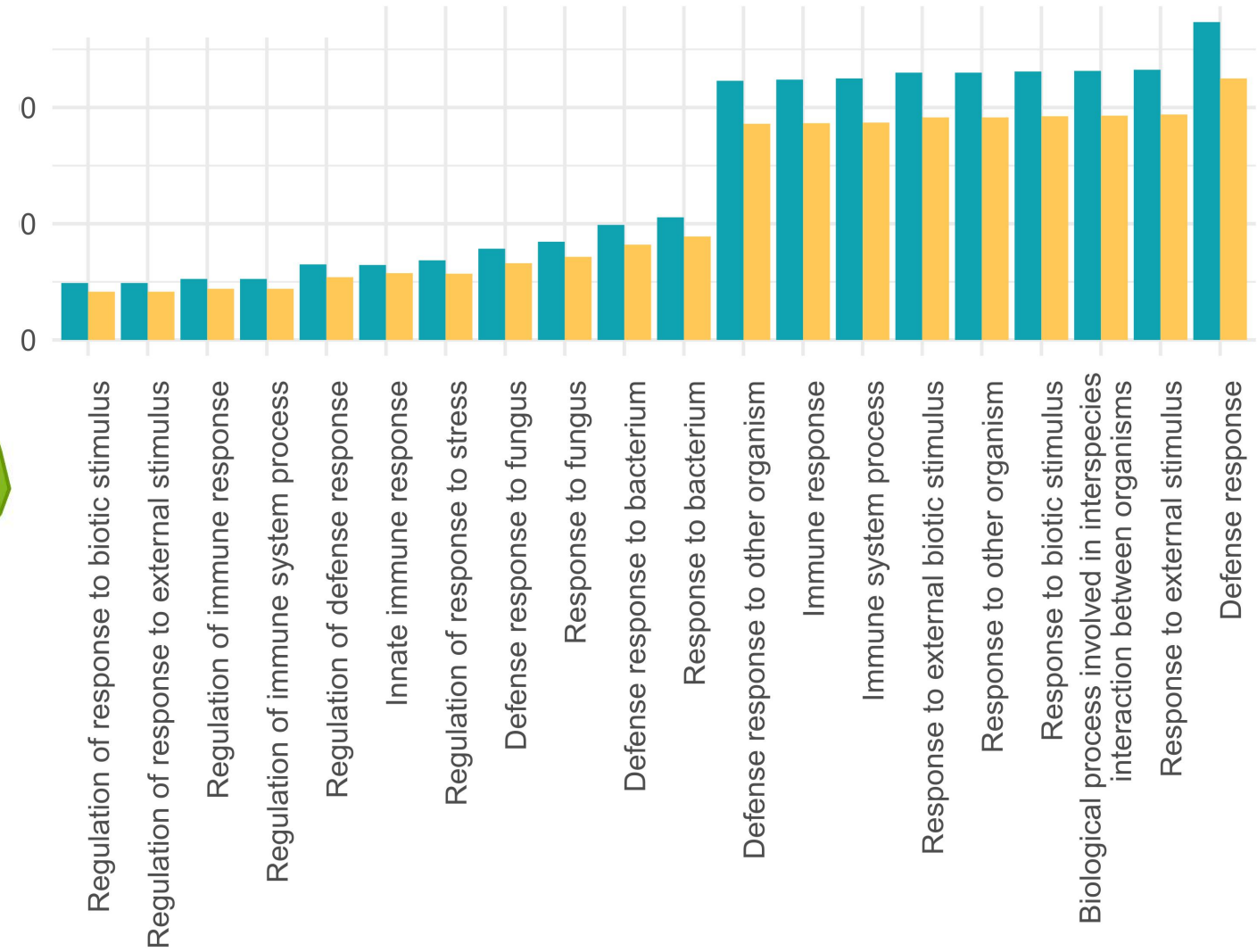


Mechanoperception of pathogen-derived cues mediated by CMT anisotropic patterning was associated with the expression of disease resistance genes in distal cells

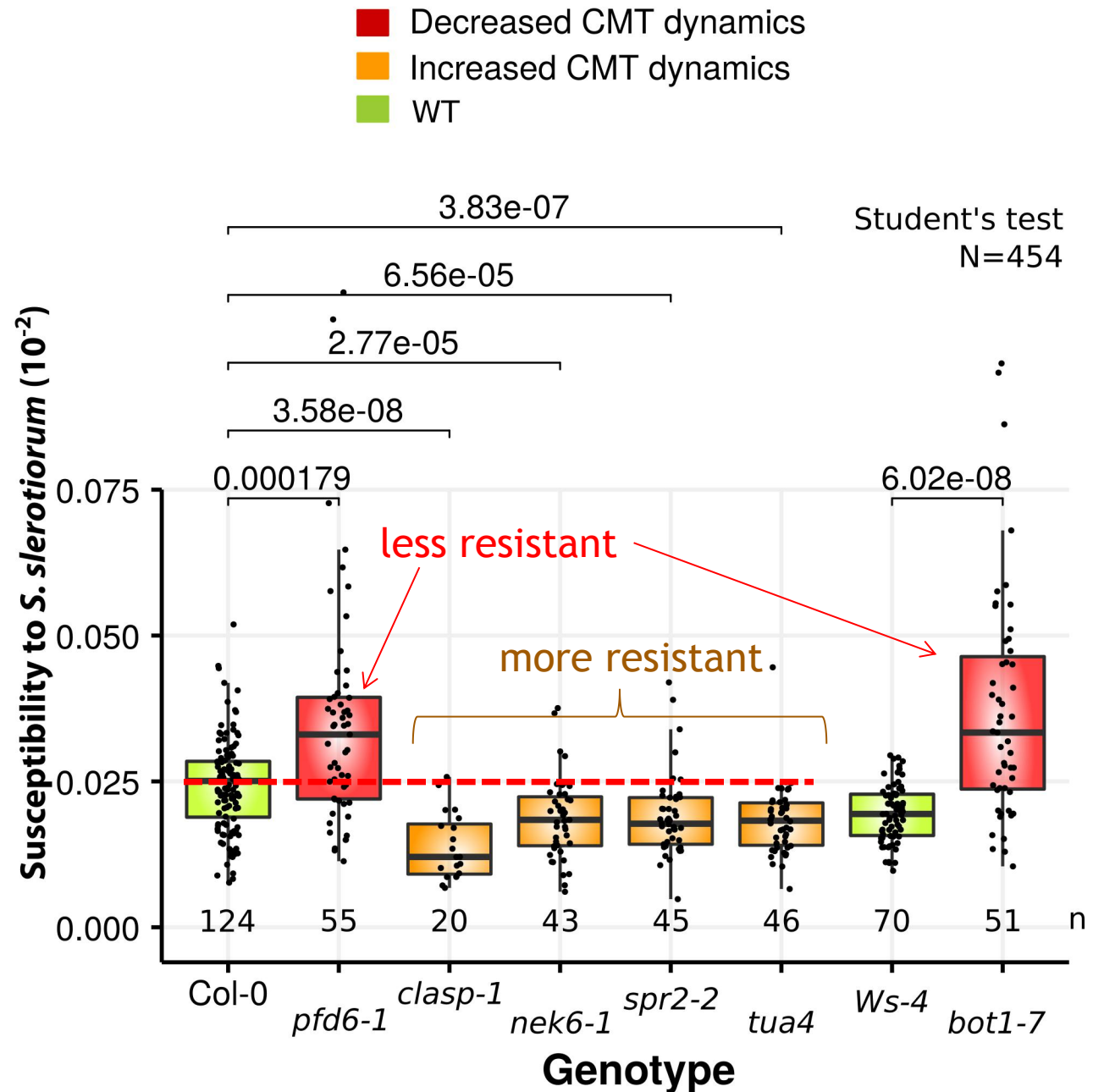
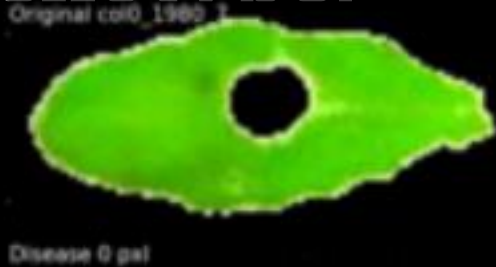


Differentially expressed during infection in

- Col-0
- pdf6-1*

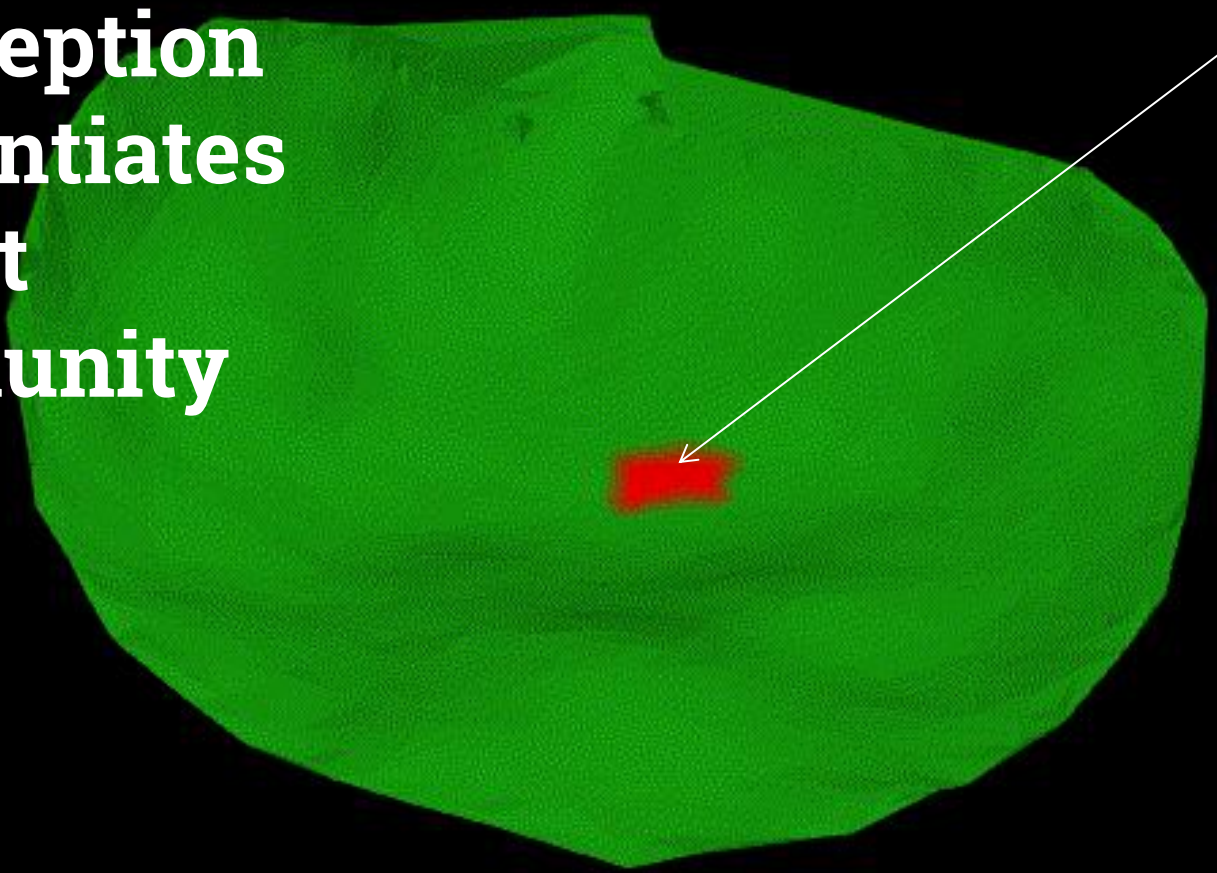


Mechanoperception of pathogen-derived cues mediated by CMT anisotropic patterning impacted resistance phenotype.



**Mechano-
perception
potentiates
plant
immunity**

Active MTI in the overstretched area



Time: 0.0 h

Partial release of cell wall tension caused by fungal hydrolysis



Formation of an overstretched ring = pathogen-derived cues



Differential resistance genes transduction in healthy through CMT anisotropic patterning

Quantitative immunity in plant (LIPME)

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Laure Flipo (M2) (-> Marie Edith Chabouté)
Rémy Vincent (IE)
Marie Didelon (PhD)

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Félix Hartmann
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Founded by

Thigmoimmunity(?) INRAE SPE department [Ended]
Batman (INRAE SPE department) [Starting]
Moonstone SumCrop metaprogram [Ended]

Not founded by

CNRS MITI (x2)
FRAIB Toulouse
ANR JCJC
Labex TULIP

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