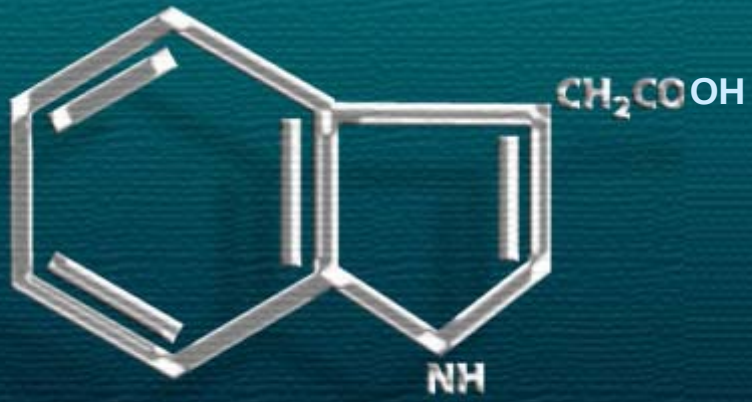
Canalization of auxin flow by regulation of PIN polarity



Ivan Paponov
Department of Botany, University of Freiburg

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Overarching scientific context

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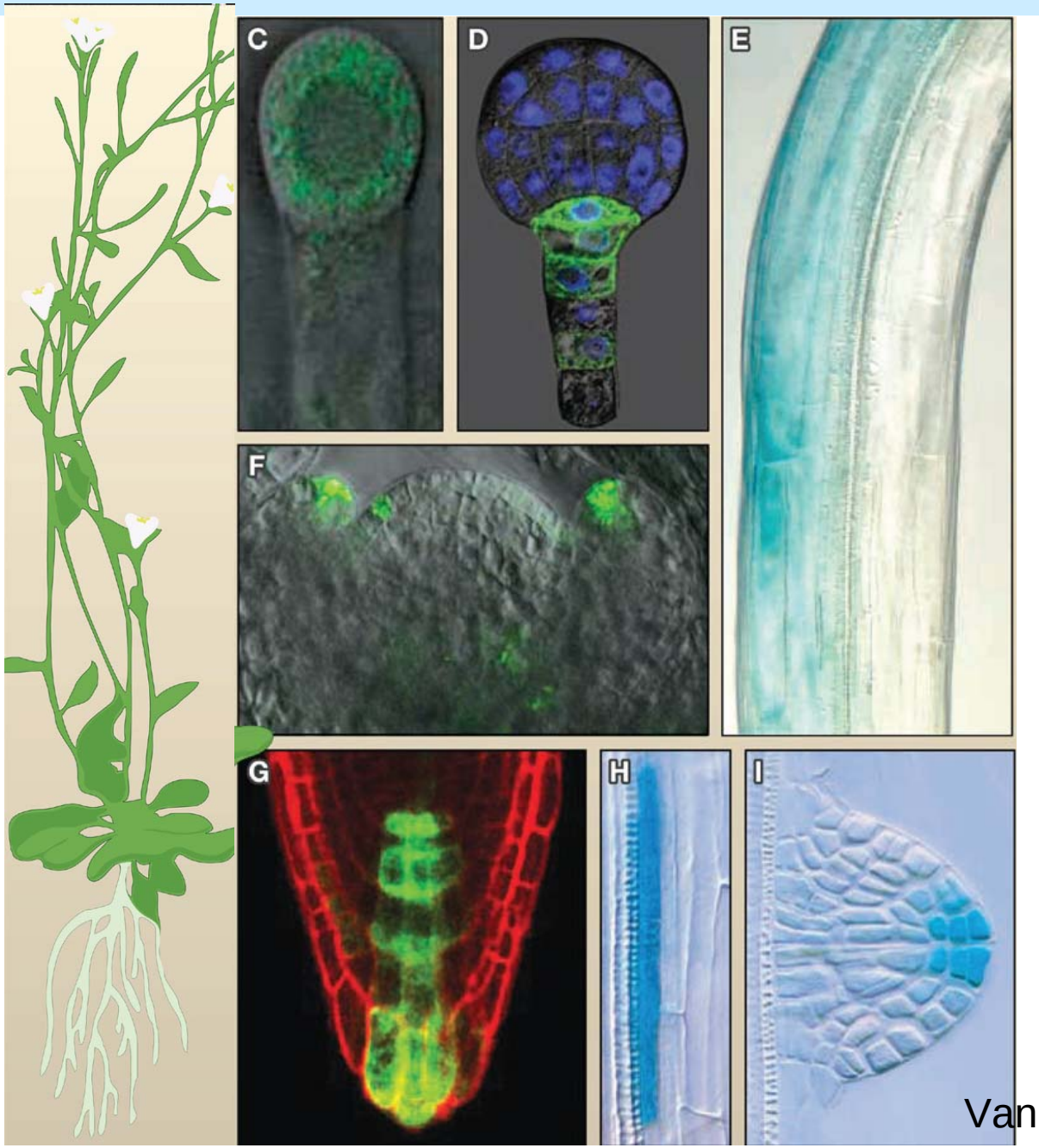
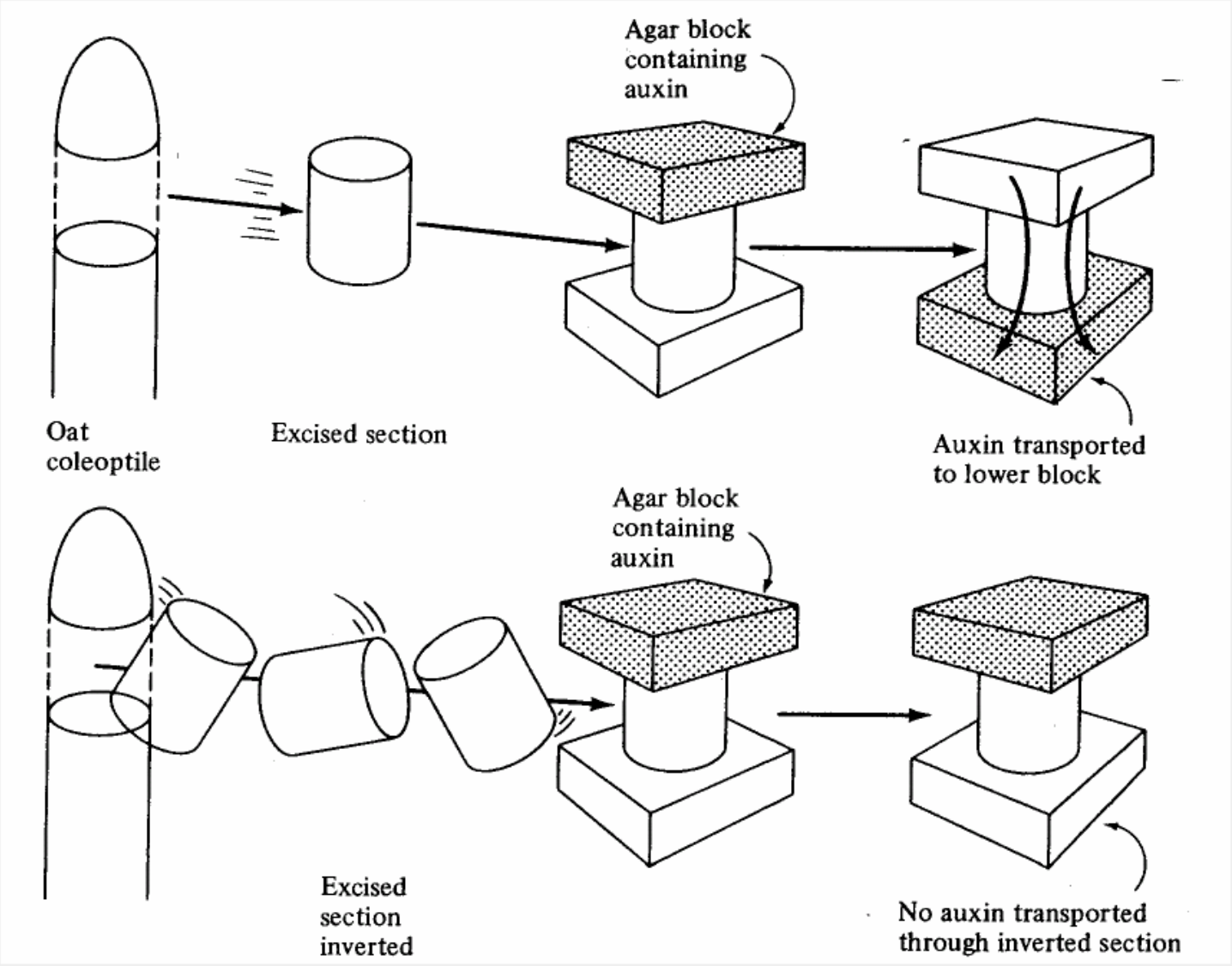
Auxin as morphogen



Vanneste et al 2009

Polar auxin transport



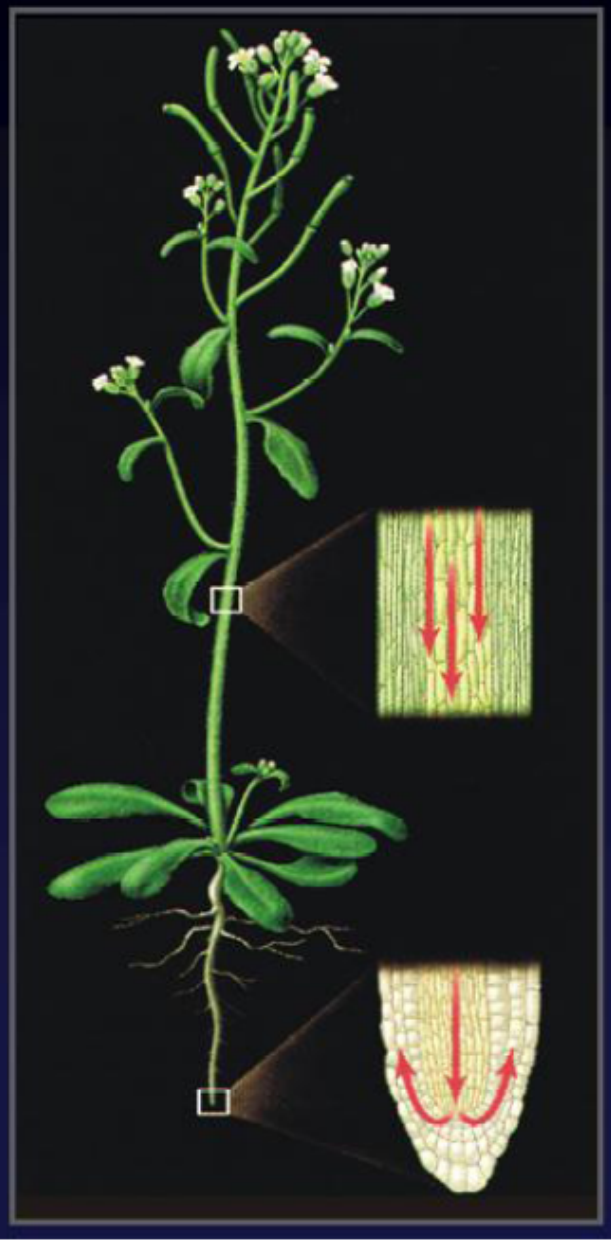
IAA is a weak acid

$$IAA(H) \iff IAA^- + H^+$$

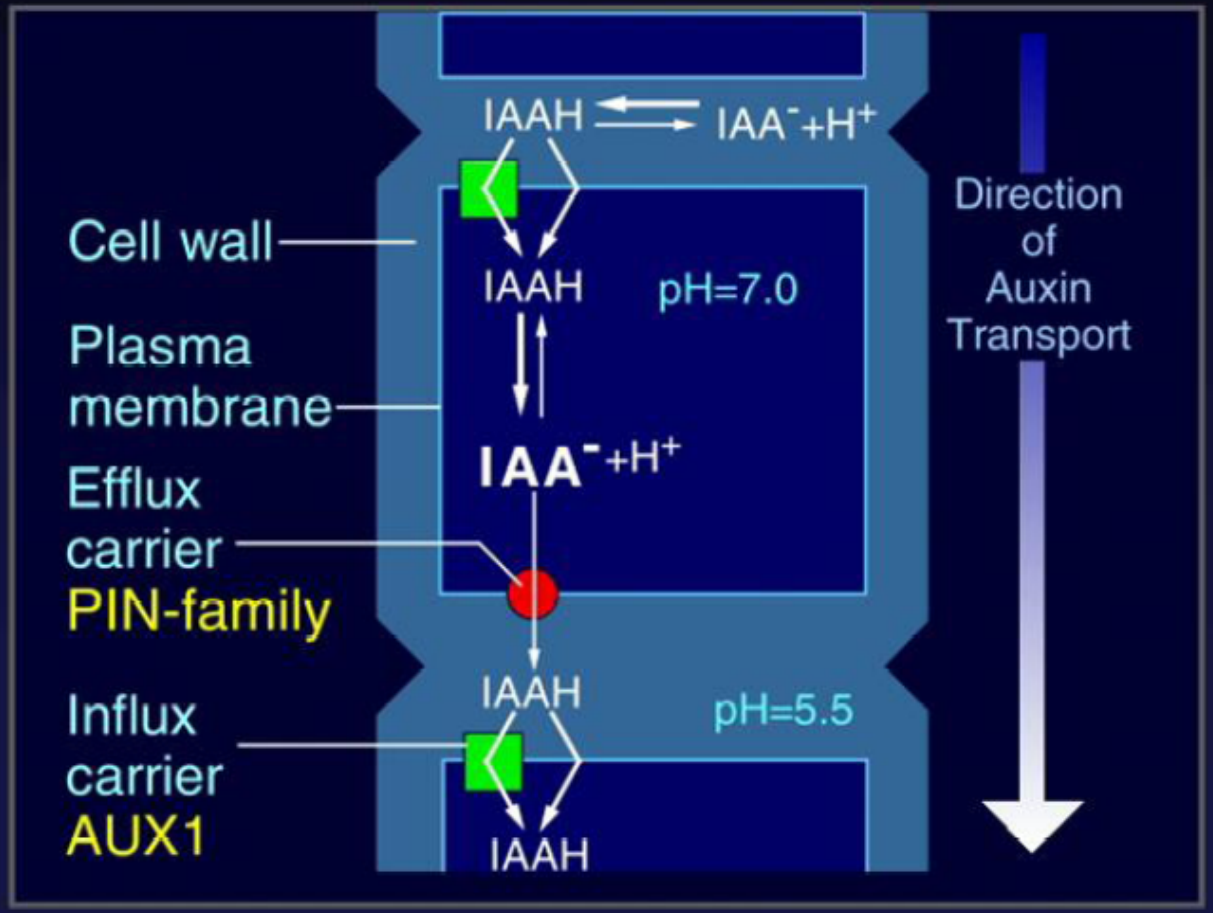
$$Kd = [IAA^-][H^+] / [IAA] \quad \text{at pH 4.7, } [IAA^-][H^+]/[IAA] = 1$$

Apoplast, pH = 5.0		Cytosol, pH = 7.2
IAA / IAA^-	>	IAA/IAA^-

Auxin Transport



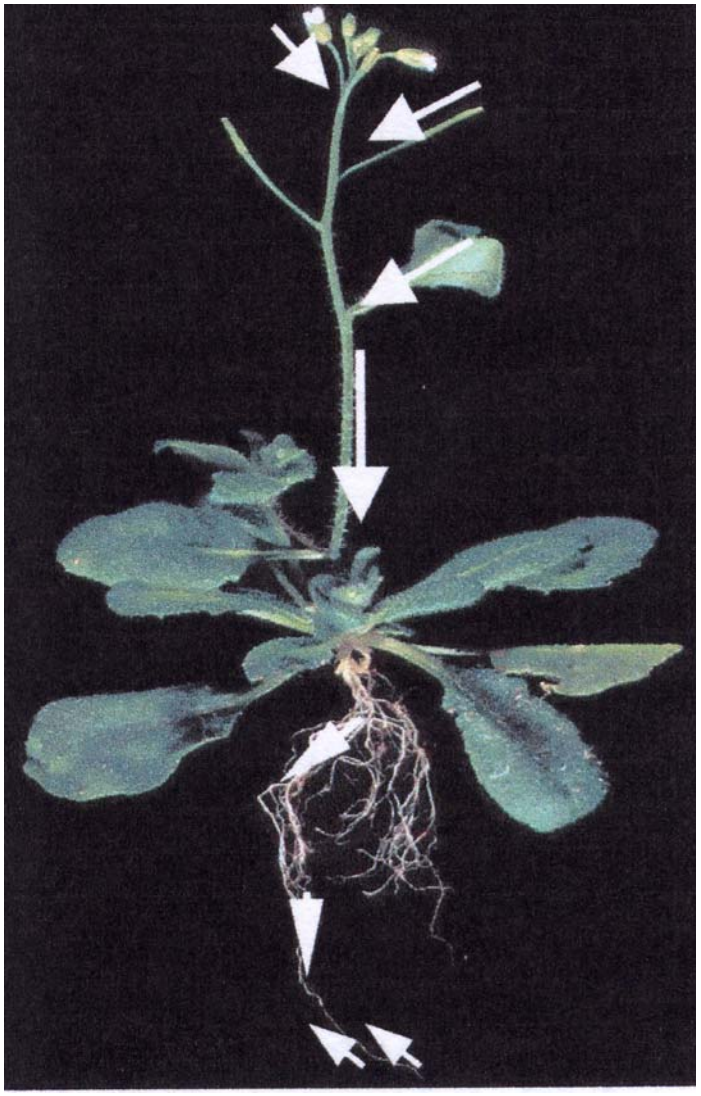
Chemiosmotic hypothesis



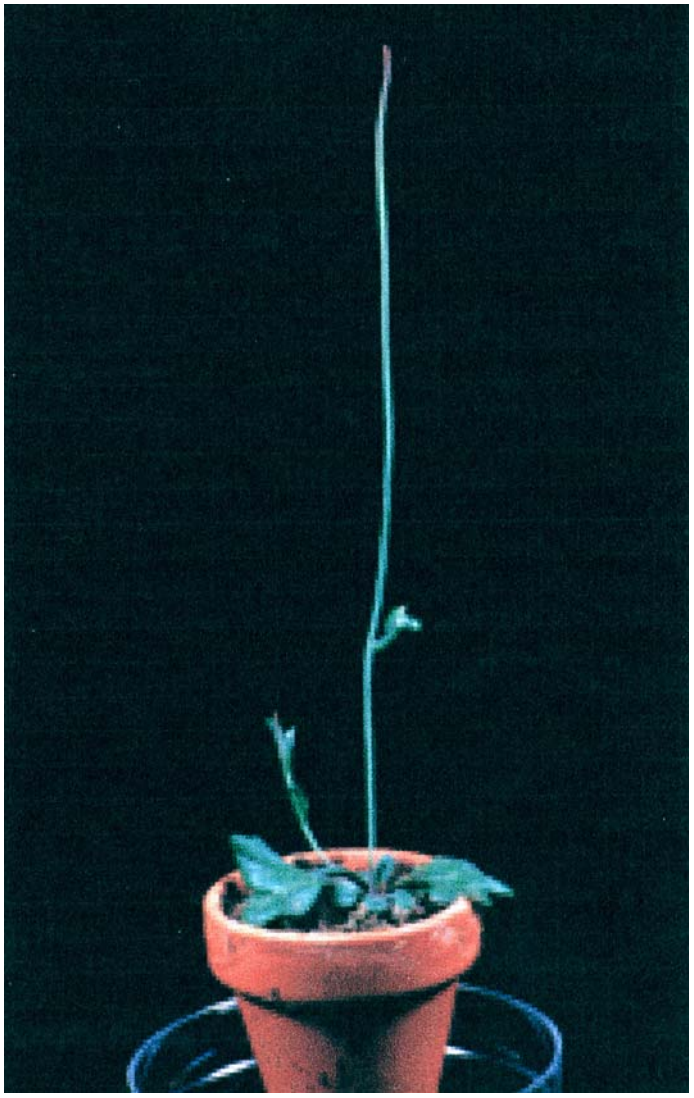
Rubery and Sheldrake 1974; Raven 1975

Phenotype of *pin1*

Wild type

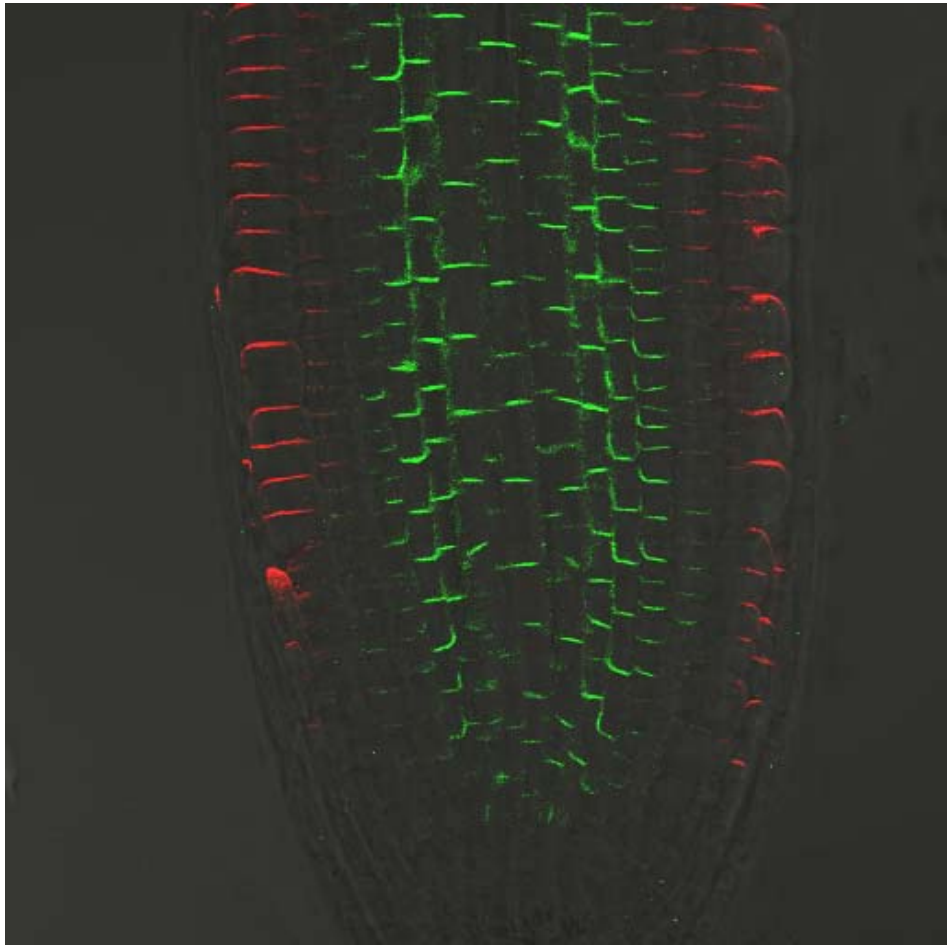


pin1

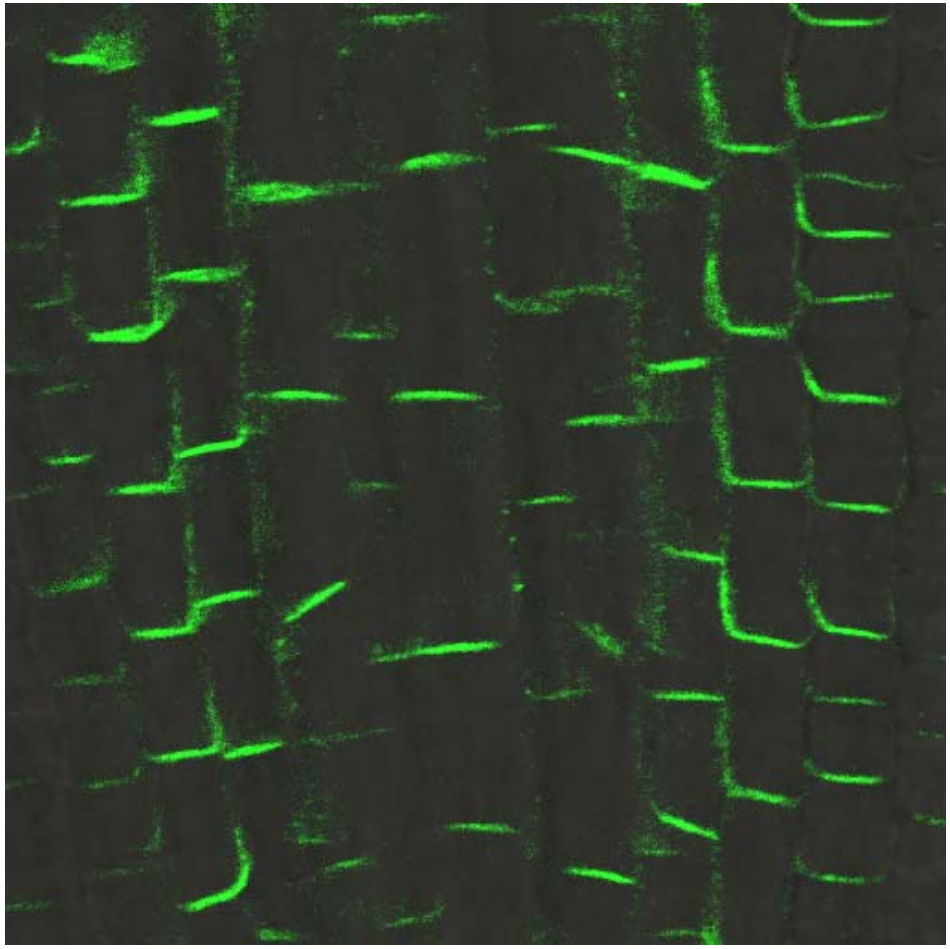


Polar localization of auxin efflux carriers

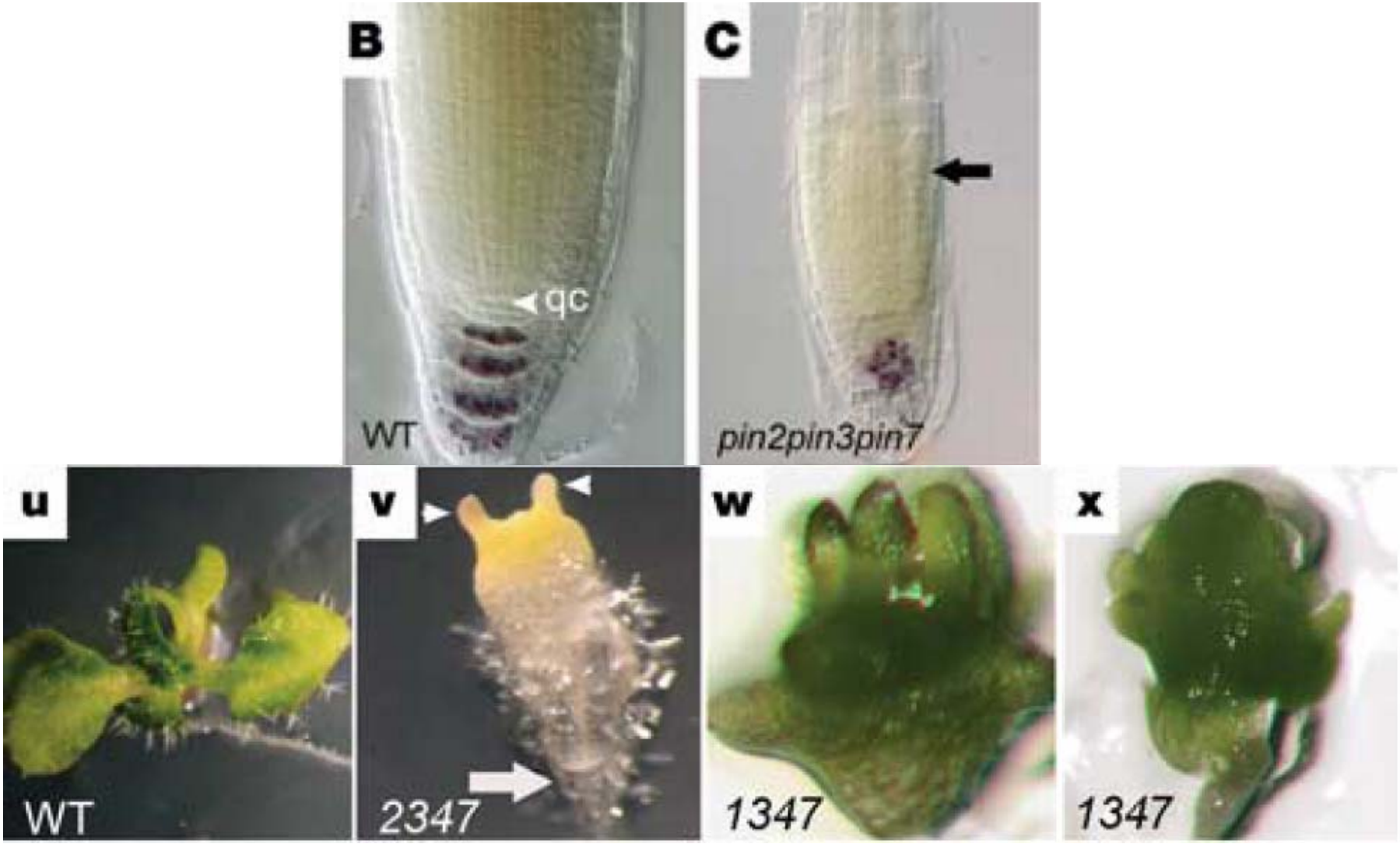
PIN1 PIN2



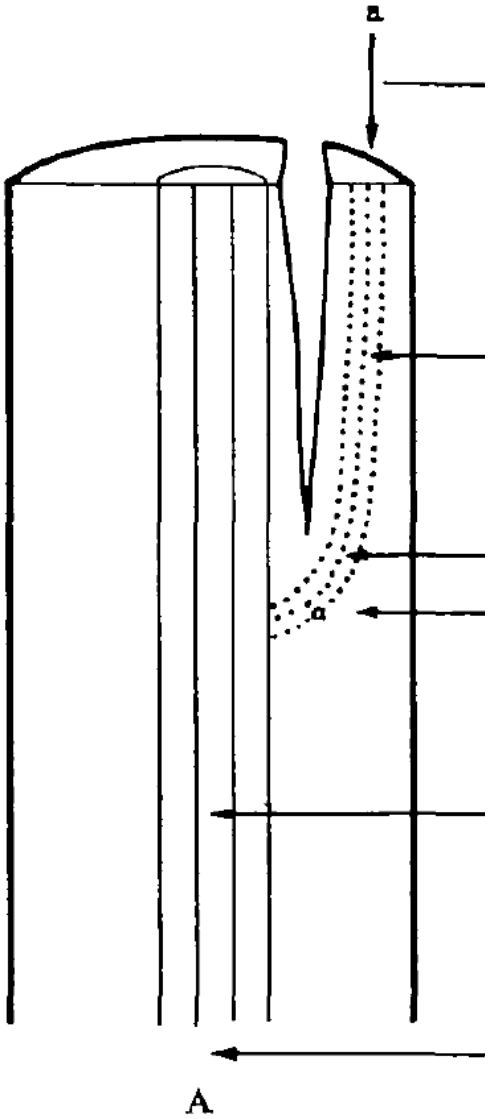
PIN1



Strong defects in triple and quadruple mutants



Blilou et al. (2005) Nature



Point of auxin application

Separated tissue

Induced xylem

Area of strand connection

Vascular cylinder

Contact to intact root

From Sachs T. 1968 Ann.Bot.

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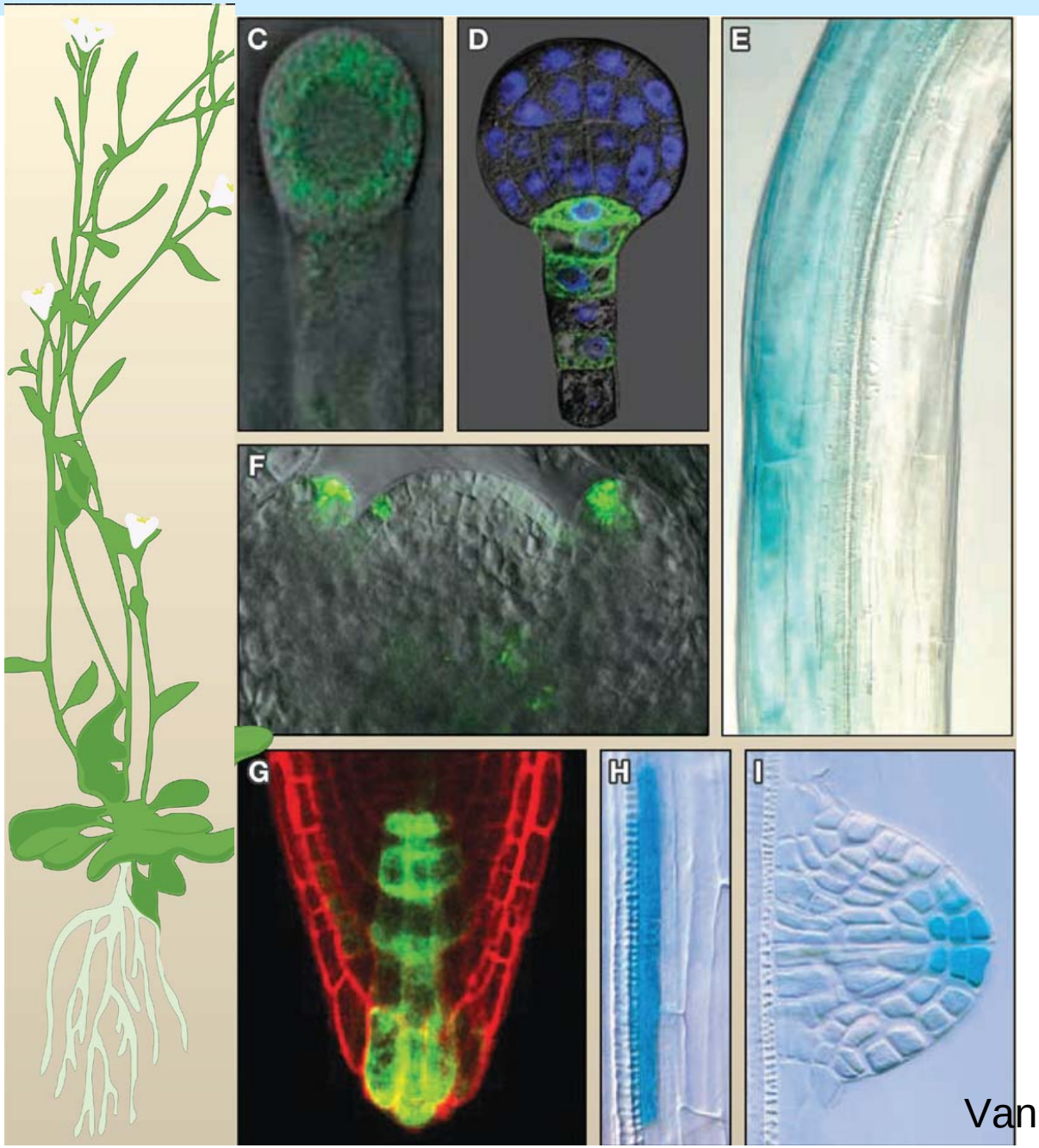
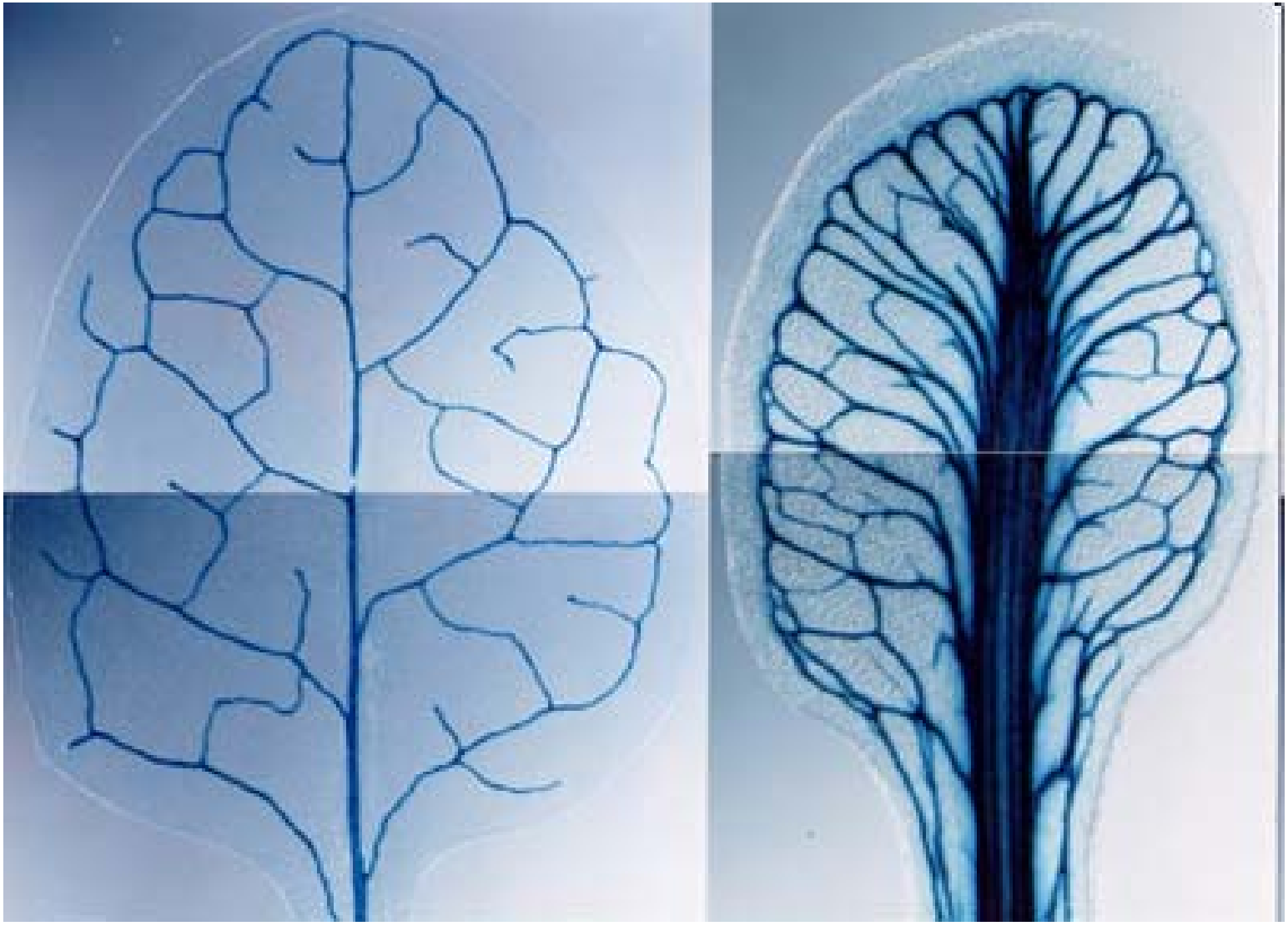


Vanneste et al 2009

Vein formation



DR5 signal in roots

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How does auxin regulate the plant development?

How does auxin regulate the vascular development, phylotaxis,...?

How does auxin regulate PIN localization?

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Models of auxin-mediated cell polarity

Flux-based

Cells of the provascular strand have a high auxin flux but a low auxin concentration

No auxin flux sensor has been found

Concetration-based

Rely on a feedback between PIN polarity and differences in mean auxin concentration between adjacent cells.

Rely on unknown and unspecified signal to communicate information about auxin concentration between adjucent cells

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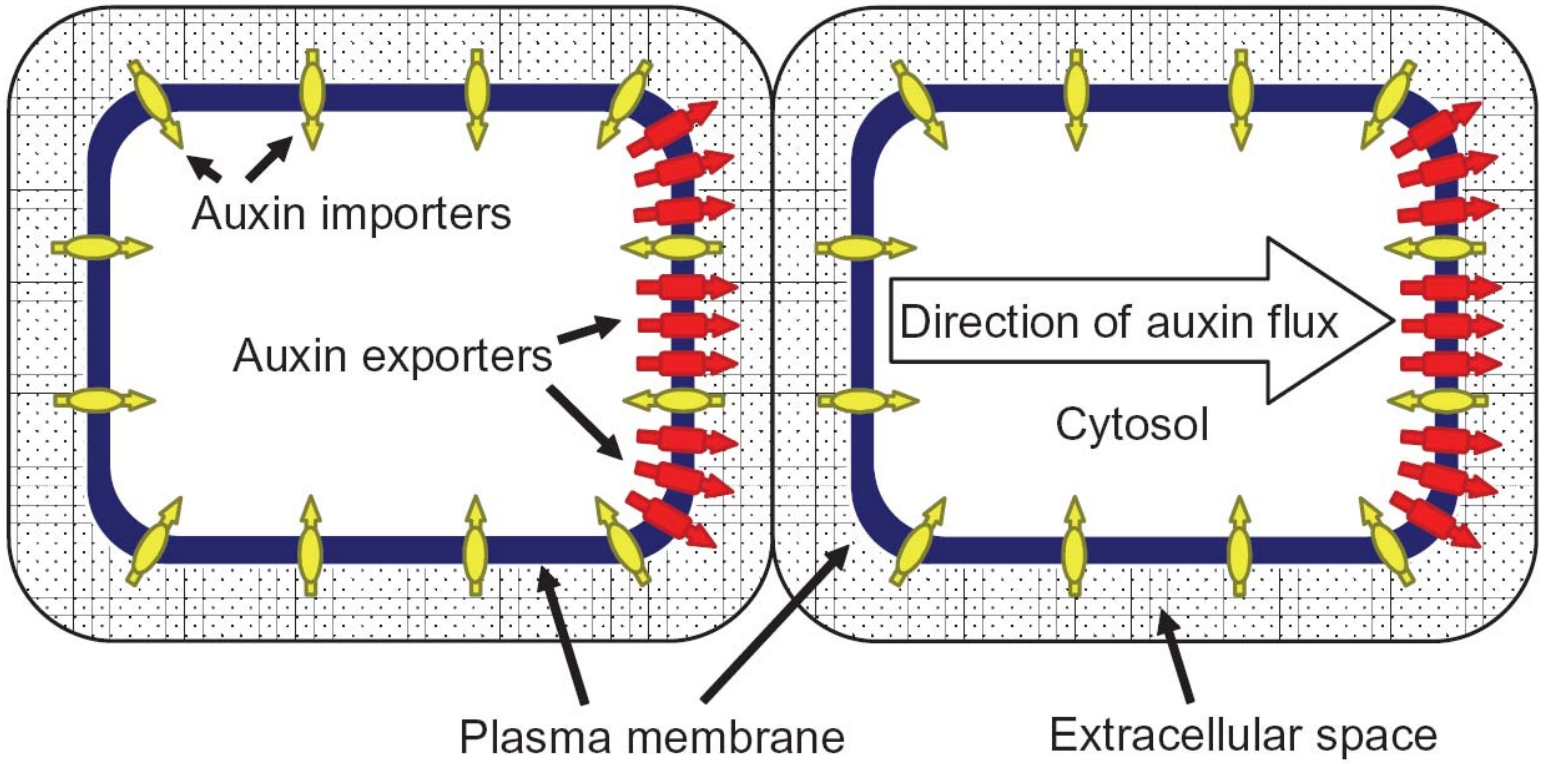

From Smith and Bayer (2009)

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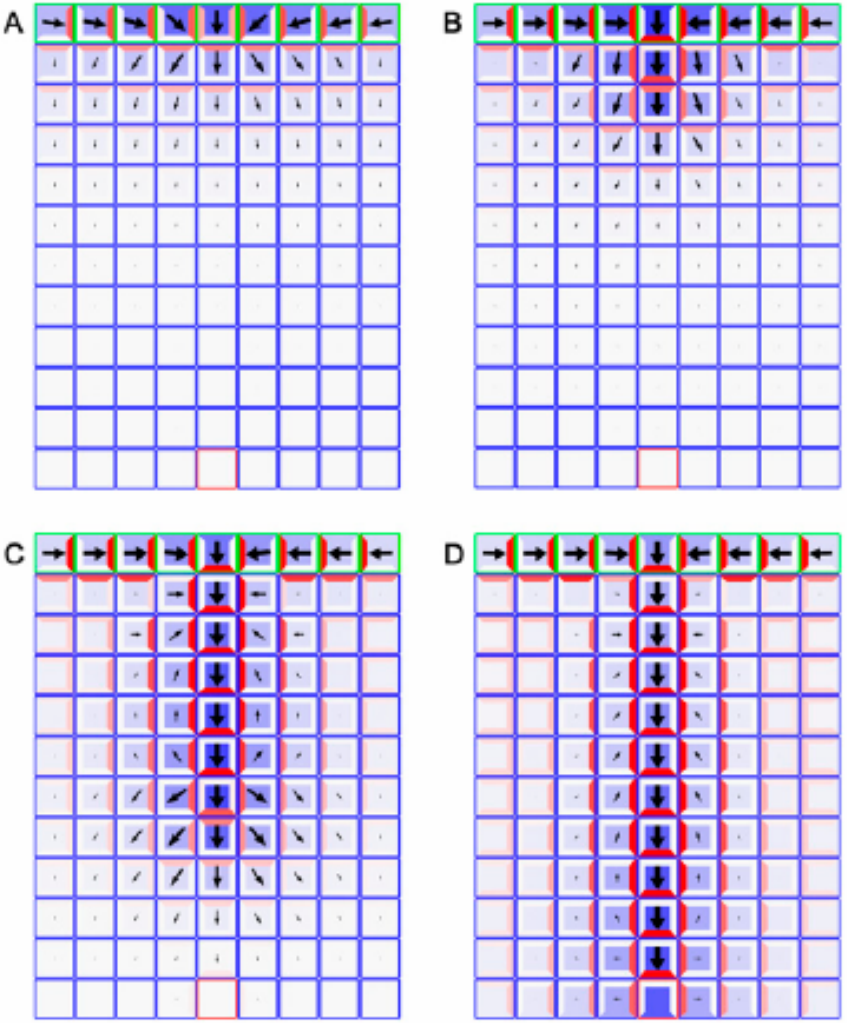
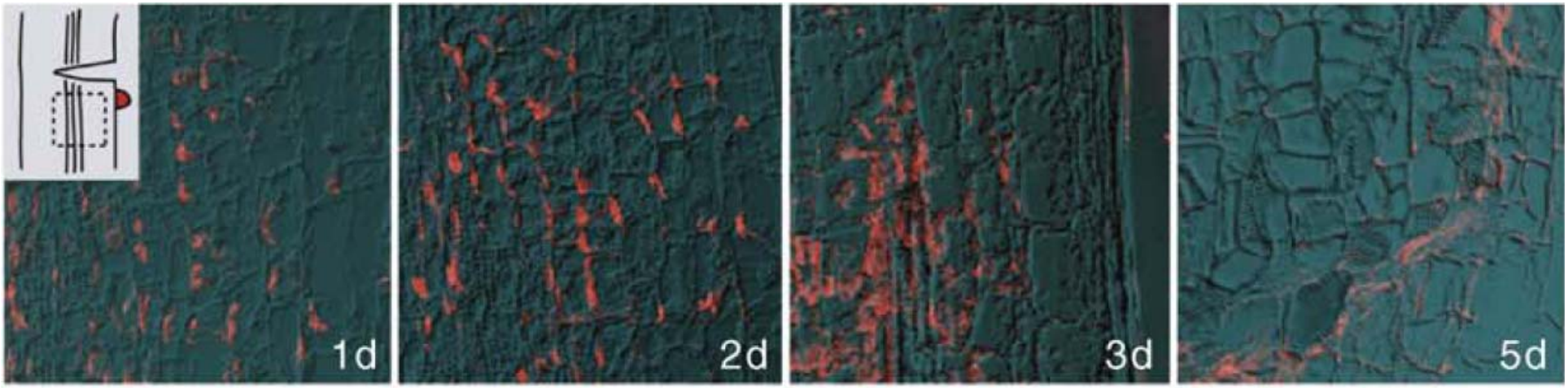
Concetration-based model



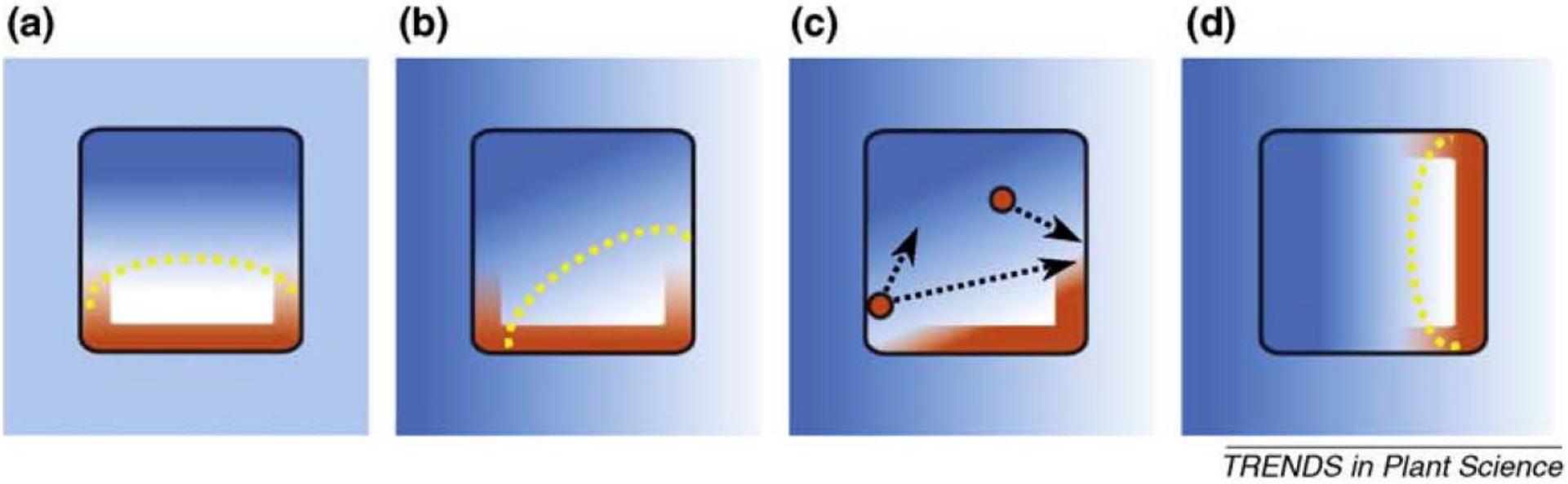
Bayer et al. (2009) Genes Dev

PIN1 polarity during vascular development



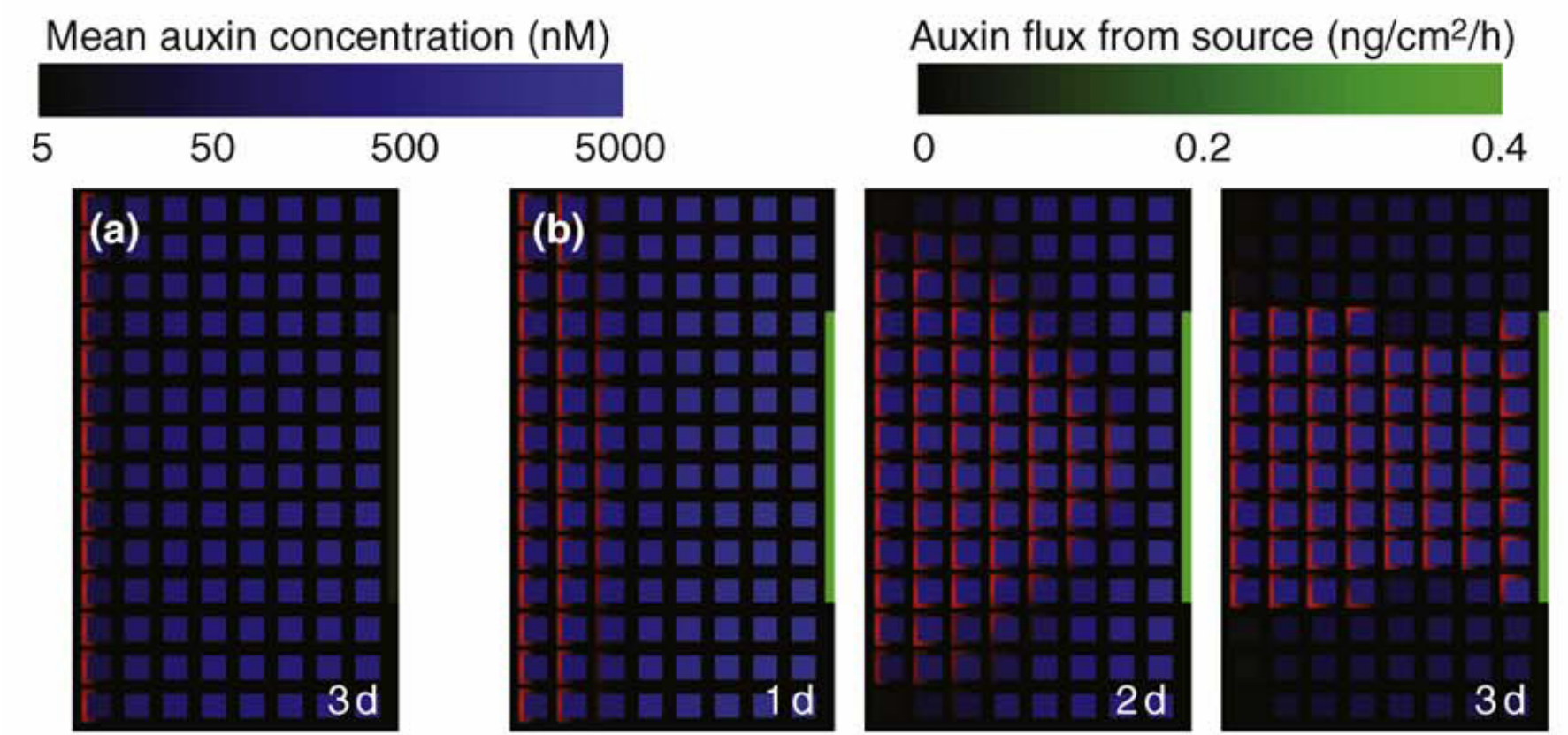
Sauer et al. (2006) Genes Dev.

Sketch of the proposed interaction between the cytoplasmic auxin gradient and PIN efflux carriers (red).



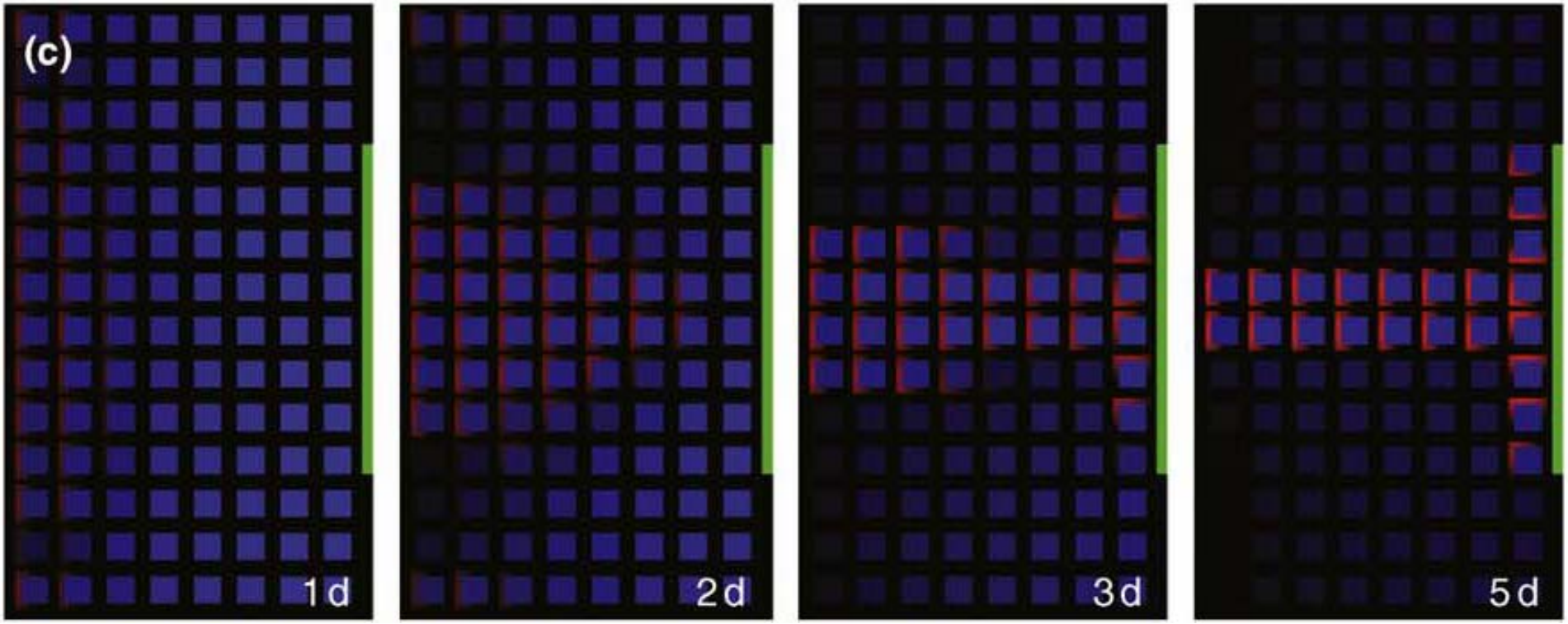
Feedback between auxin and PIN

Model of vascular development

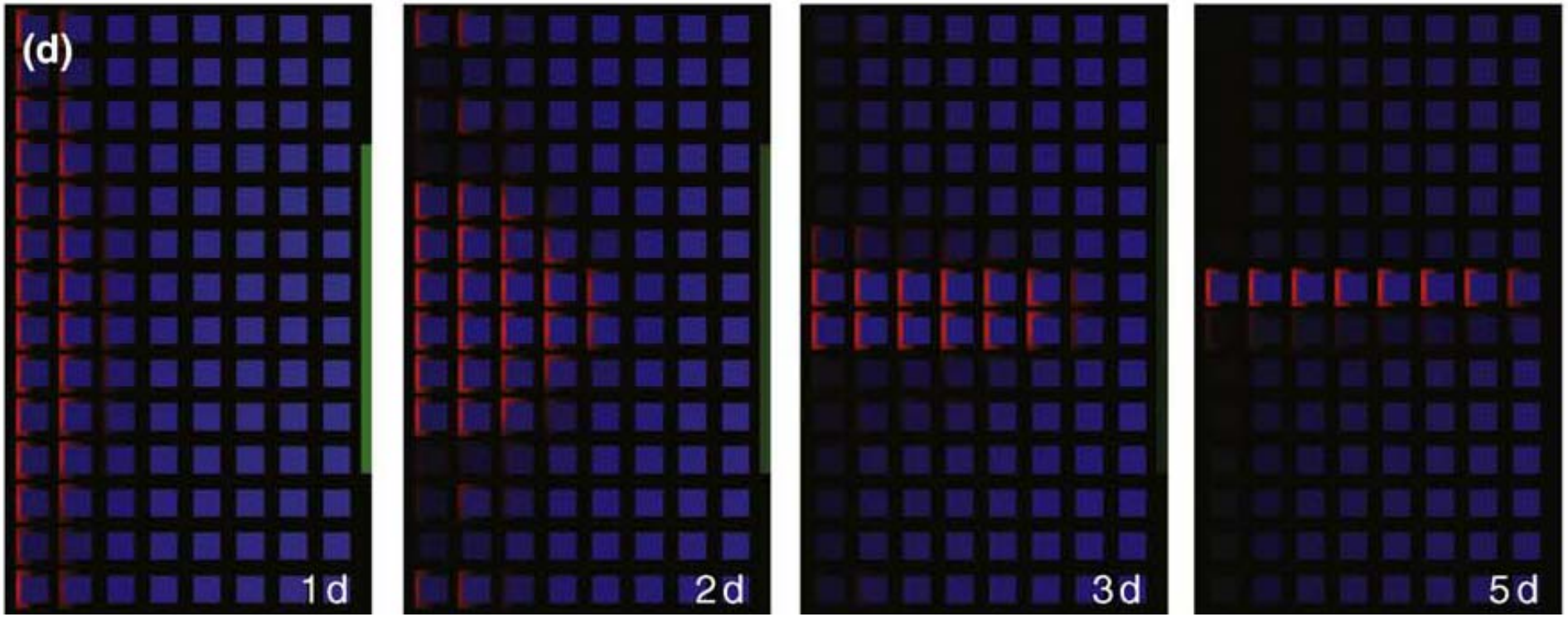


Kramer (2009) TIPS

If the number of auxin carriers per cell is allowed to gradually increased from day 1 to day 5, then the canal narrows to two cell files.



If the auxin source gradually decreases, then the canal also narrows



Kramer (2009) TIPS

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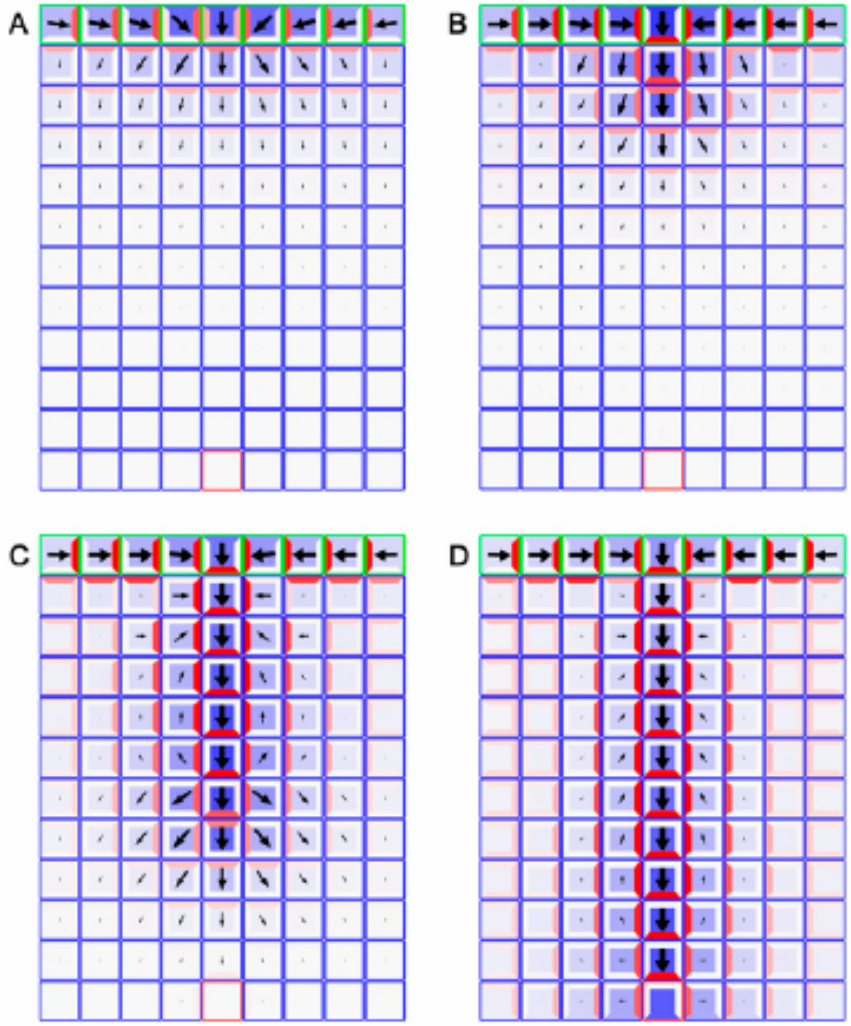
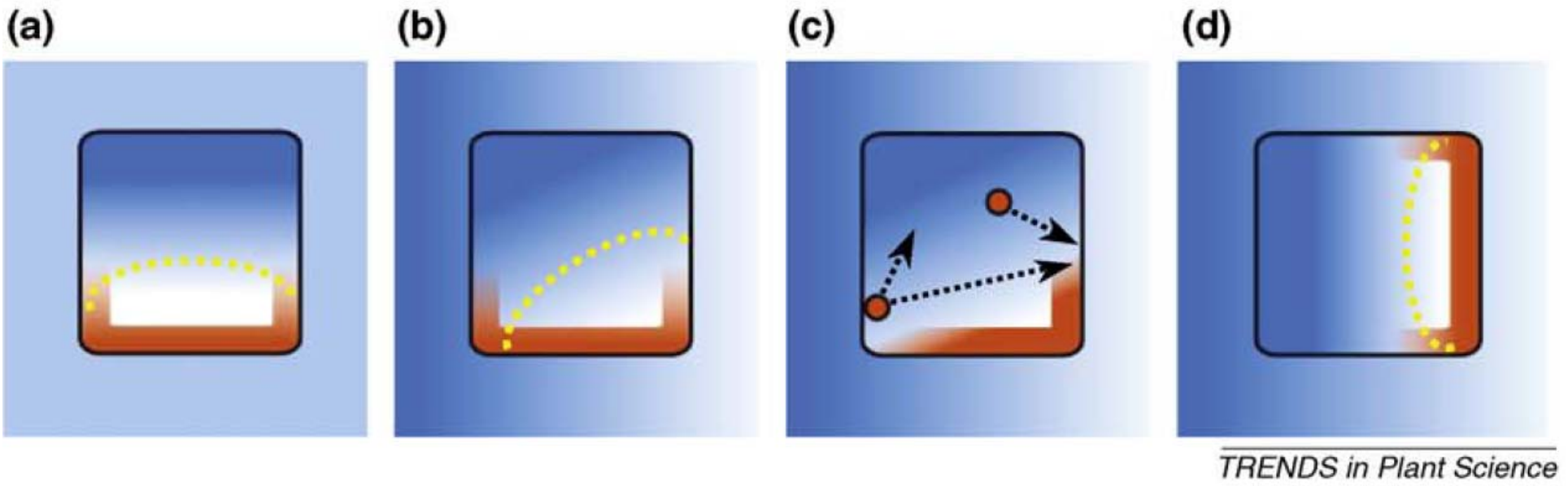


Bayer et al. (2009) Genes Dev

Modified flux-based model



Vascular development is driven by a feedback between cytoplasmic auxin gradient and PIN polarity

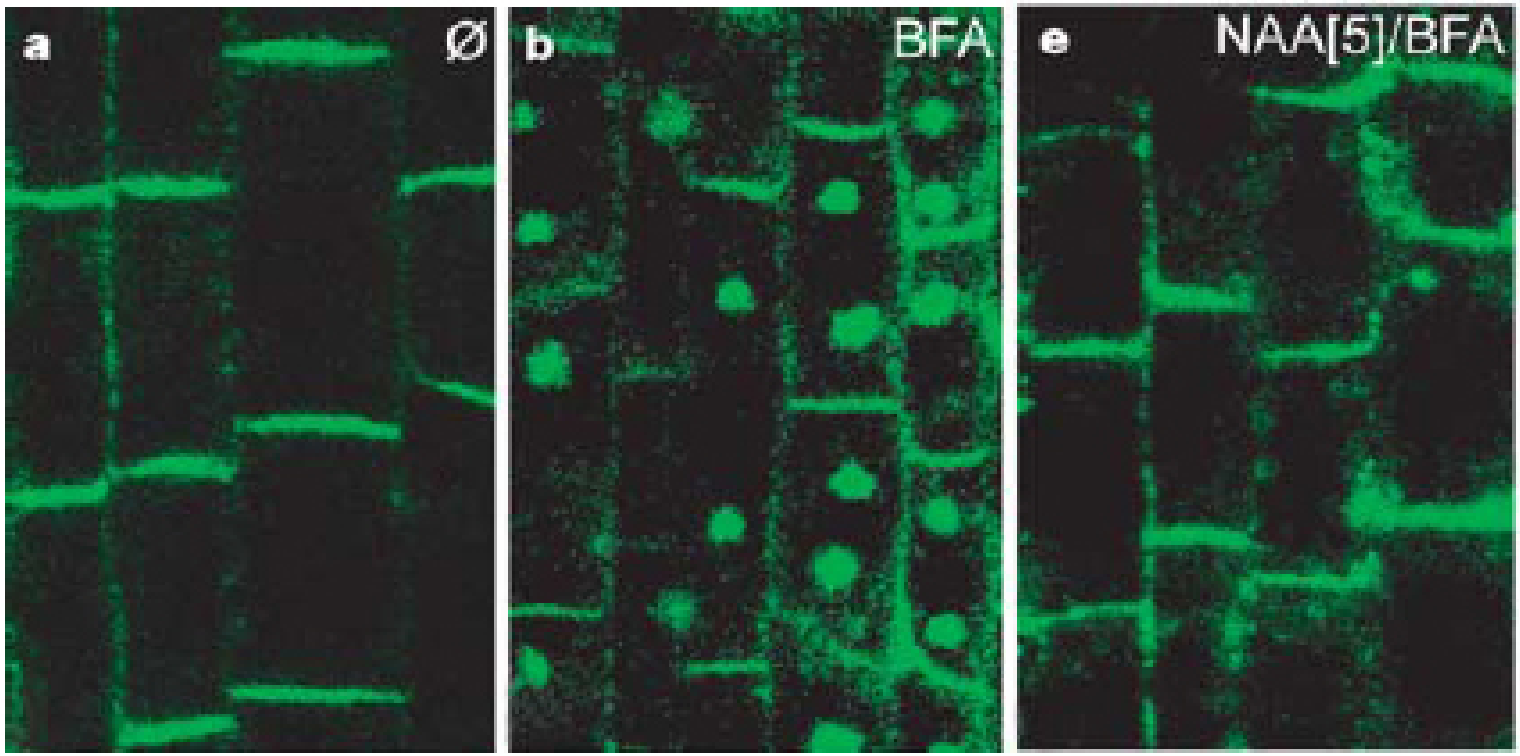
Vol 435|30 June 2005|doi:10.1038/nature03633

nature

LETTERS

Auxin inhibits endocytosis and promotes its own efflux from cells

Tomasz Paciorek[1], Eva Zažímalová[2], Nadia Ruthardt[3], Jan Petrášek[2], York-Dieter Stierhof[1], Jürgen Kleine-Vehn[1], David A. Morris[2,4], Neil Emans[3], Gerd Jürgens[1], Niko Geldner[1] & Jiří Friml[1]



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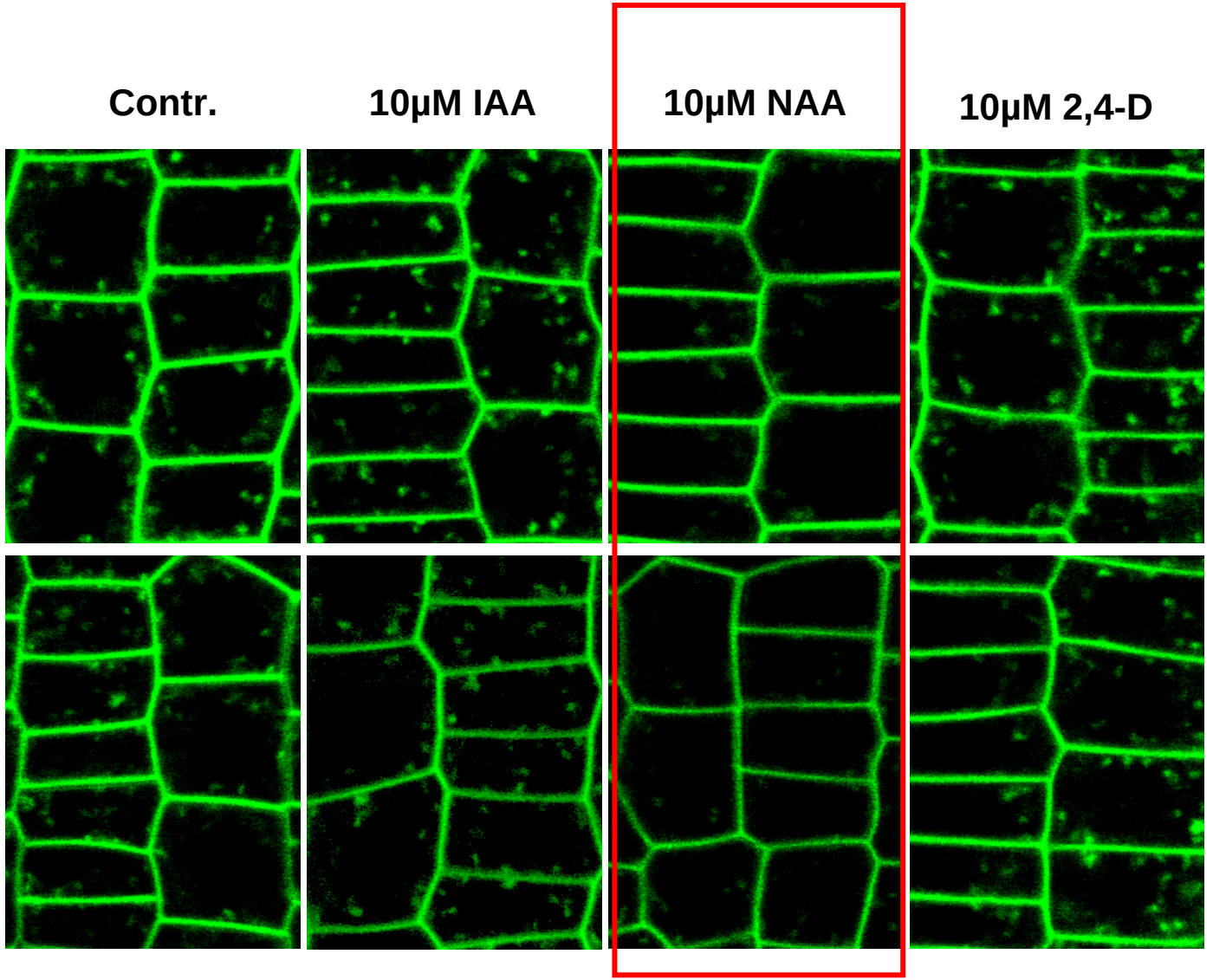
Methods to measure endocytosis

1. Using exocytosis inhibitor (BFA)
2. Using endocytosis marker (FM4-64)

Only 1-NAA inhibits endocytosis

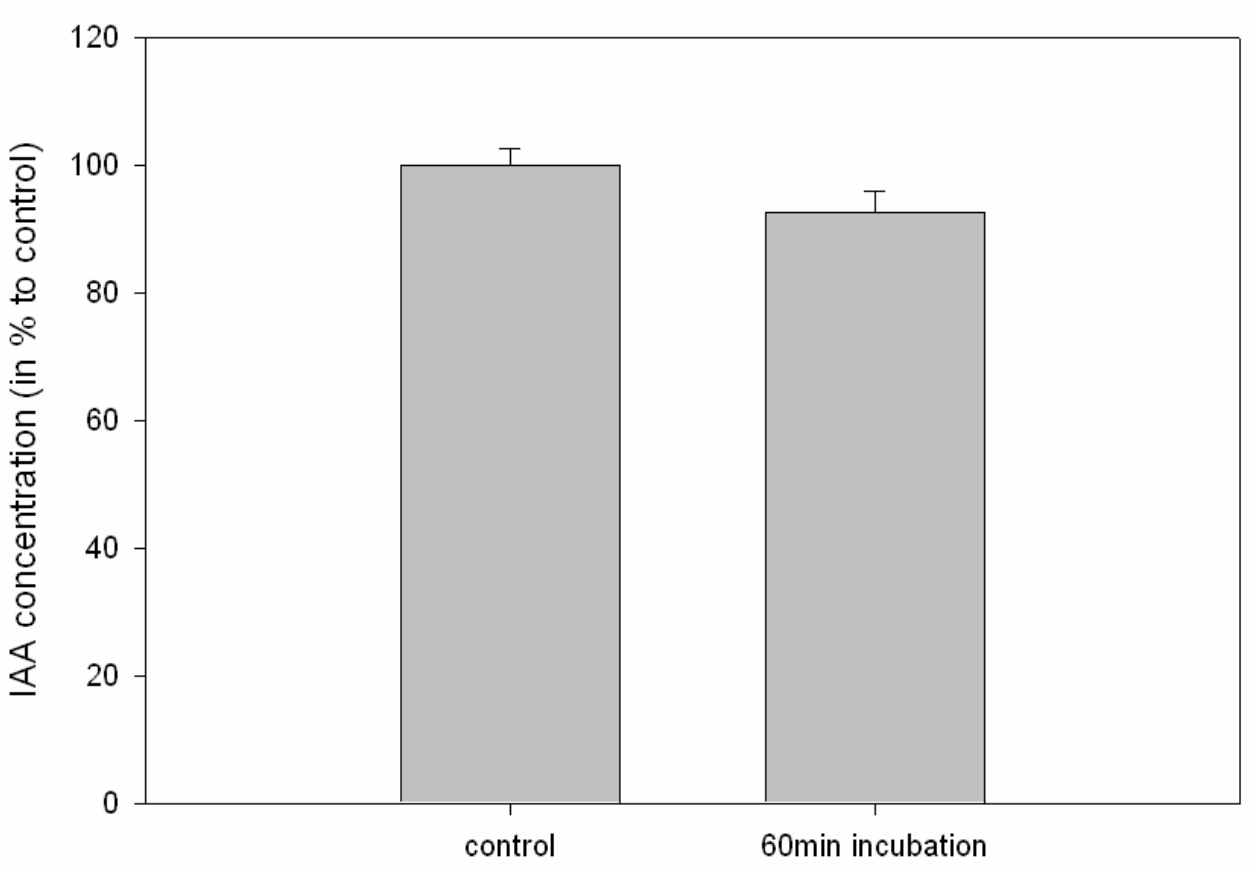
FM4-64



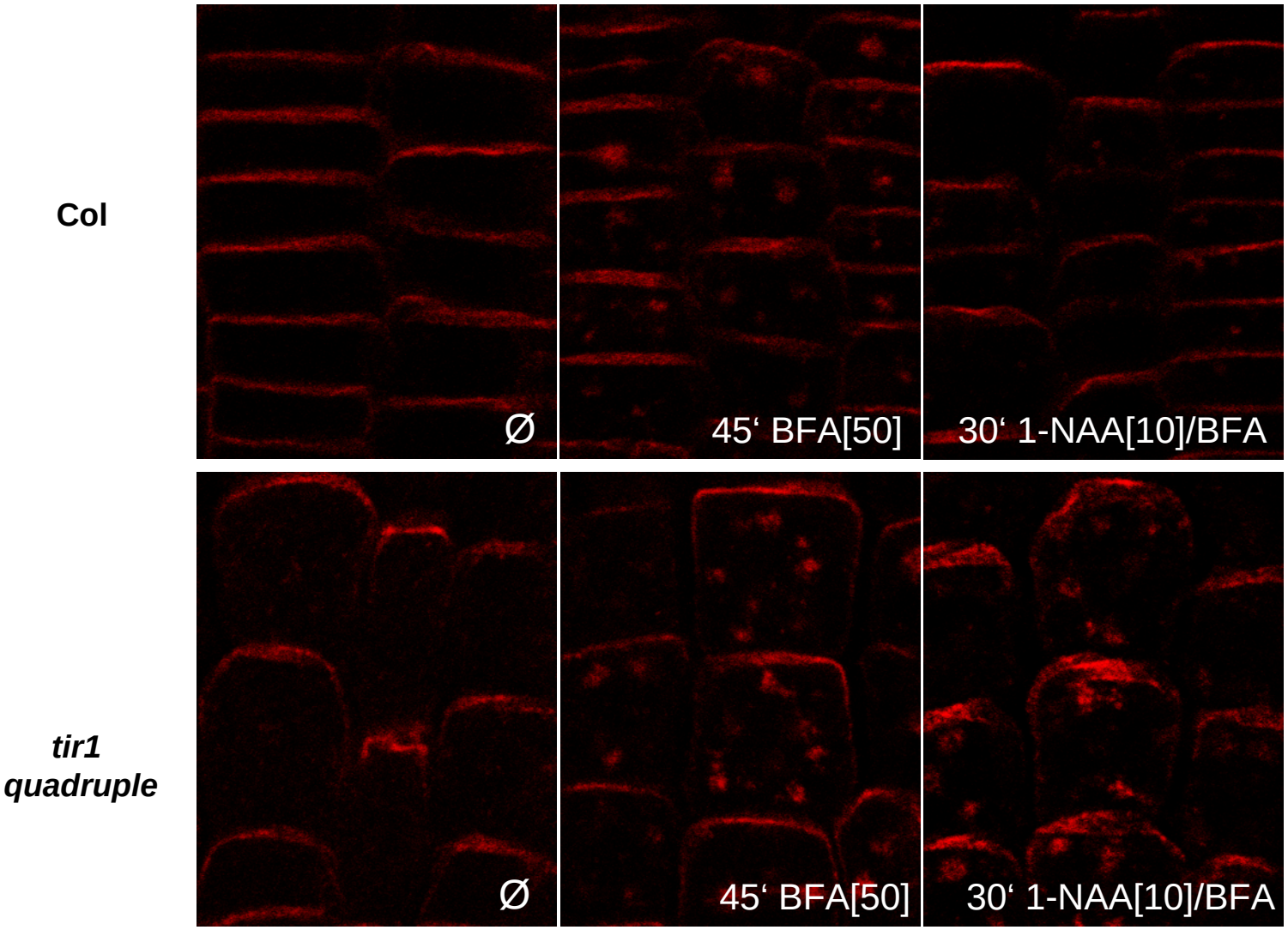
Exp291...

IAA is not significantly degraded during pre-incubation period

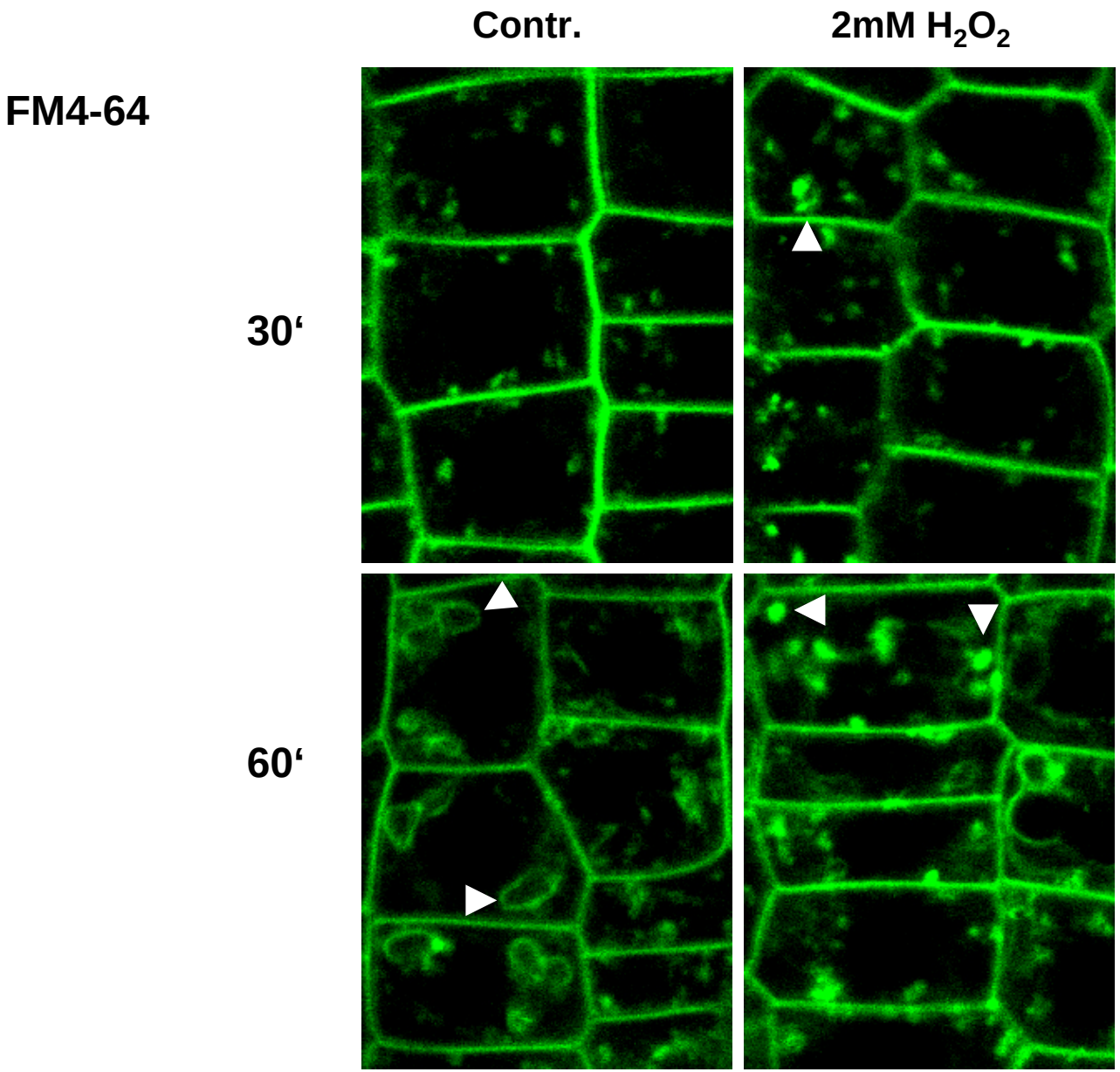
Concentration of IAA in the incubation solution (by HPLC)



1-NAA does not inhibit PIN2-internalization in *tir1 quadruple* mutant



Effect of Reactive Oxygen Species (ROS) on Endocytosis



Auxin reduces ROS level in the roots

Histochemical analysis (O^{2-})

NBT

Effect of Auxin on O_2^--concentration

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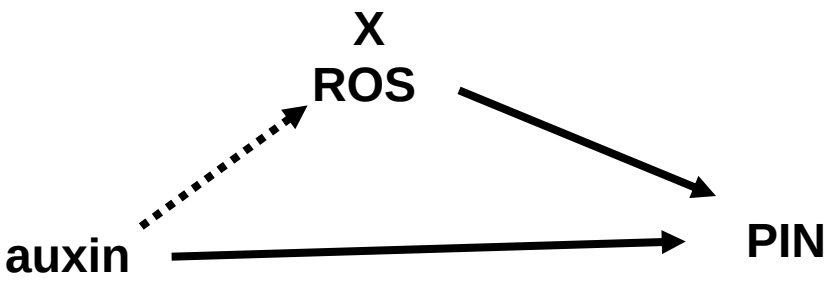
Conclusions and possible applications

Natural auxin, IAA, does not reduce endocytosis.

ABP1 is not a sensor of auxin in regulation of endocytosis

Auxin regulates ROS, which themselves can regulate endocytosis



Acknowledgments

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Martina Paponov (chemical genetics)

Perrot-Rechenmann C. (abp1) CNRS, Gif sur Yvette

Klaus Palme