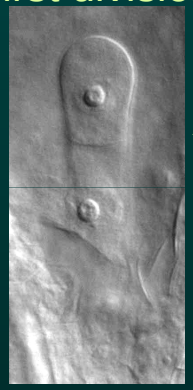
Hormonal Cross-Talk in Plant Organogenesis

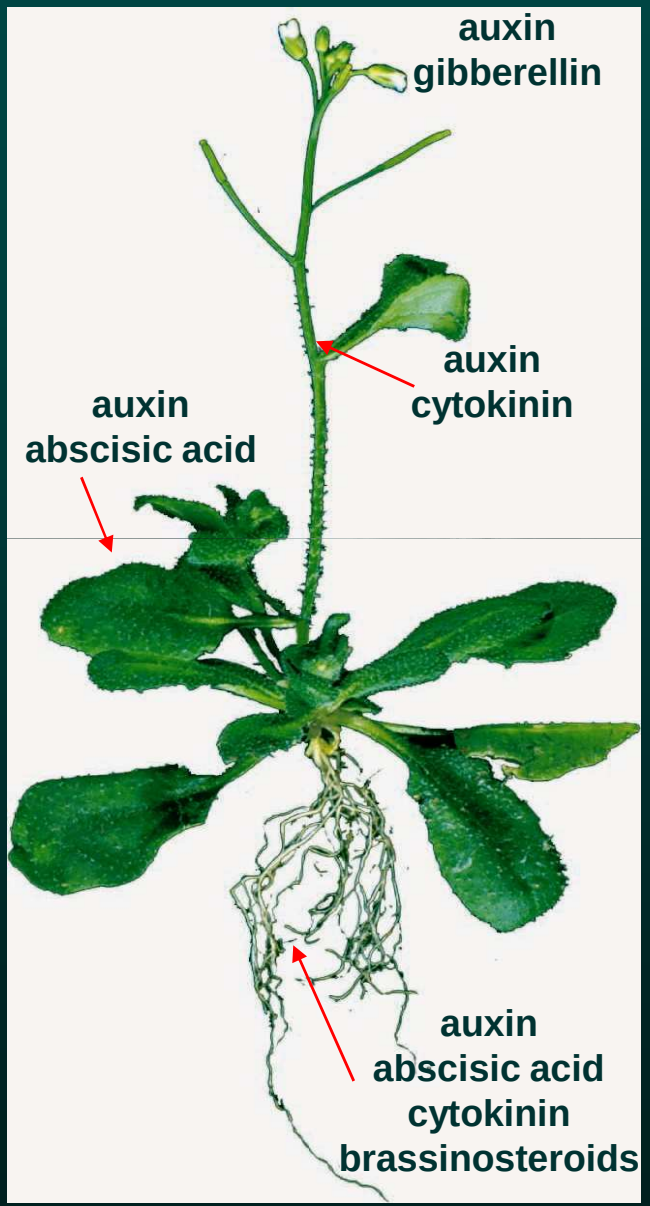
ZYGOTE
first division



EMBRYO

SEEDLING

PLANT



HORMONAL CROSS-TALK

Metabolism

Biosynthesis

Degradation

Conjugation

Distribution

AUXIN: polar transport
Other hormones:
Passive distribution

Perception

1. Receptors:

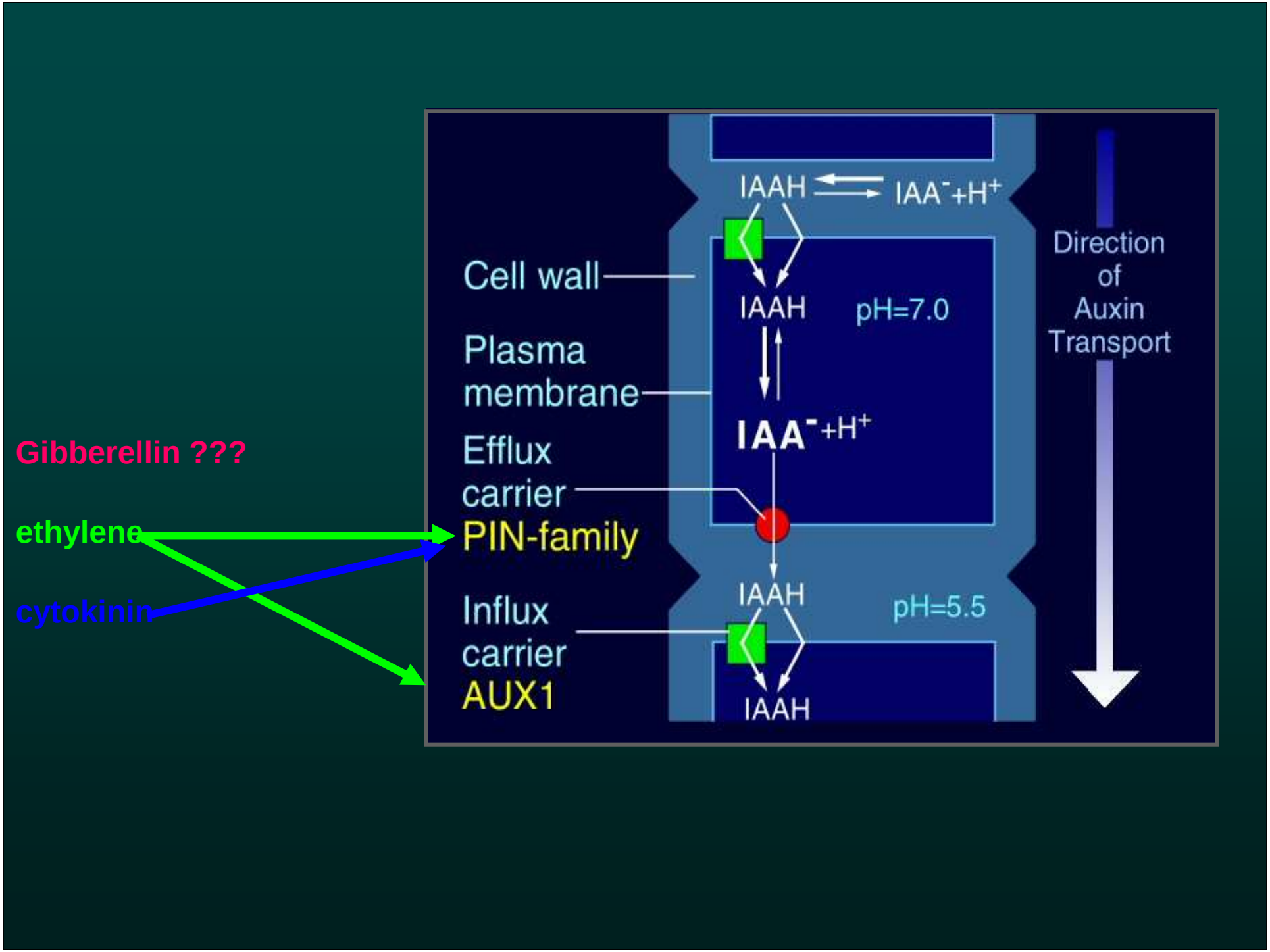
Histidine kinase (cytokinin)	Plasmatic membrane
(ethylene)	Endoplasmatic Reticulum
Kinase (brassinosteroids)	Plasmatic membrane
F-box protein (auxin)	Nucleus
RNA binding protein (abscisic acid)	Nucleus
Lipase(gibberellin)	Nucleus

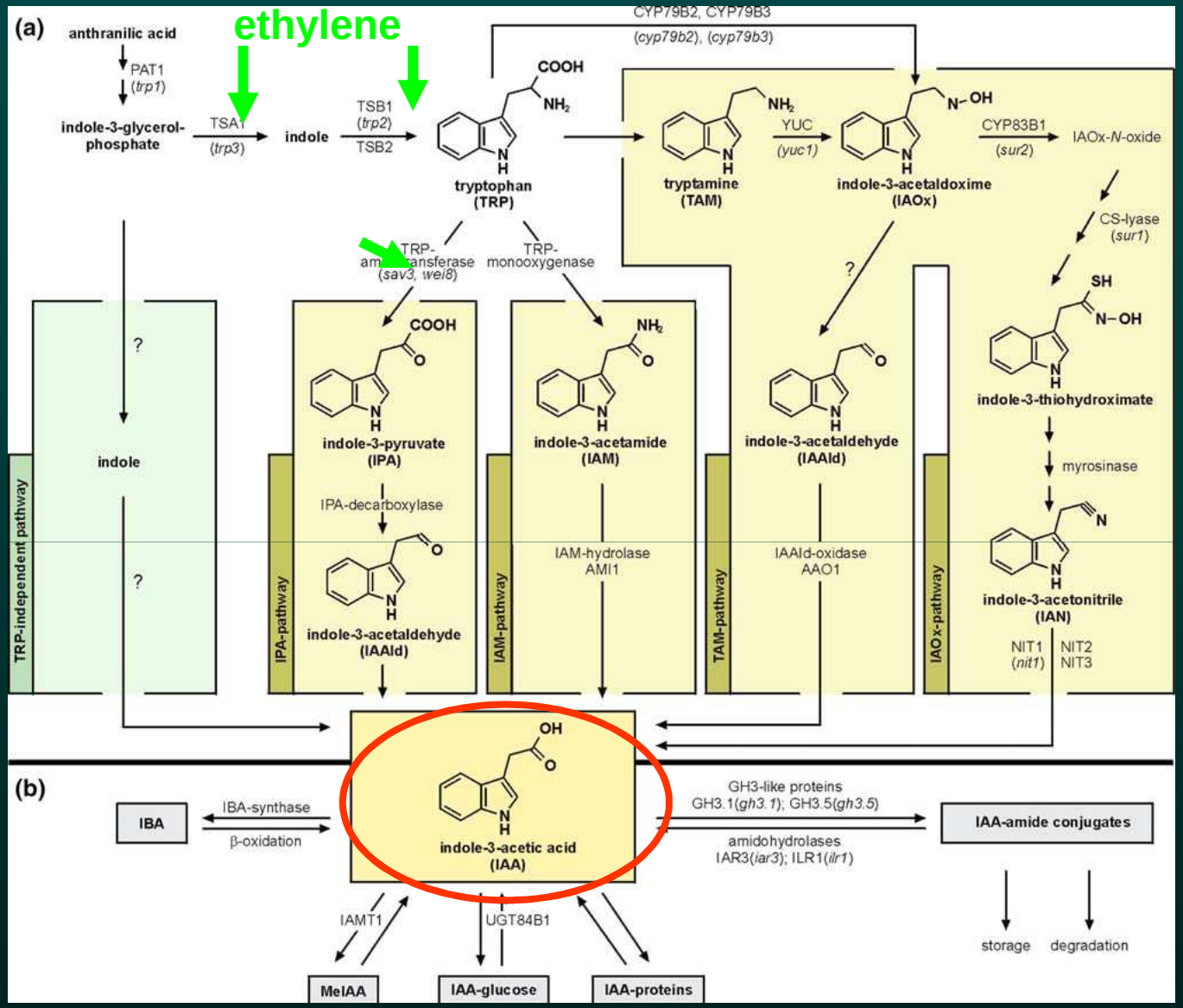
2. Signal Transduction

Phosphotransfer protein
Response regulator — positive or
Metalotransfer protein — negative regulators
Map Kinase
Short live protein (GRASS family, Aux/IAA)
Polyadenylation signal
F-box protein

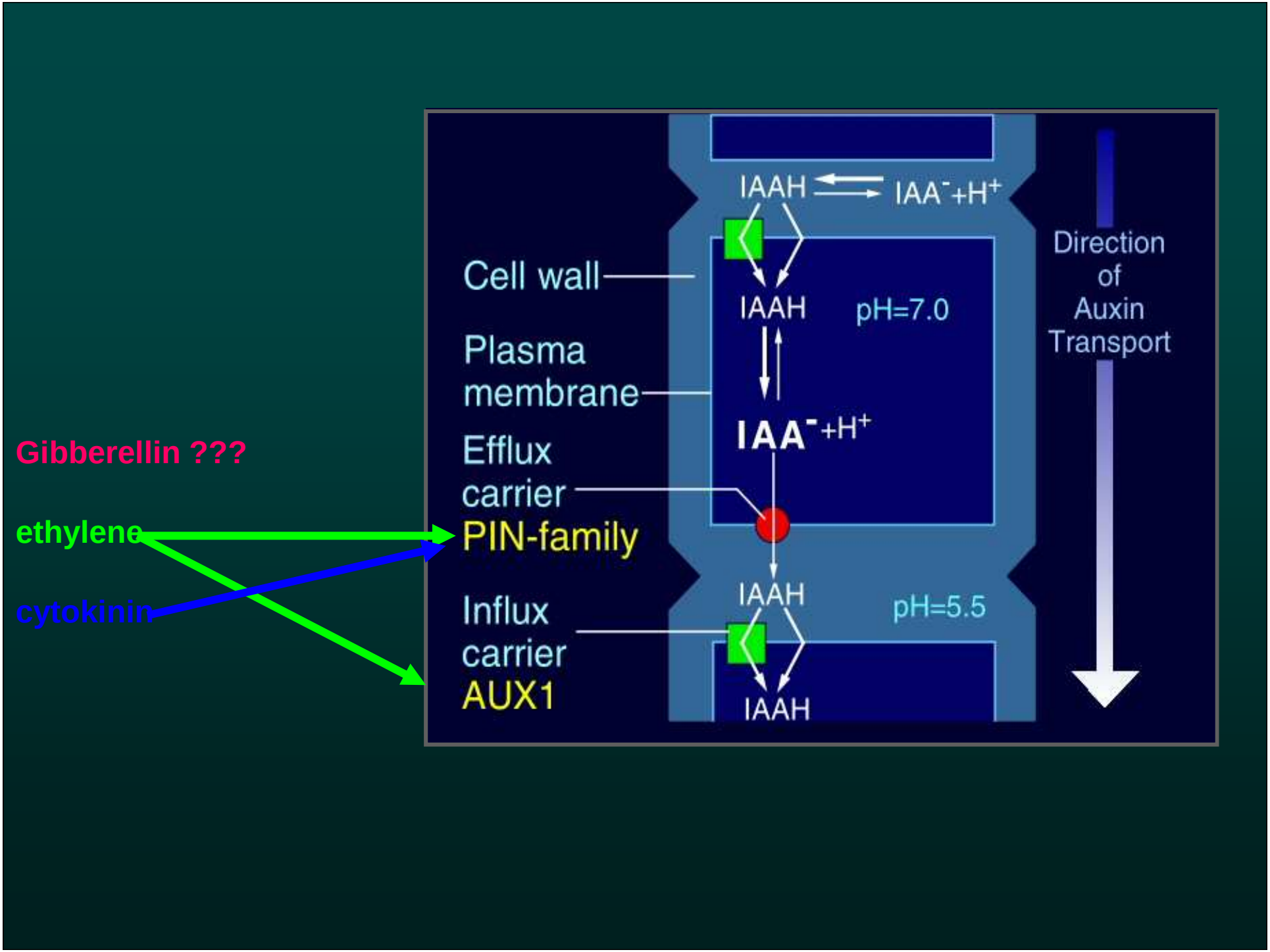
3. Transcription factors

4. Common downstream targets

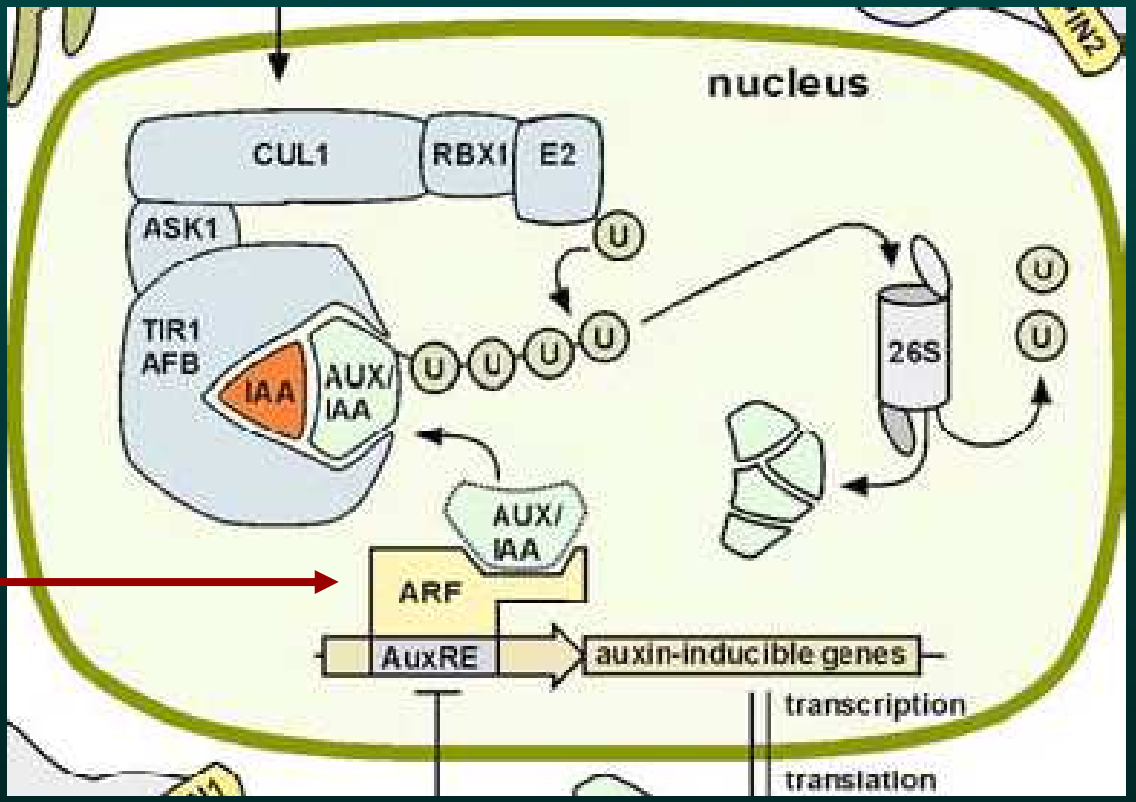

Gibberellin ???
ethylene
cytokinin
Cell wall
Plasma membrane
Efflux carrier PIN-family
Influx carrier AUX1
IAAH
IAA⁻+H⁺
IAAH
pH=7.0
IAA⁻+H⁺
IAAH
pH=5.5
IAAH
Direction of Auxin Transport



Cytokinin – slow negative effect


Gibberellin ???
ethylene
cytokinin
Cell wall
Plasma membrane
Efflux carrier PIN-family
Influx carrier AUX1
IAAH
IAA⁻+H⁺
IAAH
pH=7.0
IAA⁻+H⁺
IAAH
pH=5.5
IAAH
Direction of Auxin Transport

Brassinosteroids (BIN2)

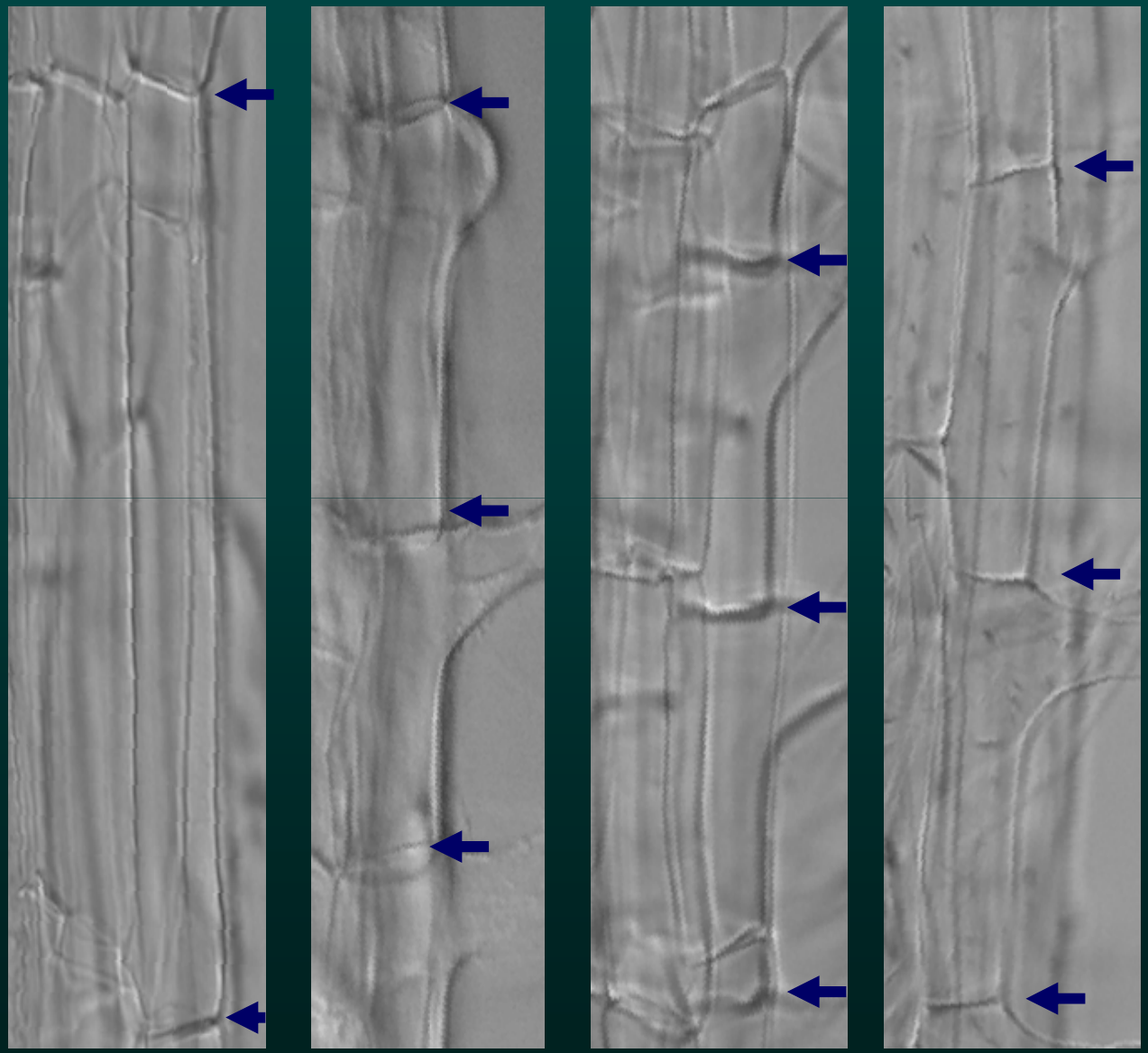


When three do the same...

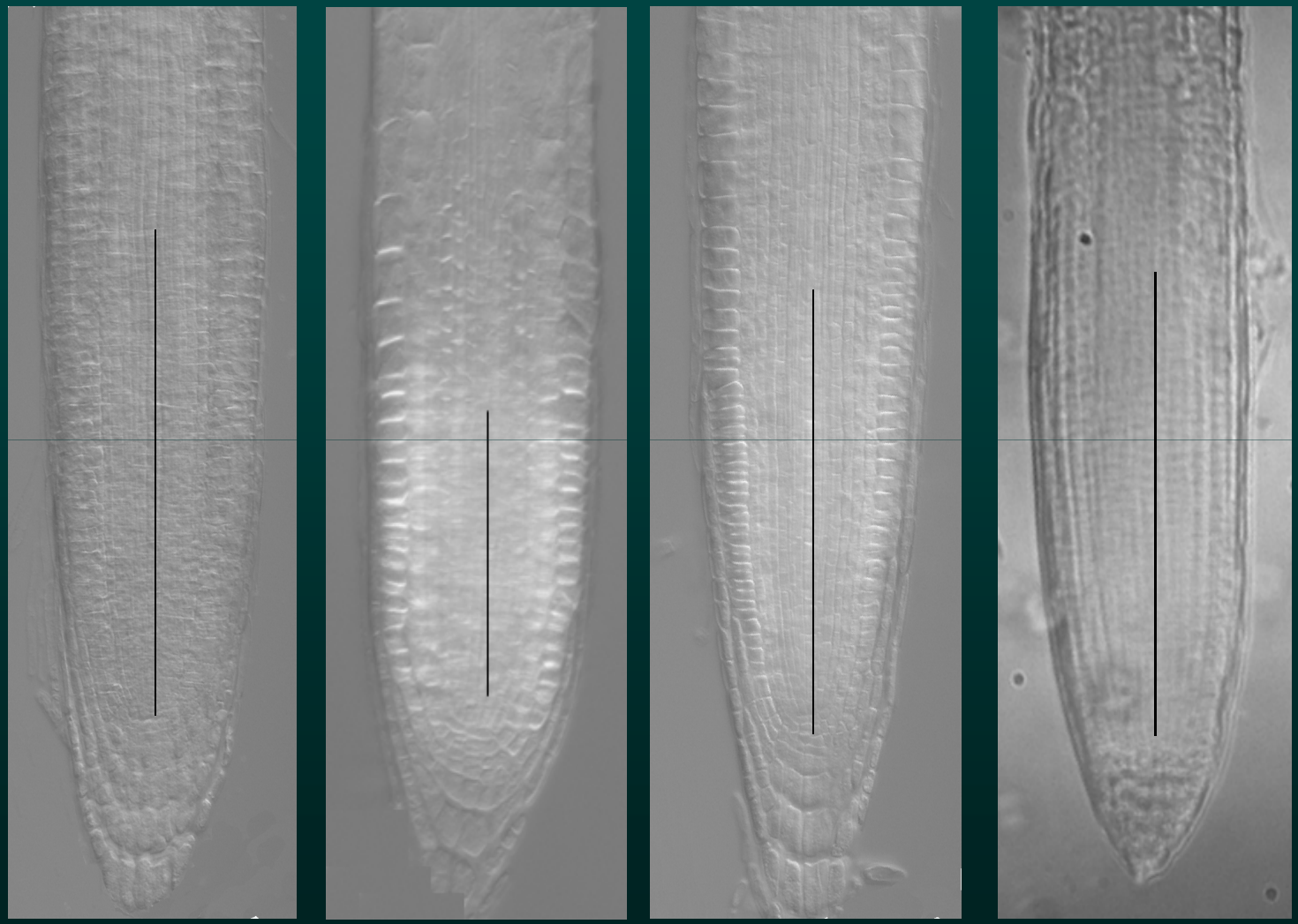
control cytokinin ethylene auxin

it does not have to be the same...

1. Cell elongation

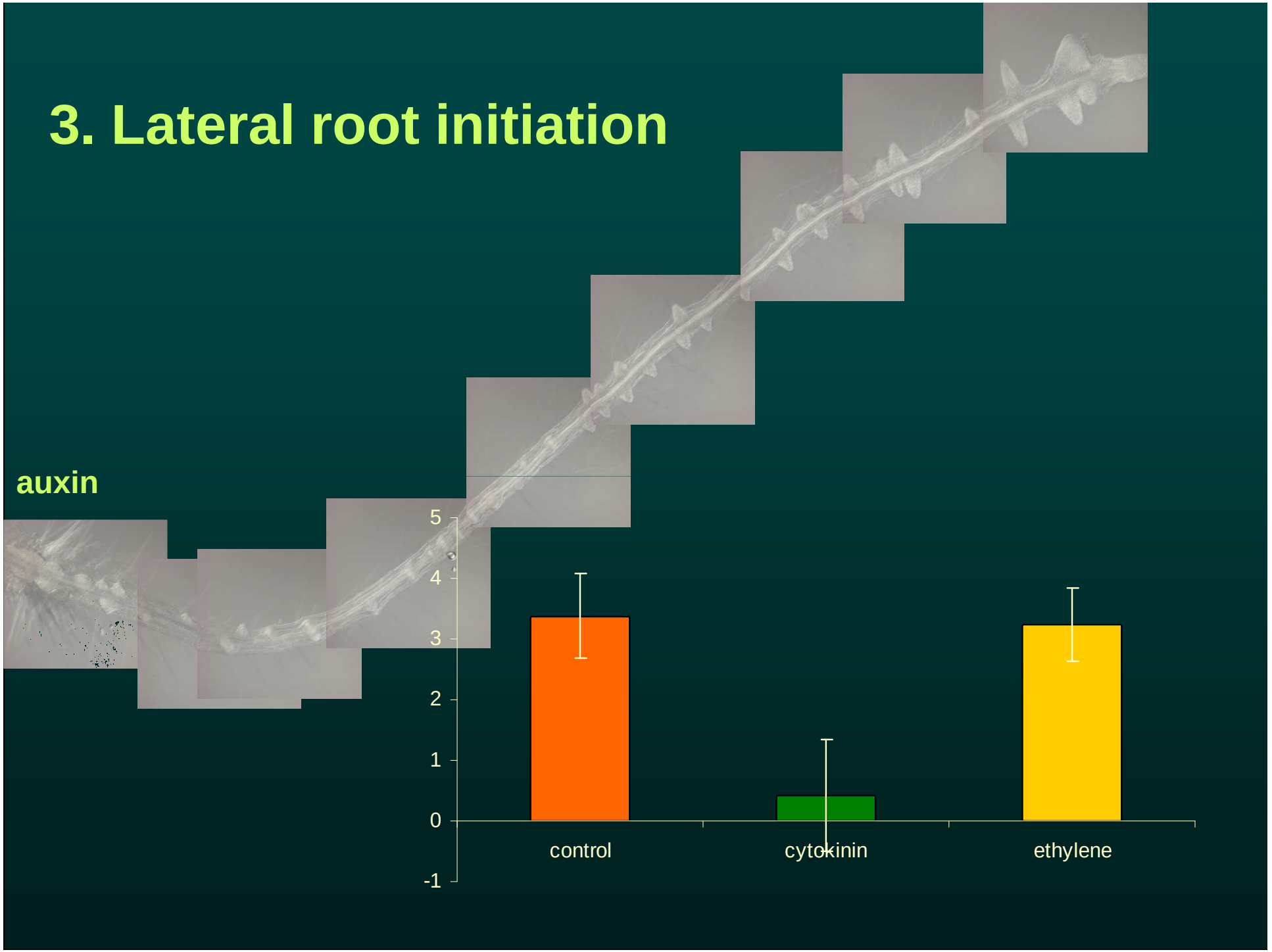


2. Root meristem growth

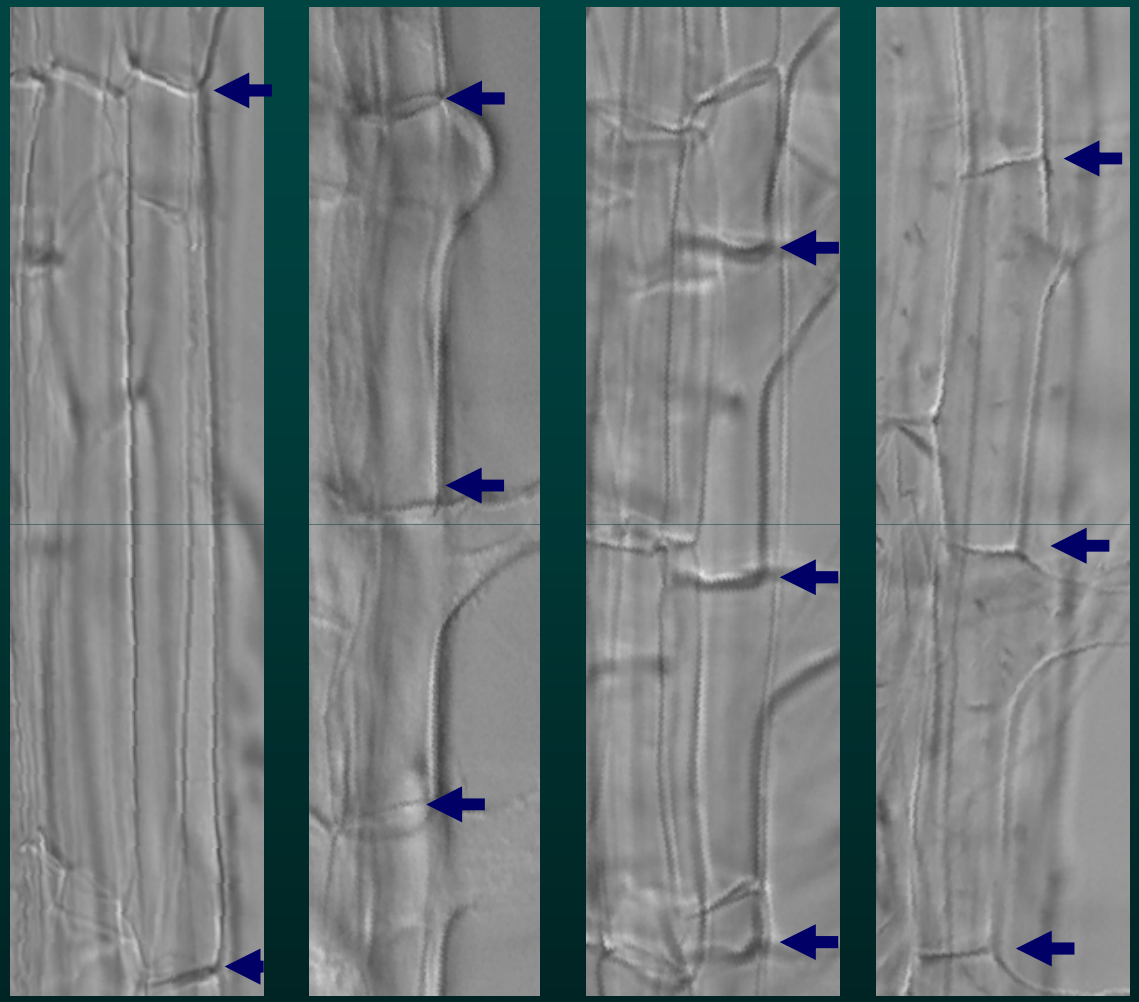


control cytokinin ethylene auxin

3. Lateral root initiation

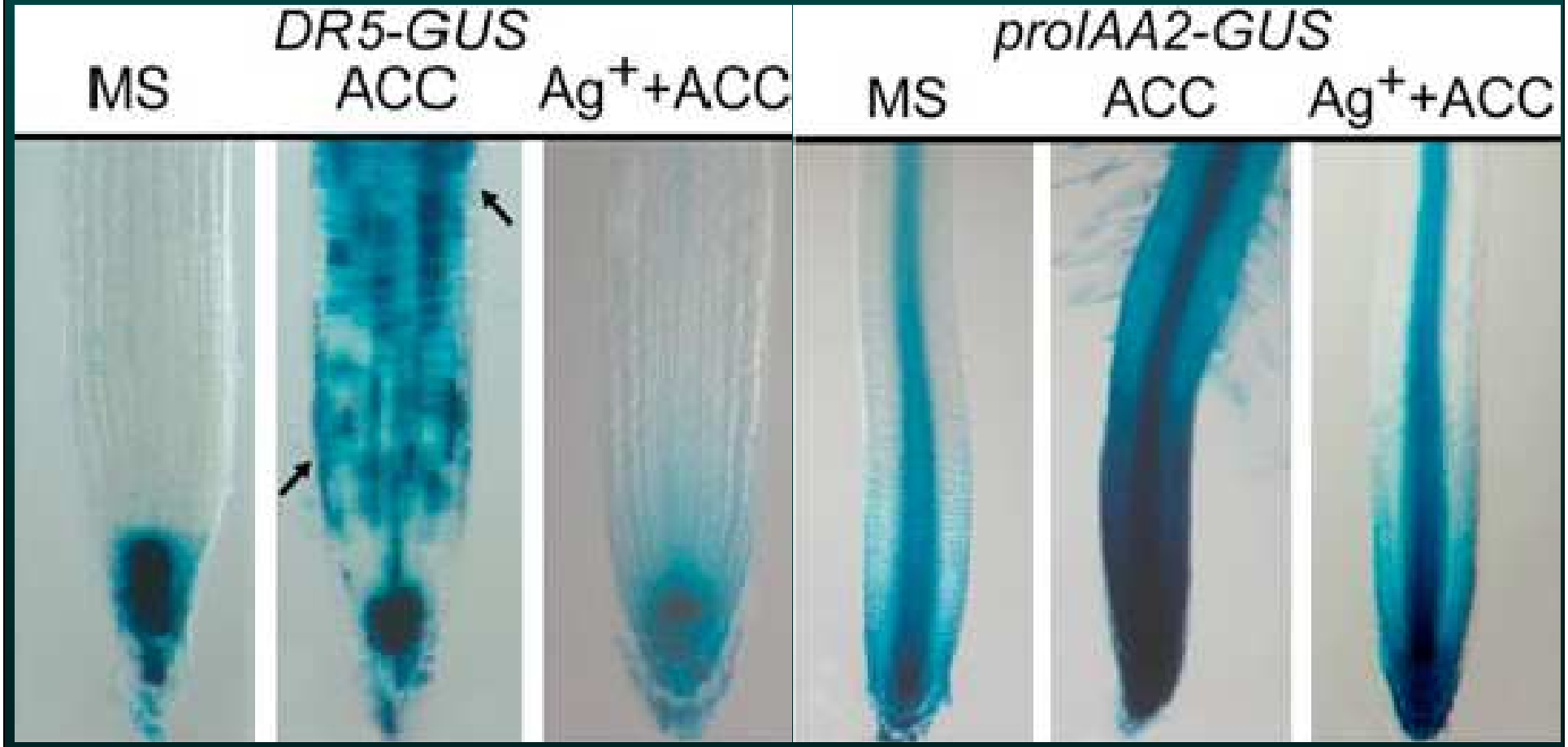


1. Hormonal interactions - regulating cell elongation

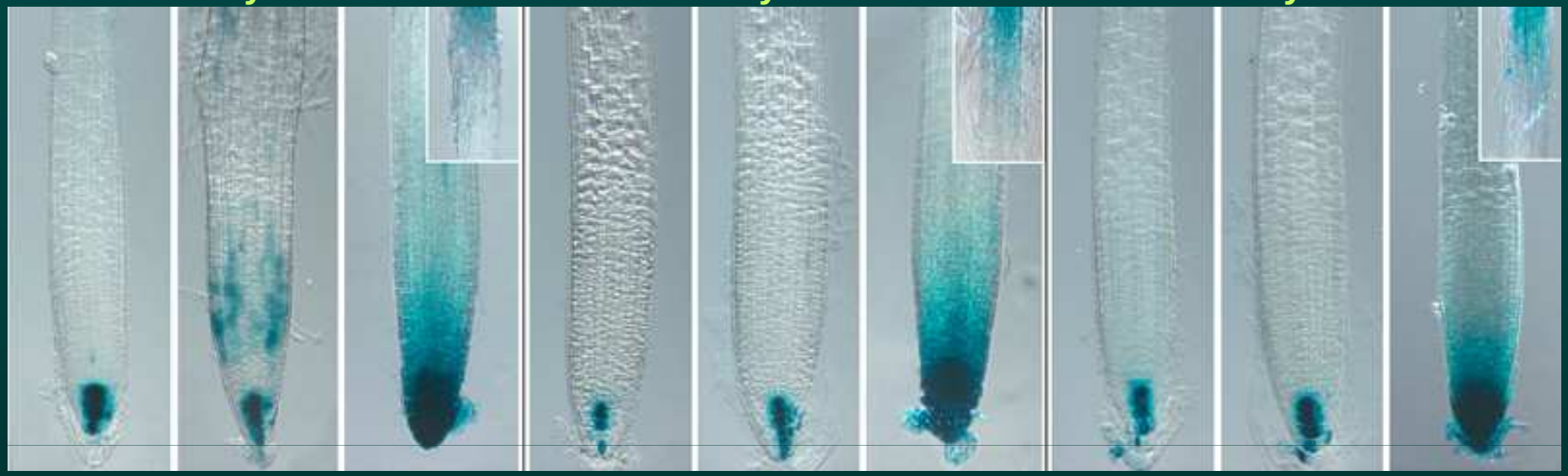


control cytokinin ethylene auxin

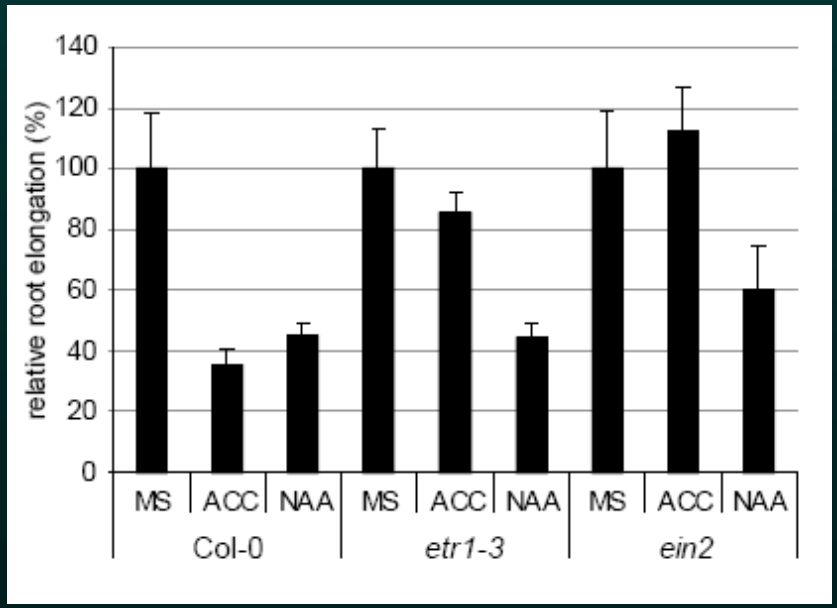
DR5 auxin reporter is up-regulated in response to ethylene



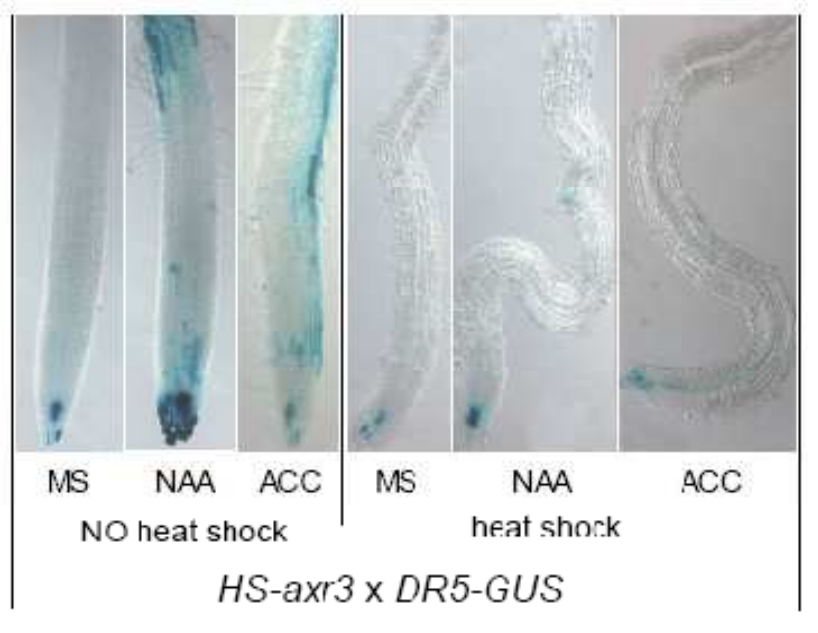
Ethylene signalling mutant are auxin sensitive

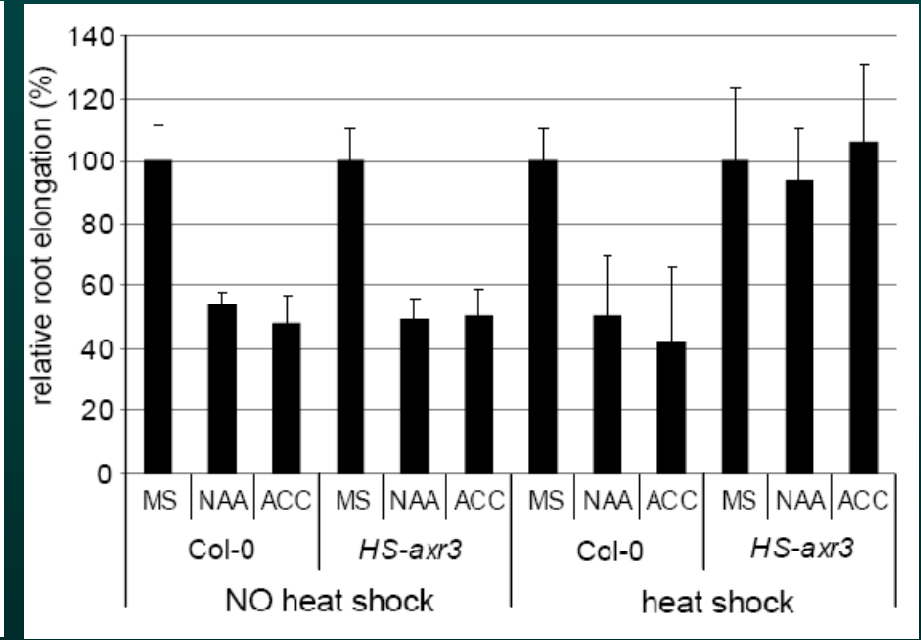


control *etr1-3* *ein2*

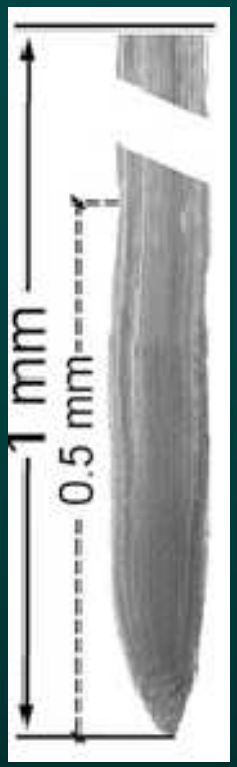


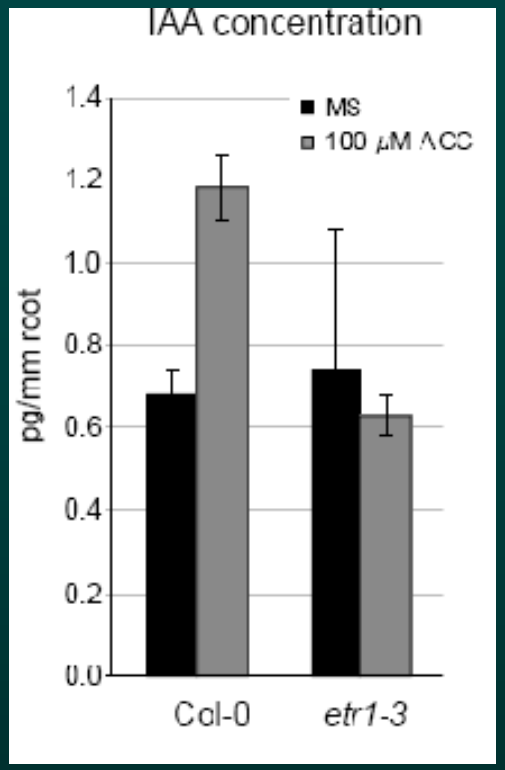
Auxin signalling is required for ethylene effect

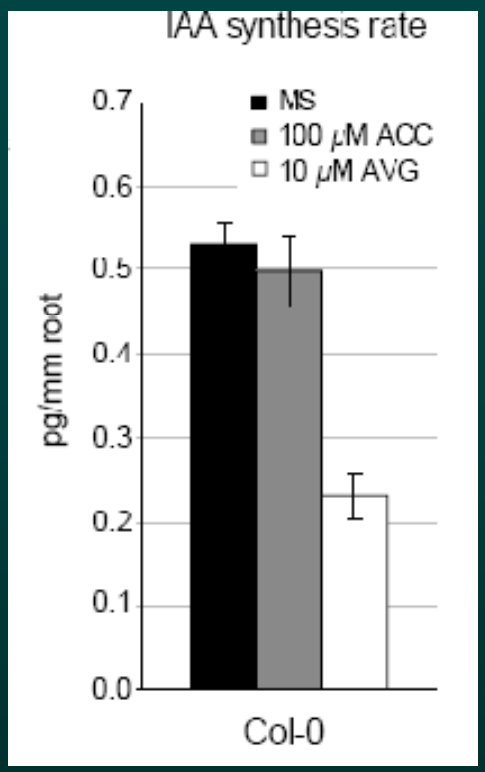




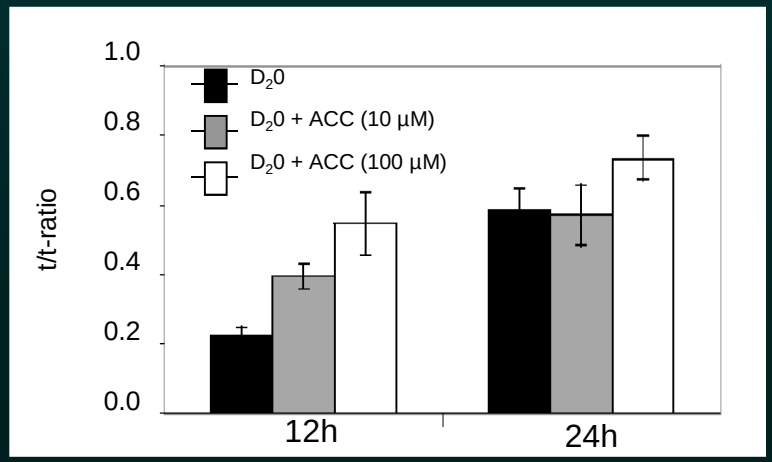
Ethylene stimulates auxin biosynthesis







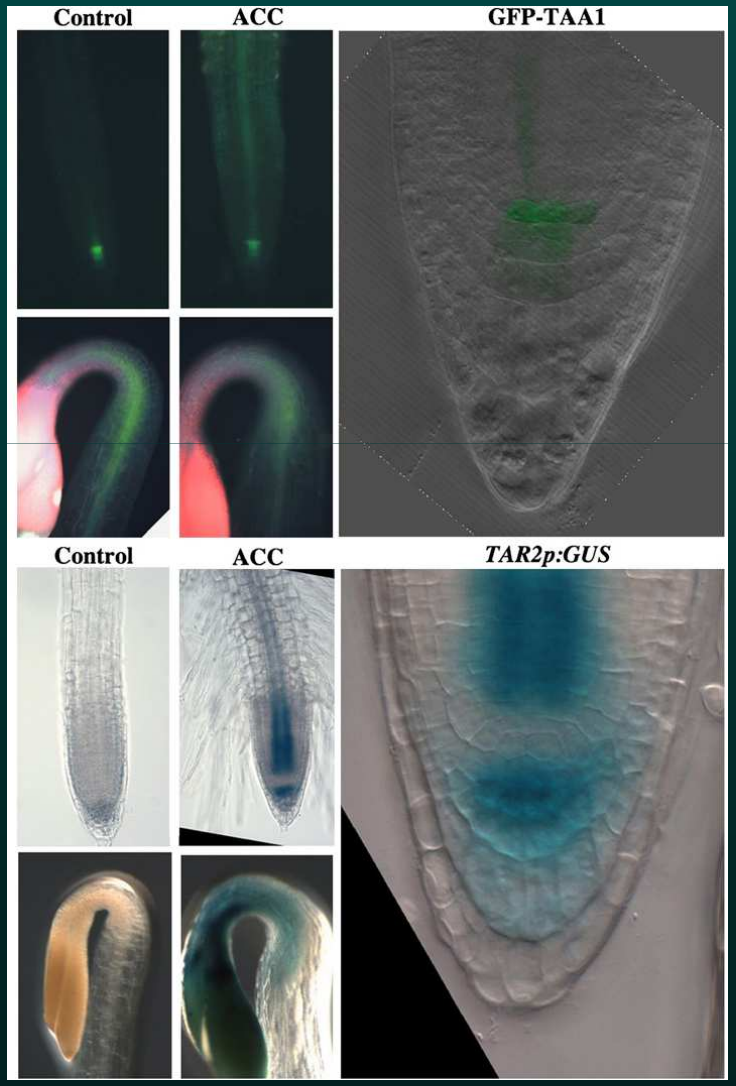
(Růžička et al., 2007)

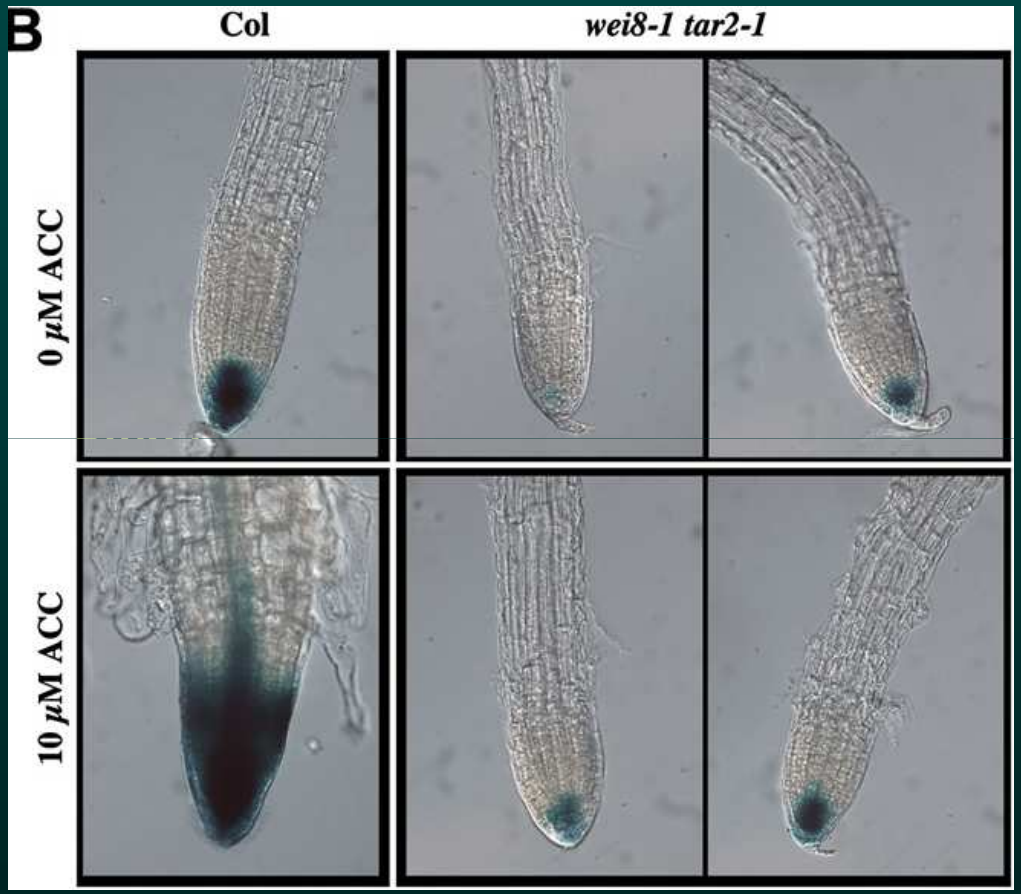


(Swarup et al., 2007)

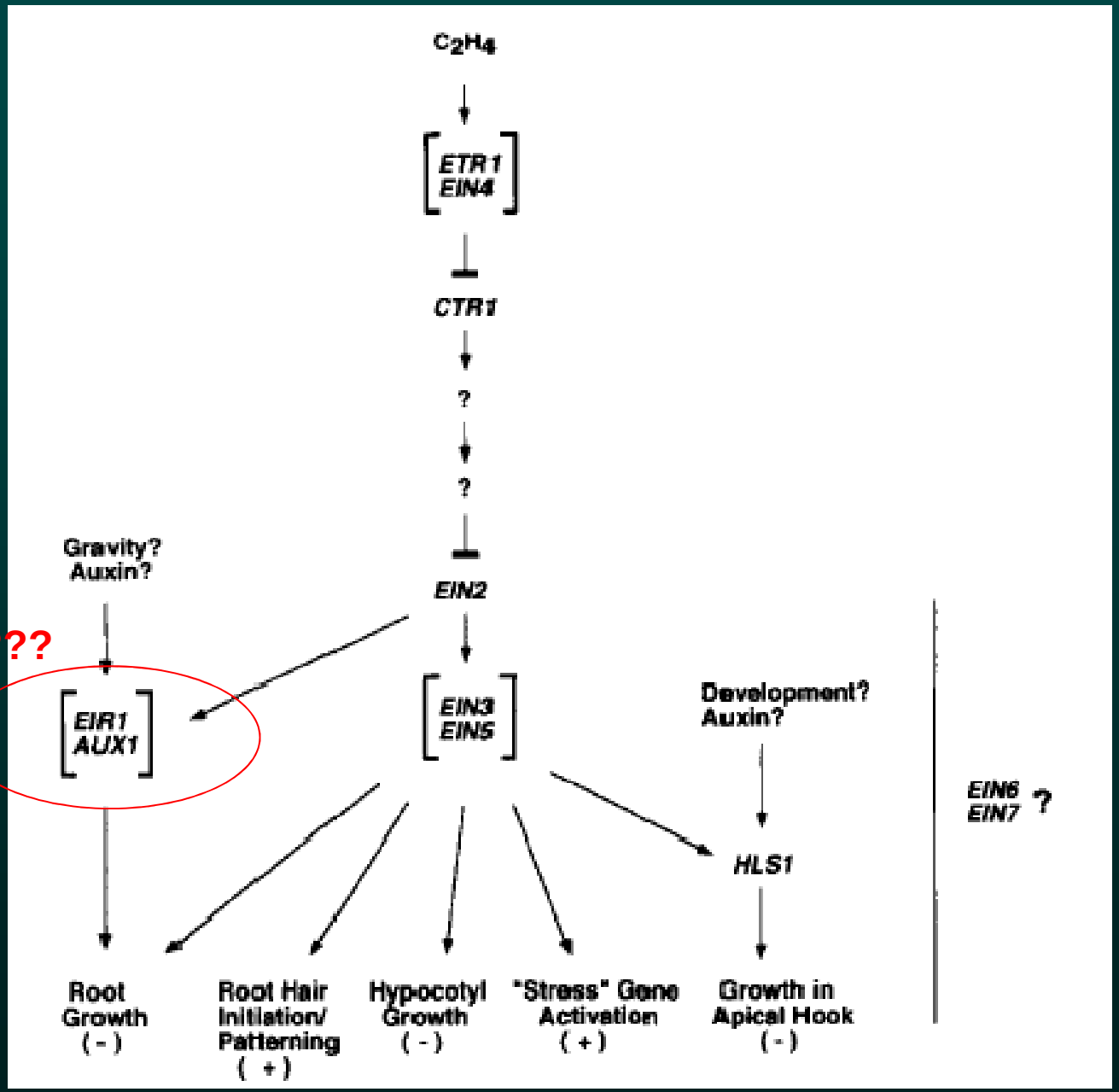
TAA1-Mediated Auxin Biosynthesis Is Essential for Hormone Crosstalk and Plant Development

TRYPTOPHAN AMINOTRANSFERASE of Arabidopsis



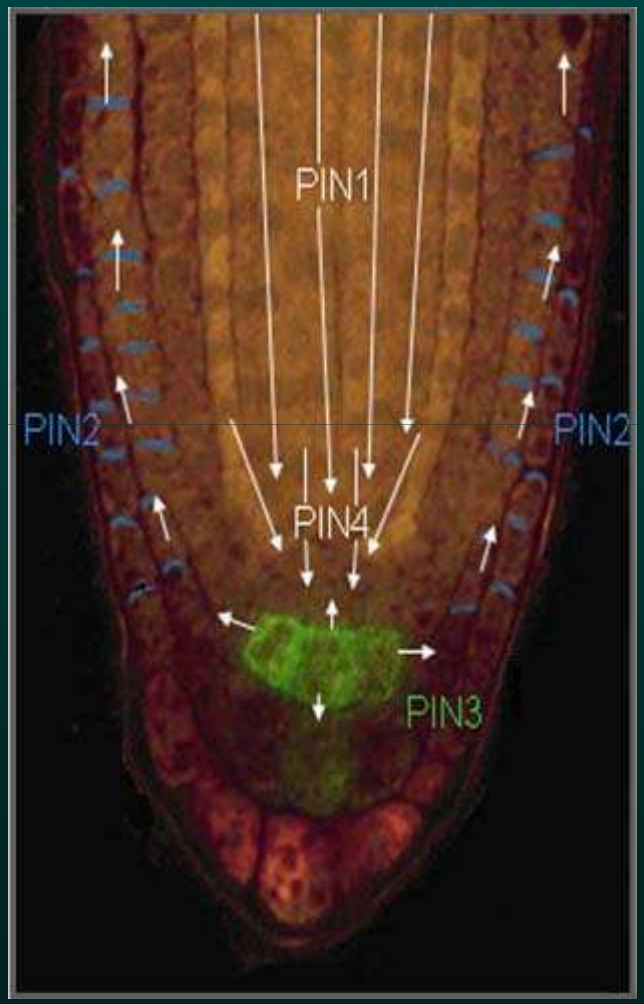


Stepanova et al., 2008

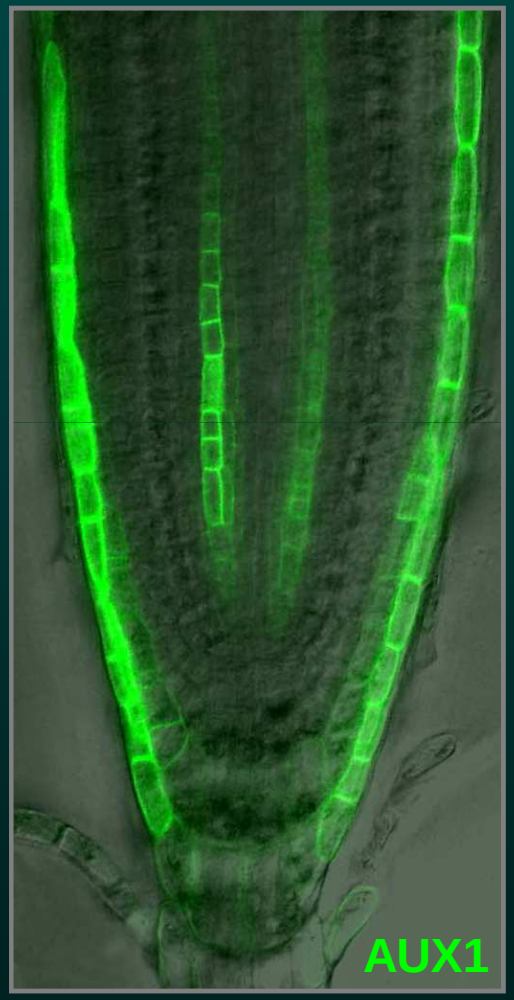


Roman et al., 1994

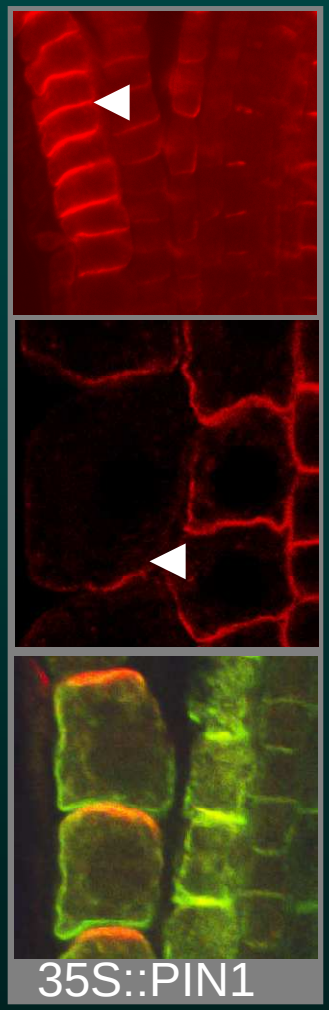
Auxin flow in the root tip



Friml *et al*. 2002

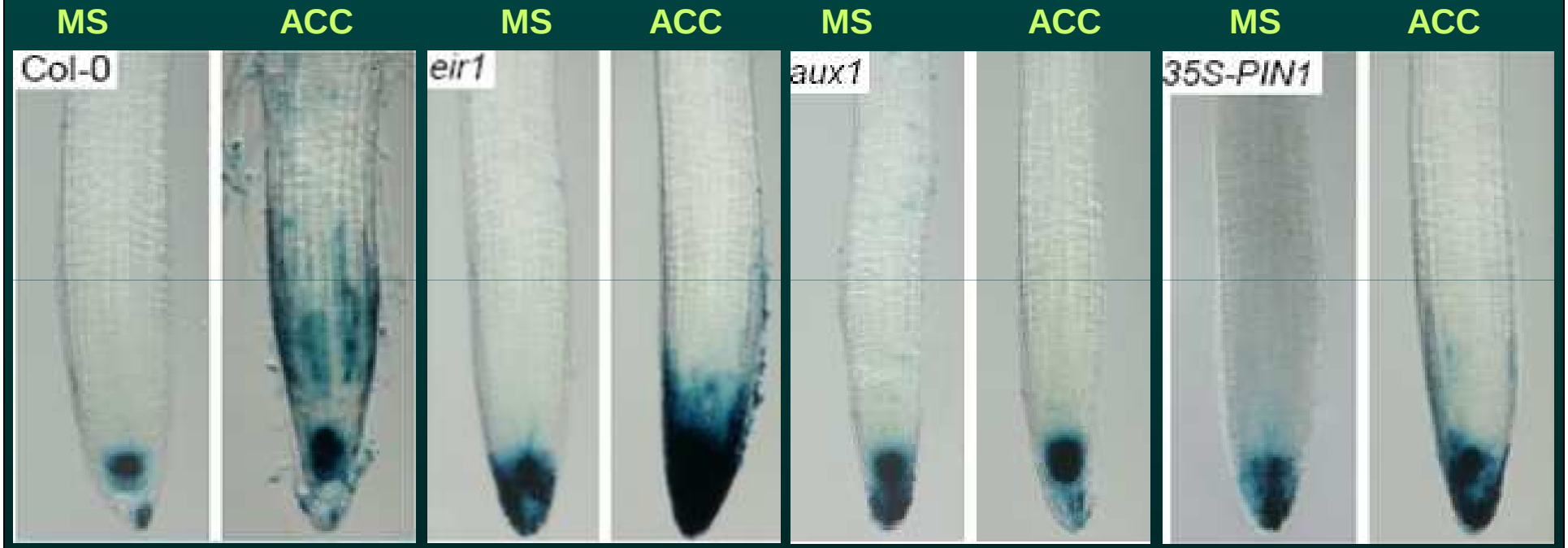


(Swarup *et al*., 2001)



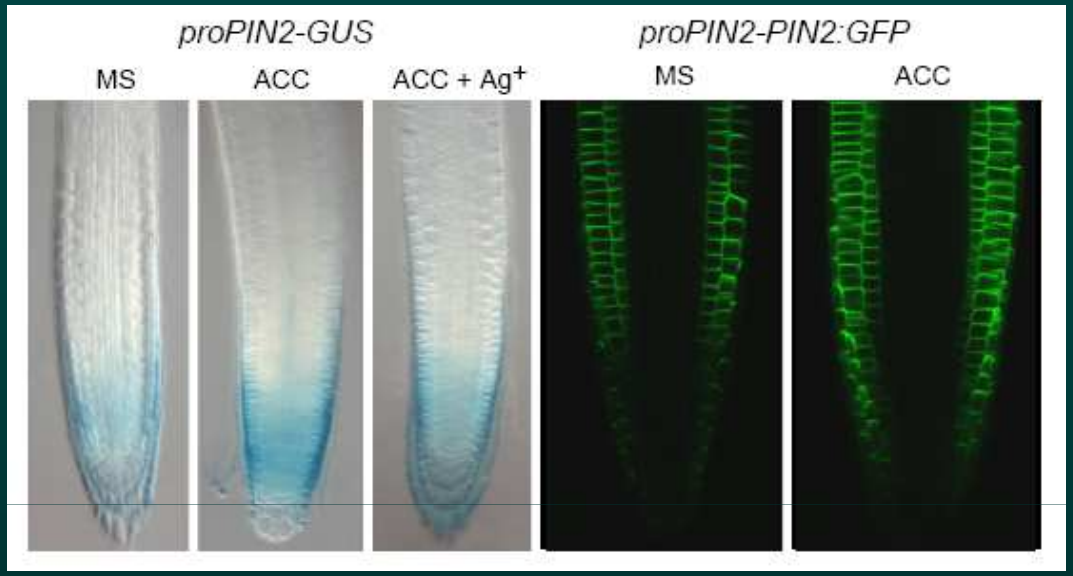
(Růžička *et al*., 2007)

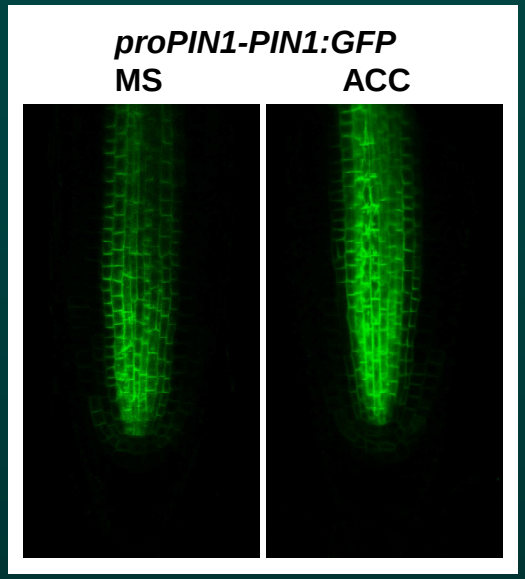
Mutants in basipetal auxin transport are ethylene resistent

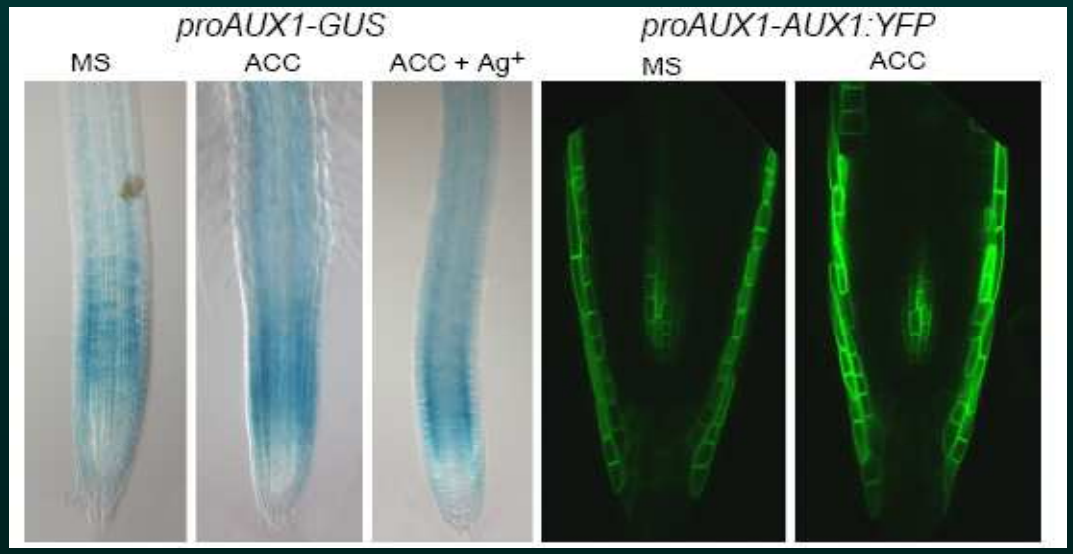


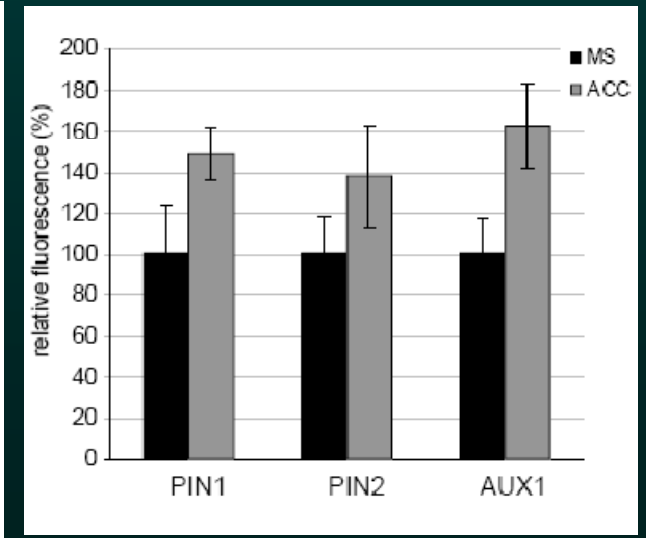
DR5::GUS

Ethylene upregulates expression of auxin transport carriers

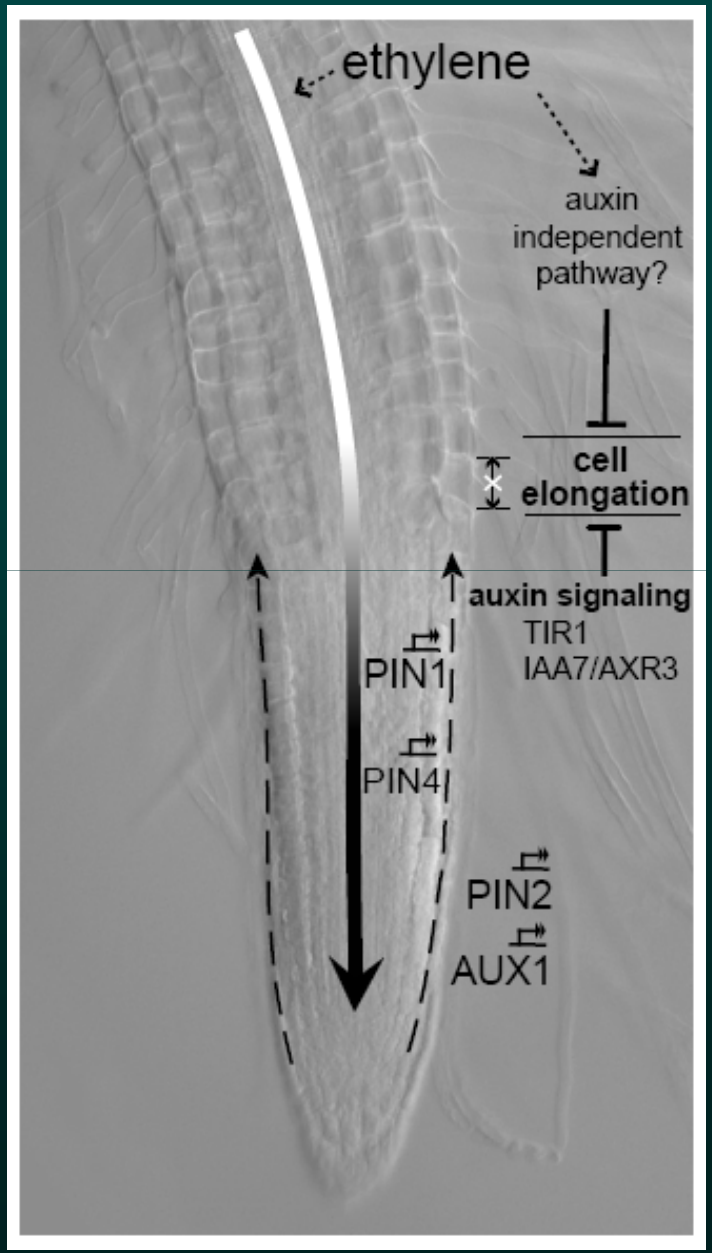








Model of ethylene regulated root growth



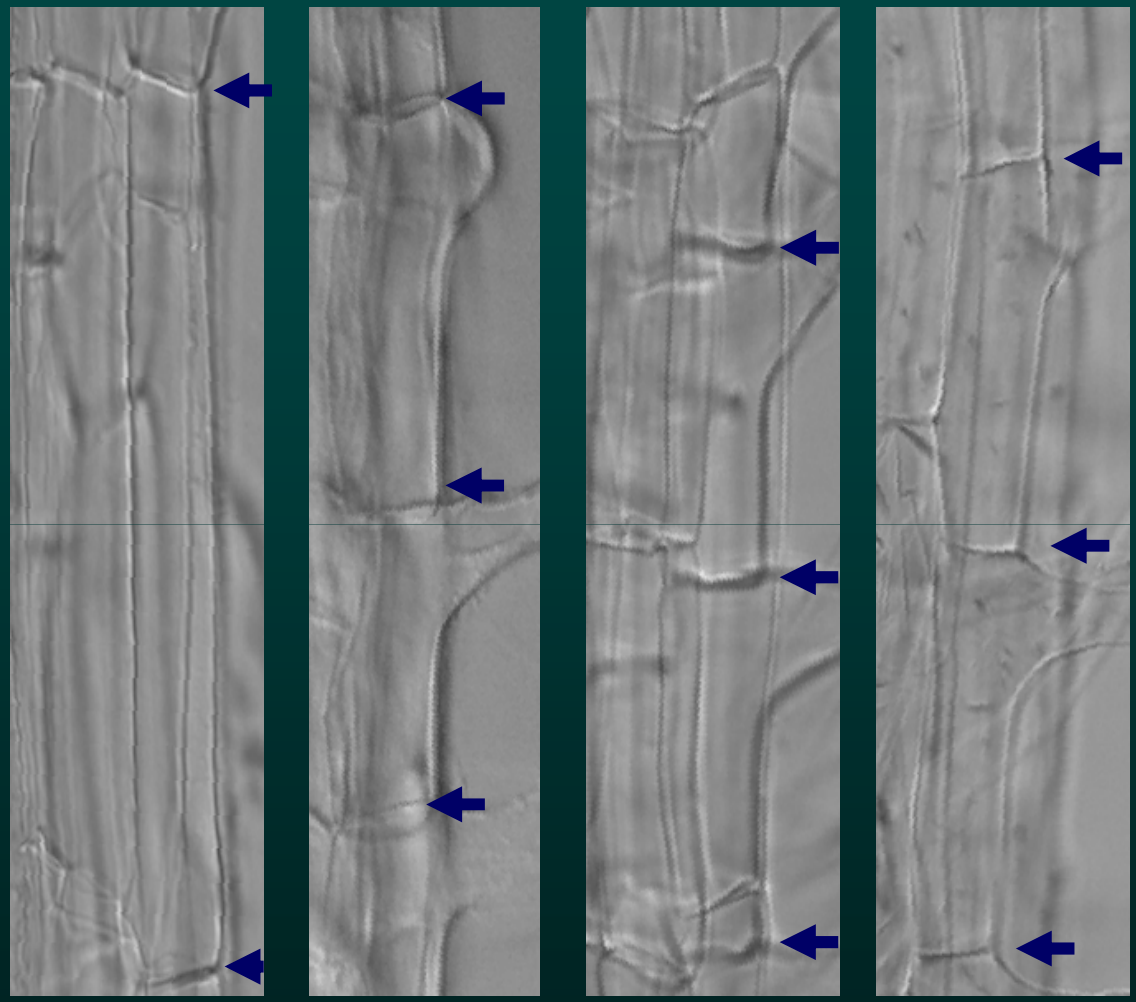
(Růžička et al., 2007)

Conclusions:

1. **Ethylene** stimulates **auxin** biosynthesis.
   -requires ethylene signalling

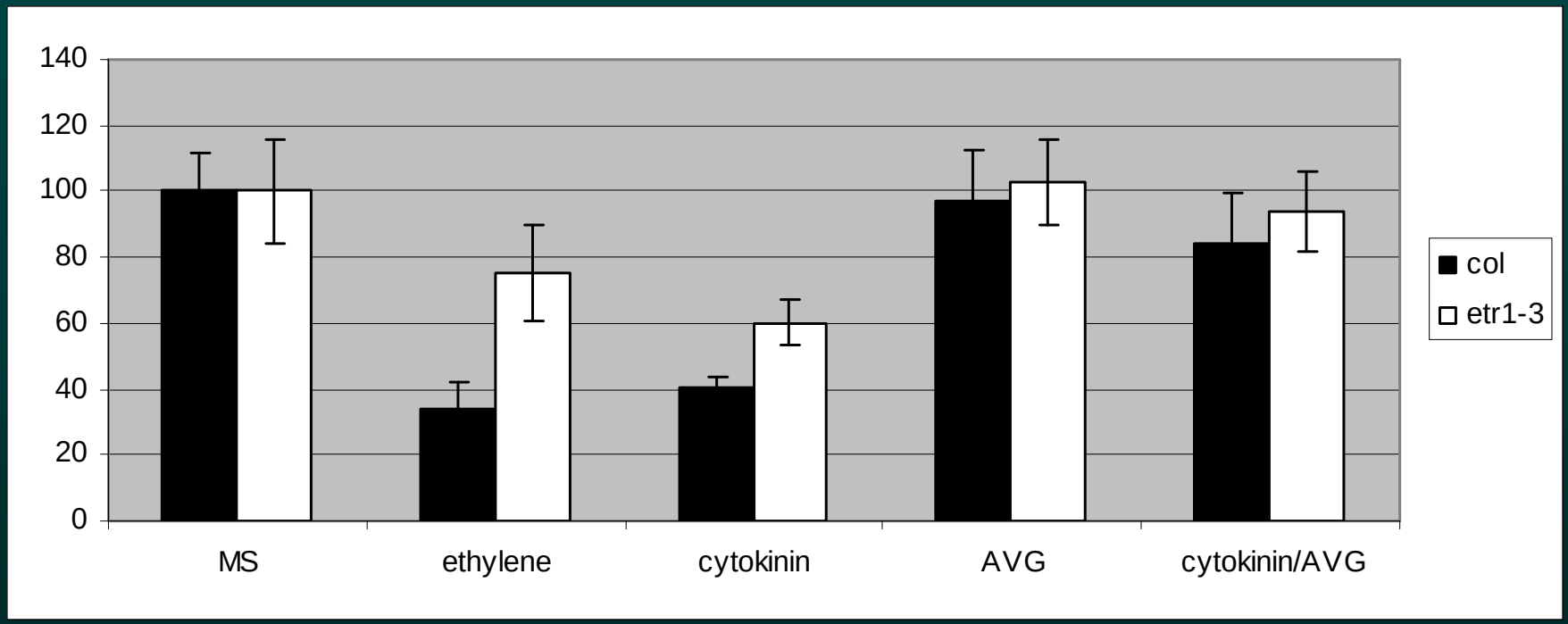
2. **Auxin** interfers with elongation of root cells.
   - requires basipetal auxin distribution
   - requires auxin signalling

Hormonal interactions - regulating cell elongation

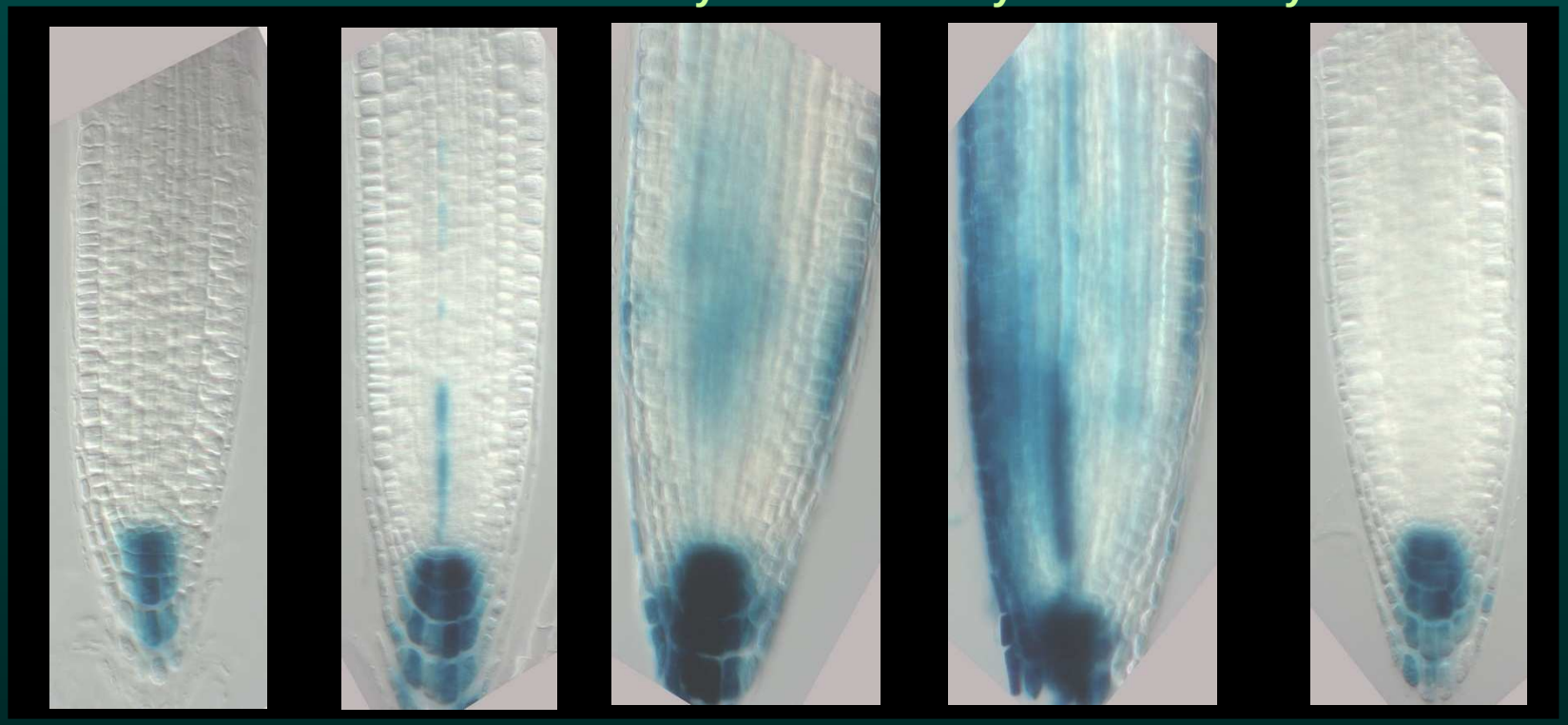


control cytokinin ethylene auxin

Ethylene perception mutants are cytokinin resistant

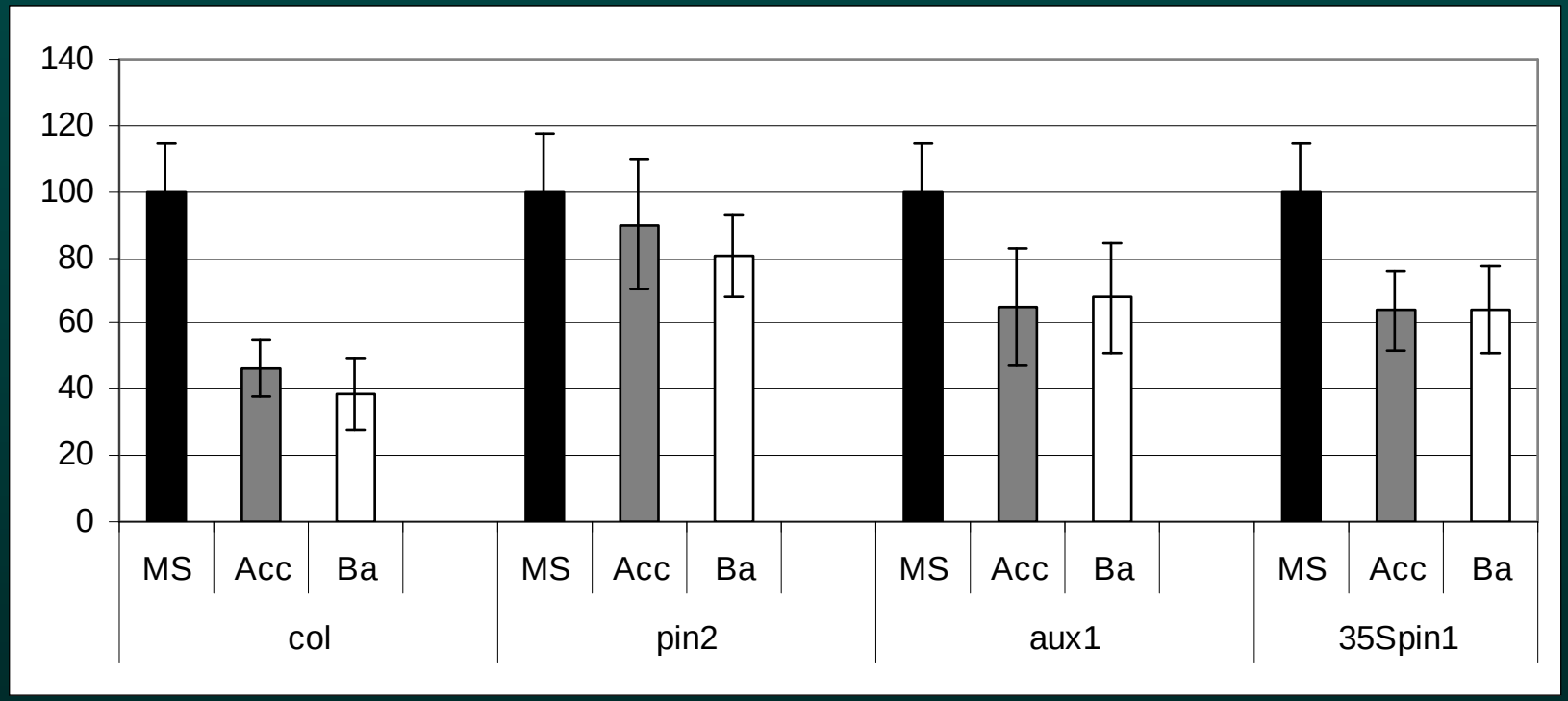


Cytokinin induced accumulation of auxin is ethylene dependent

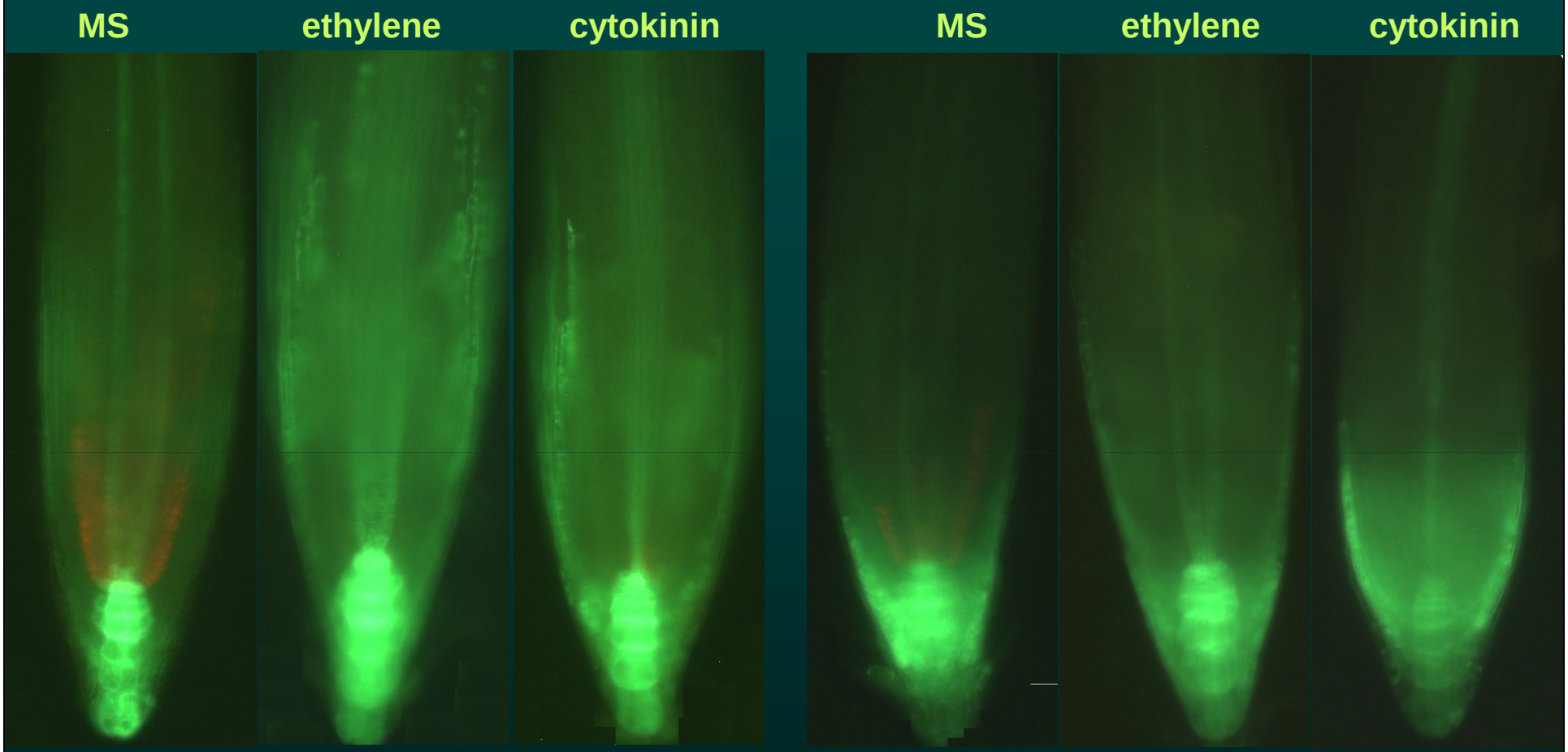


DR5::GUS

Auxin transport mutant are cytokinin resistant



Auxin transport mutant are cytokinin resistant



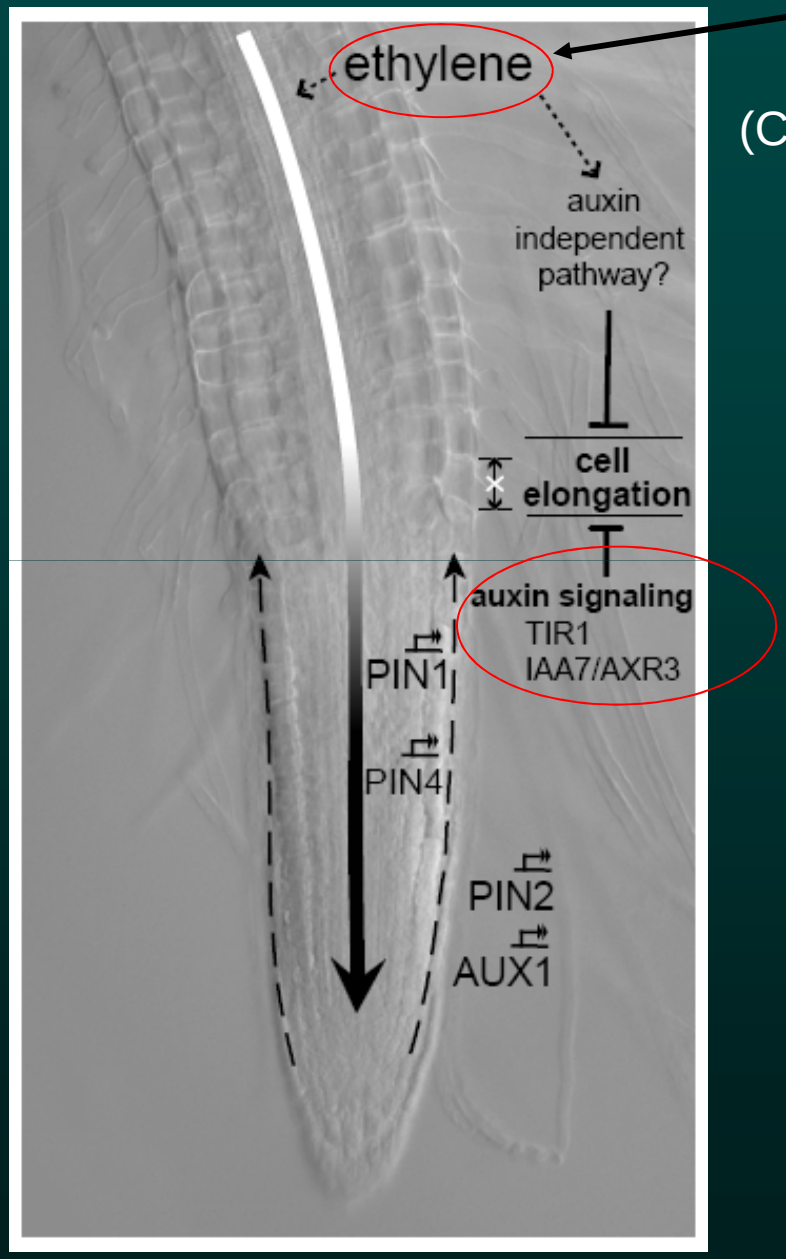
Col x DR5::GFP

Pin2 x DR5::GFP

Conclusion:

1. **Part of cytokinin** effect on root growth is mediated through **ethylene and auxin**

Model of ethylene regulated root growth

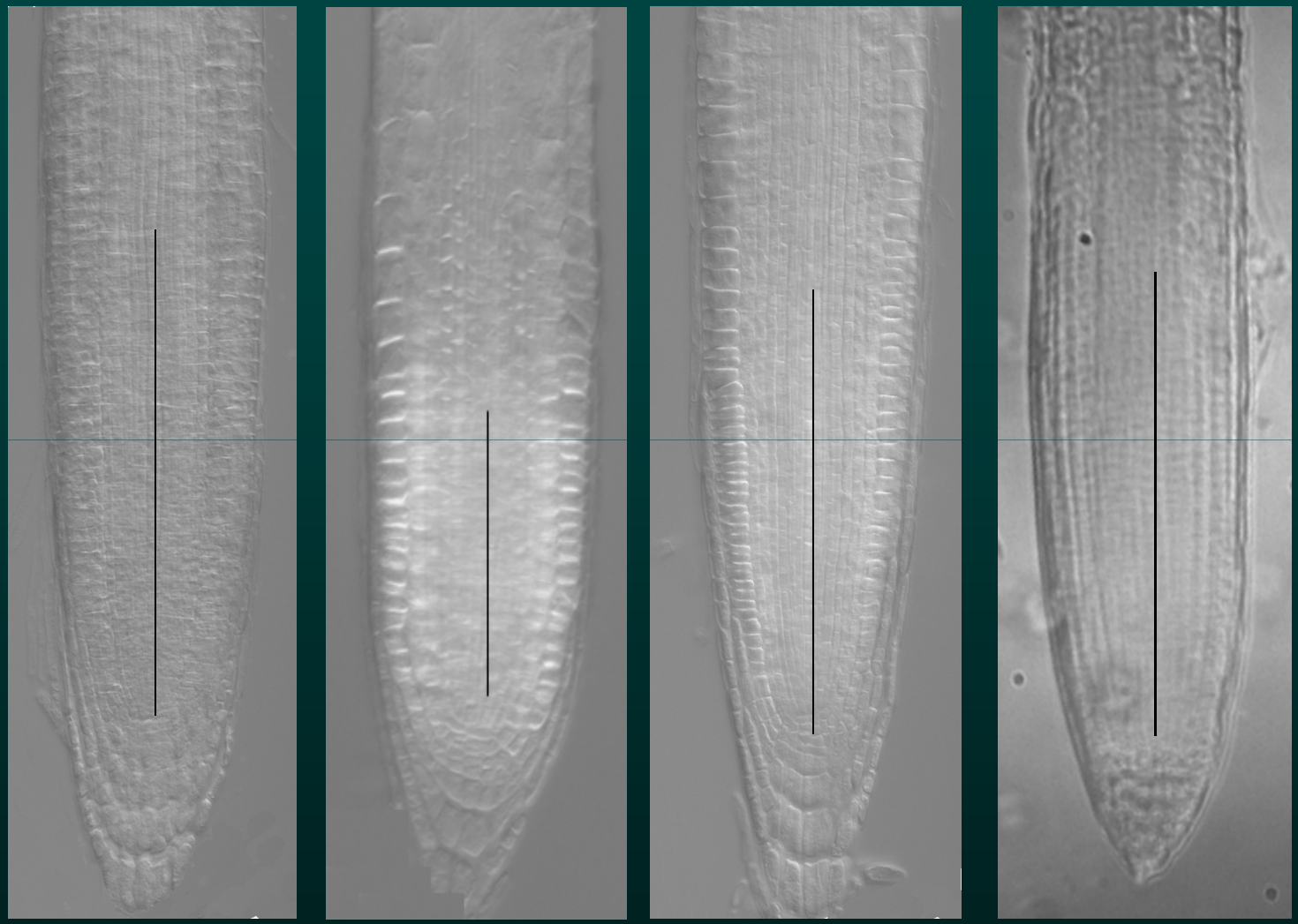


cytokinin

(Chae et al., 2003)

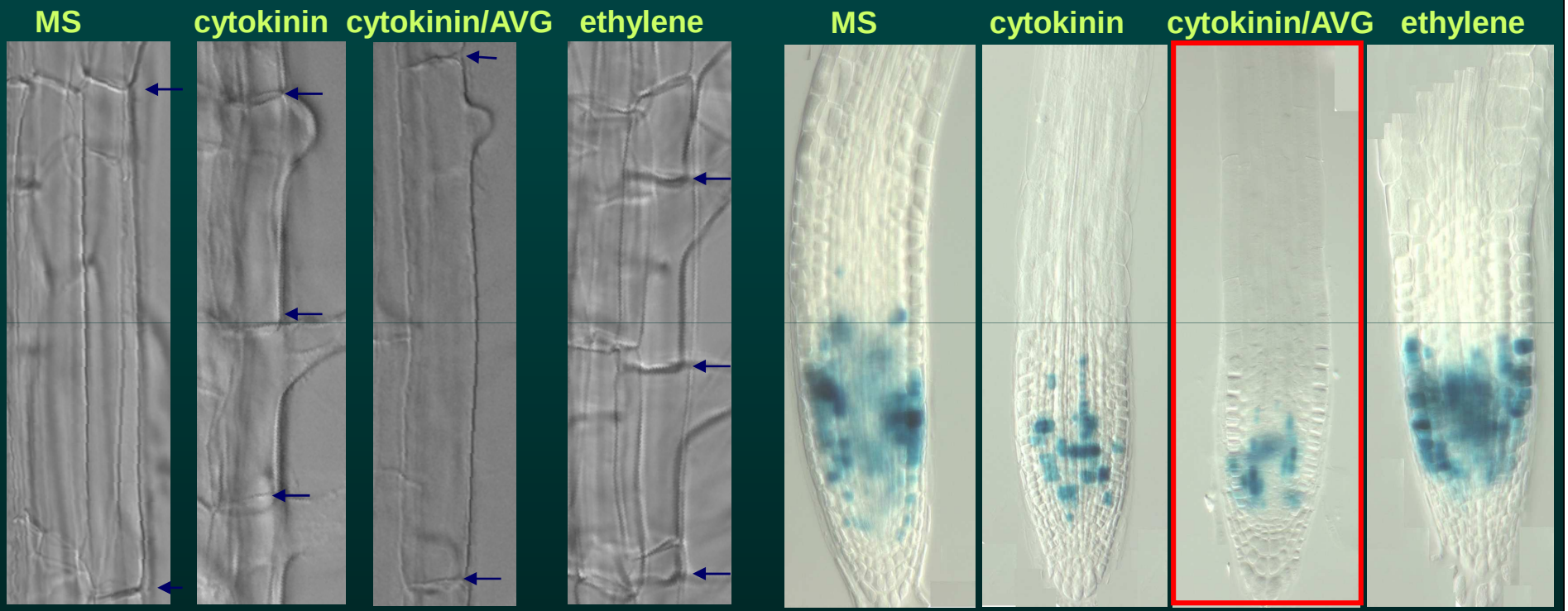
(Růžička et al., 2007)

Hormonal interactions regulating root meristem



control cytokinin ethylene auxin

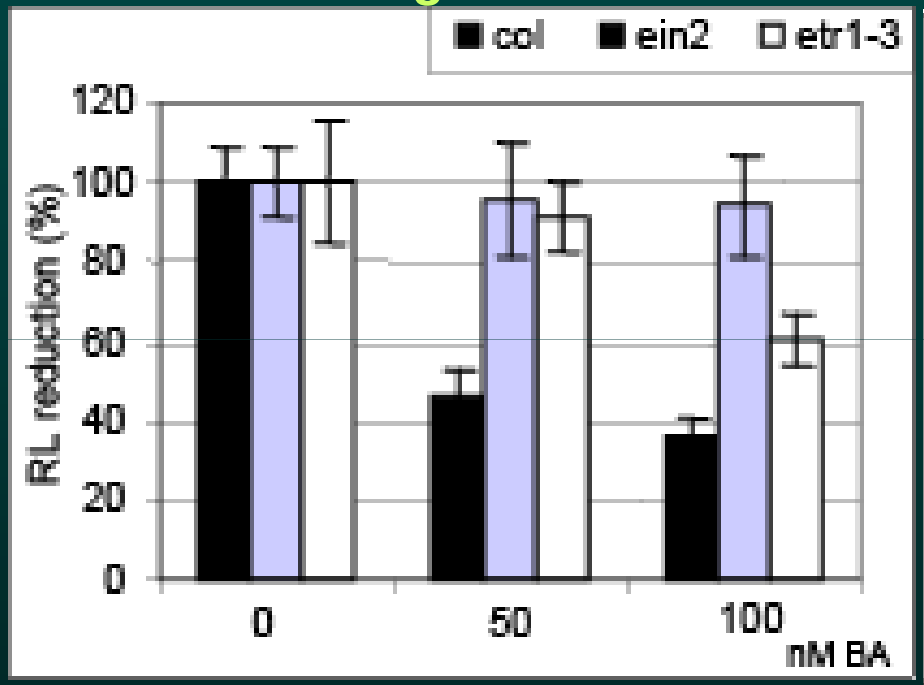
Cytokinin inhibits meristem growth



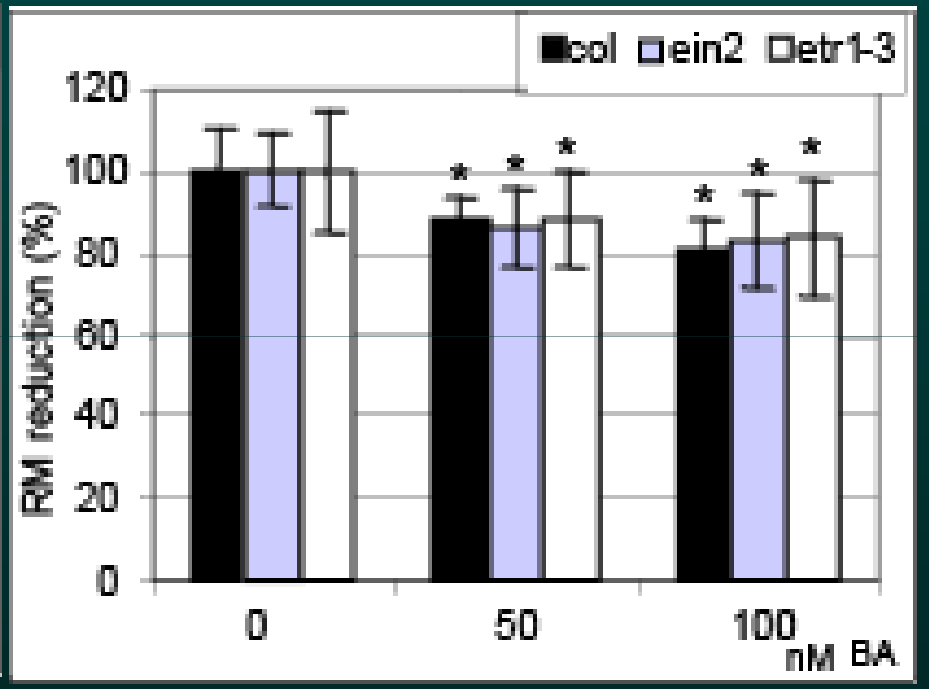
cycB::GUS

Cytokinin inhibition of root meristem growth is ethylene independent

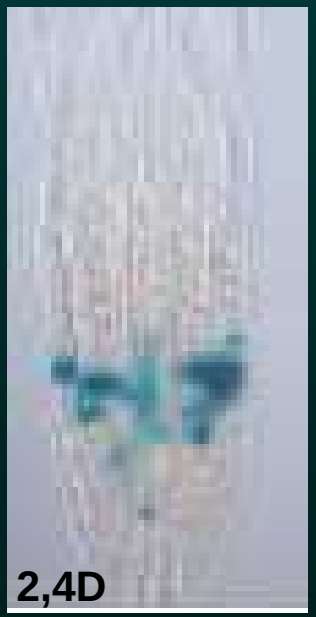
root length

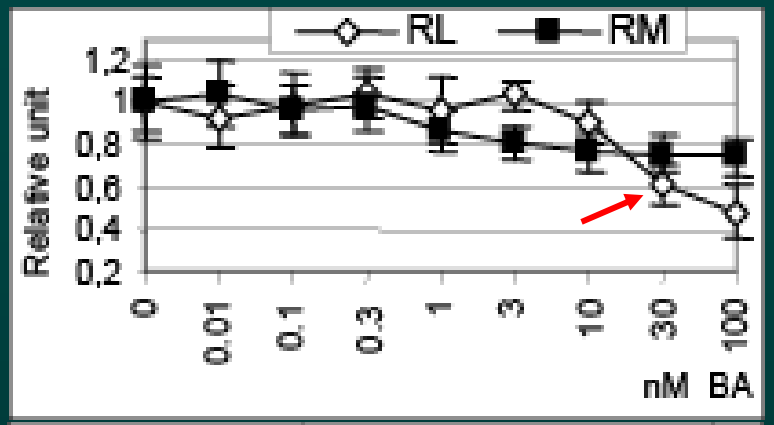


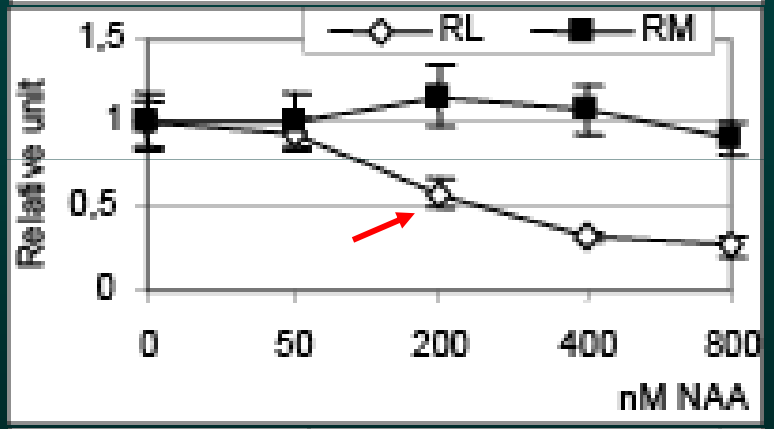
root meristem

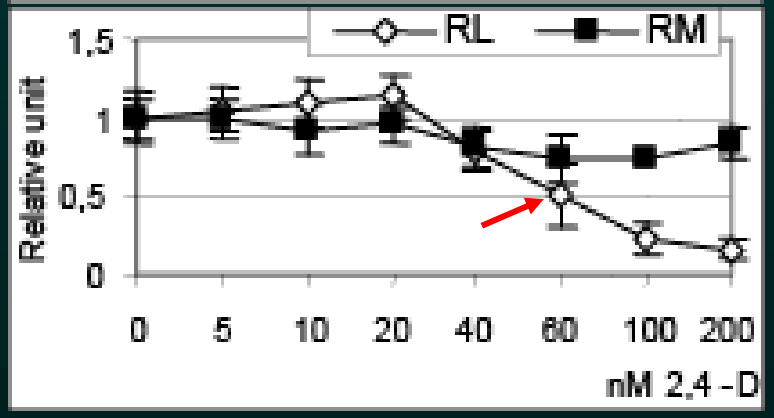


Auxin and cytokinin regulated root meristem growth

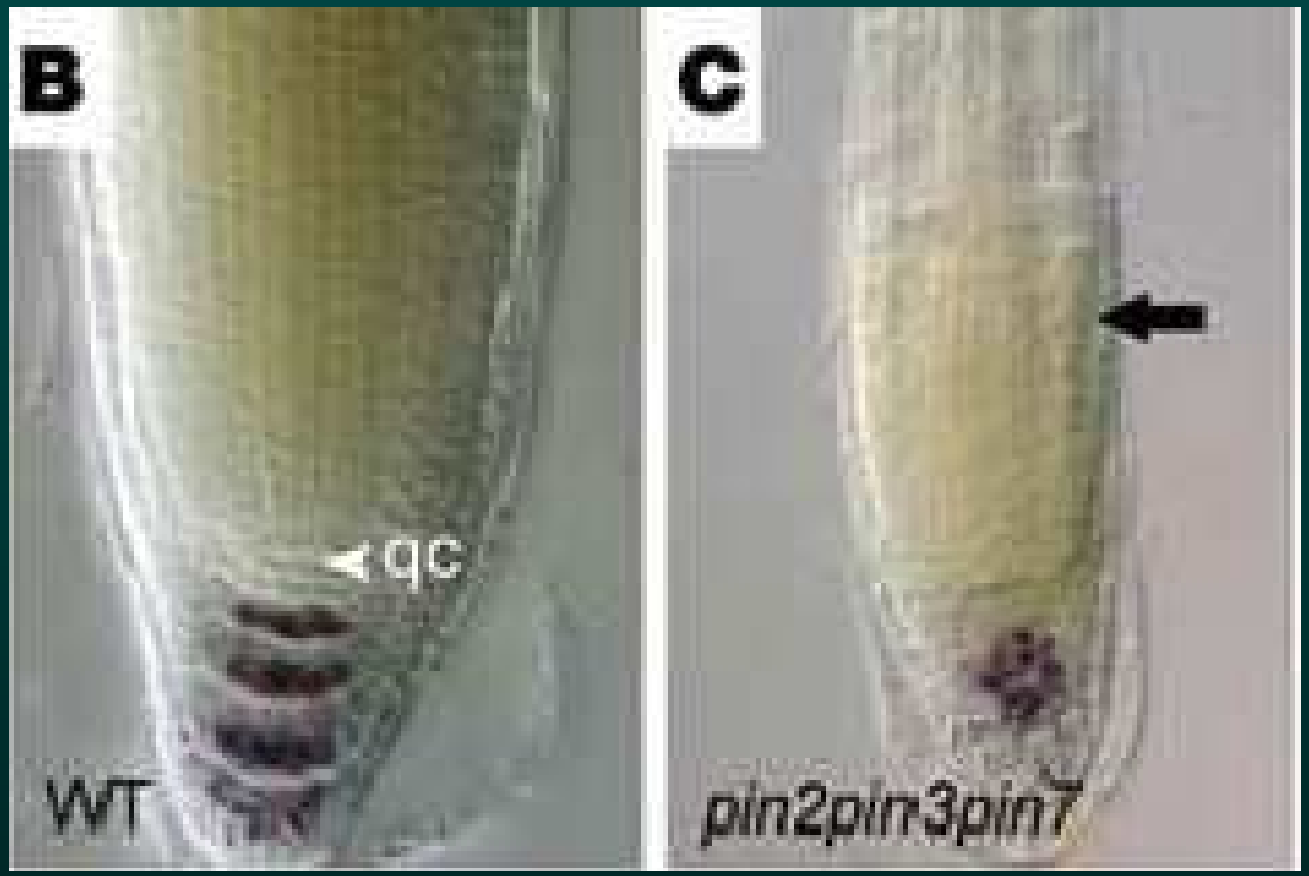






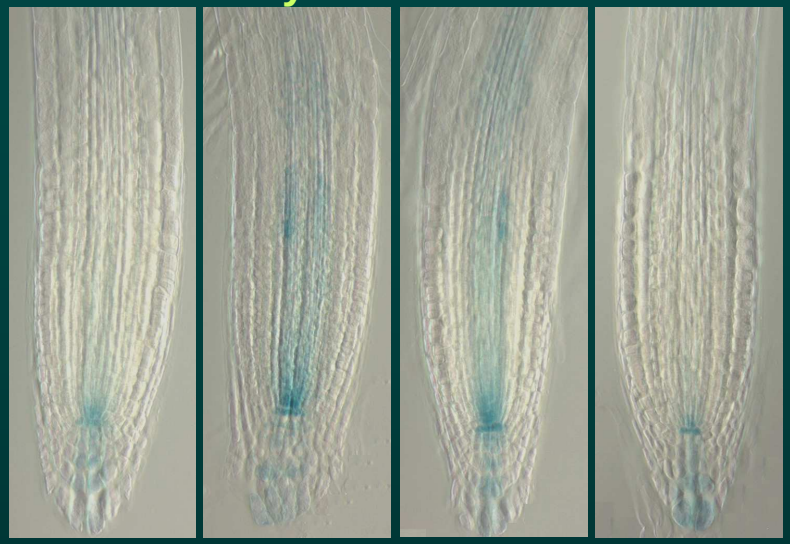


Auxin transport mutants are defective in root meristem growth

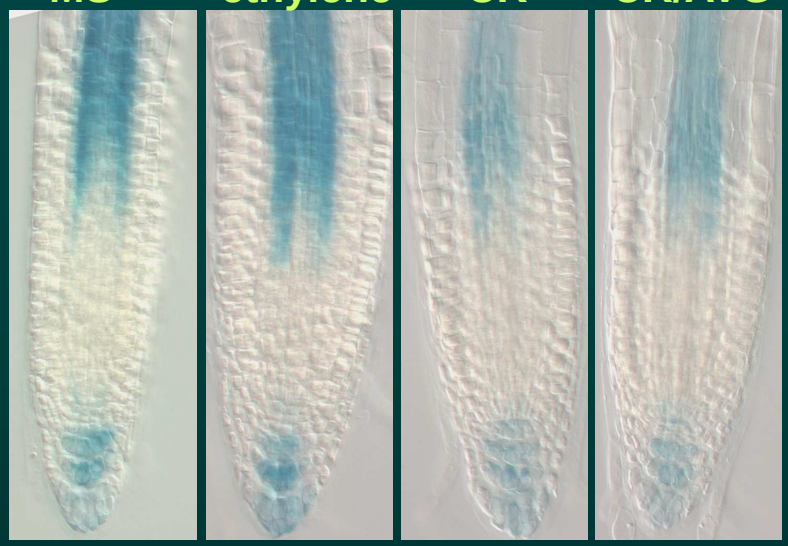


Blilou et al., 2005

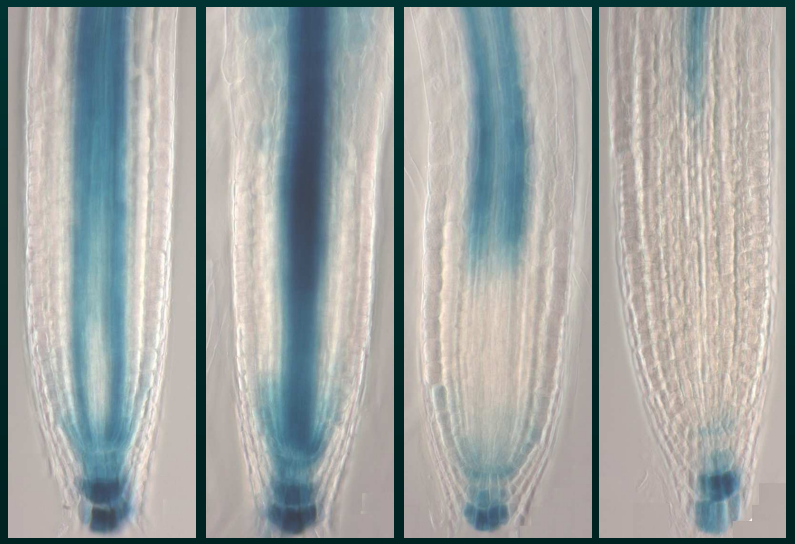
Cytokinin and ethylene regulate PIN expression differentially



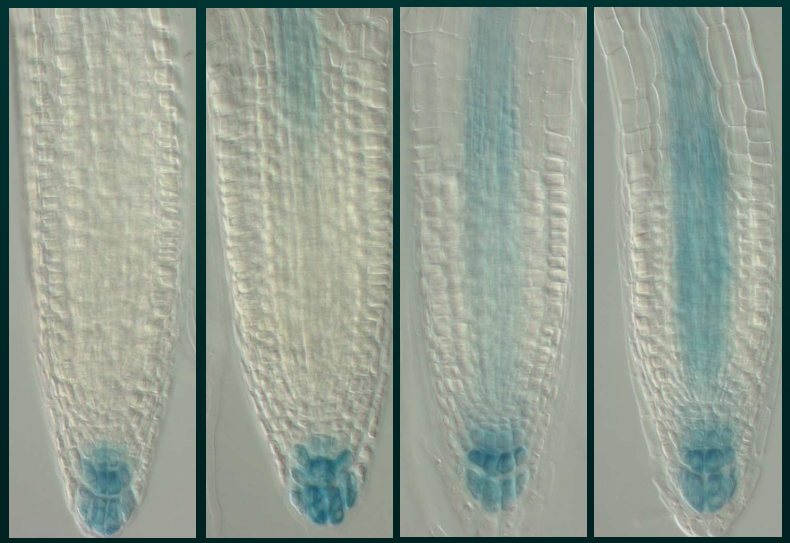
PIN1::GUS



PIN3::GUS



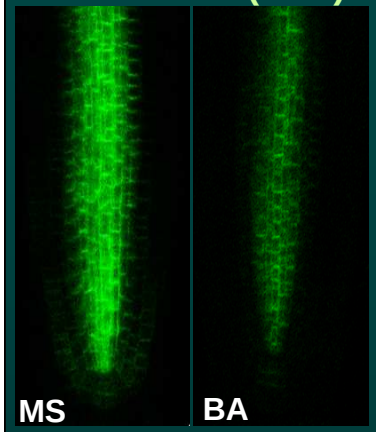
PIN4::GUS

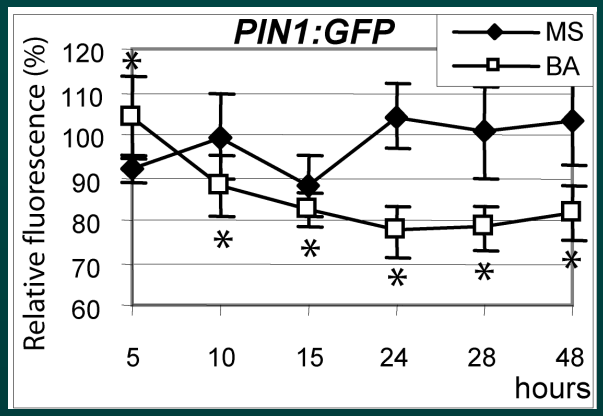


PIN7::GUS

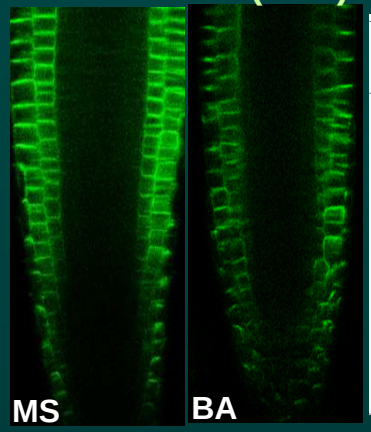
Cytokinin modulates expression of PIN genes differentialy

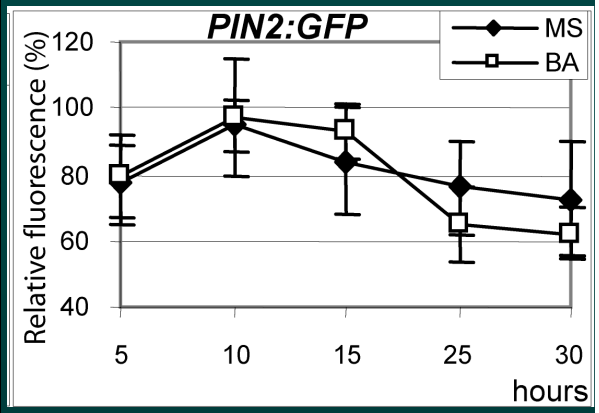
PIN1:GFP (24 h)



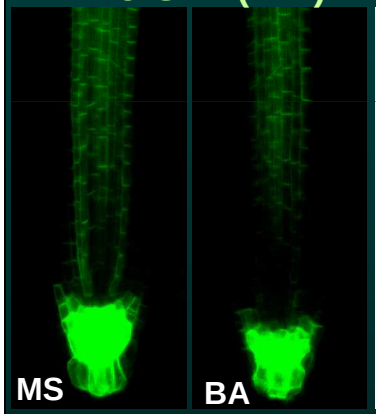


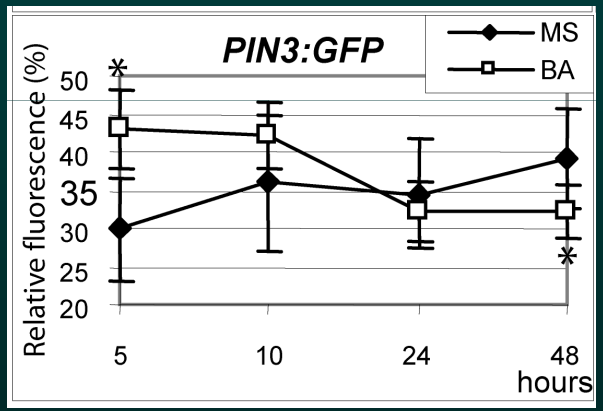
PIN2:GFP (48 h)



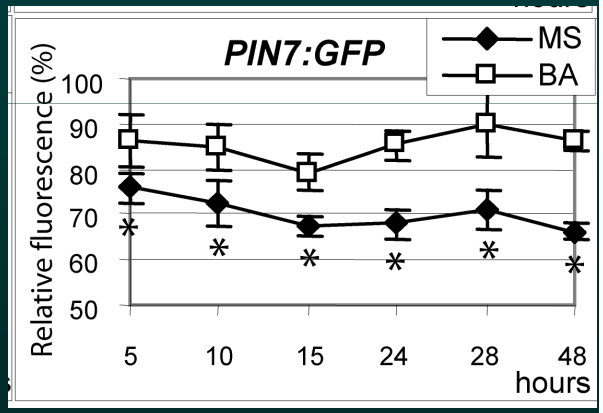


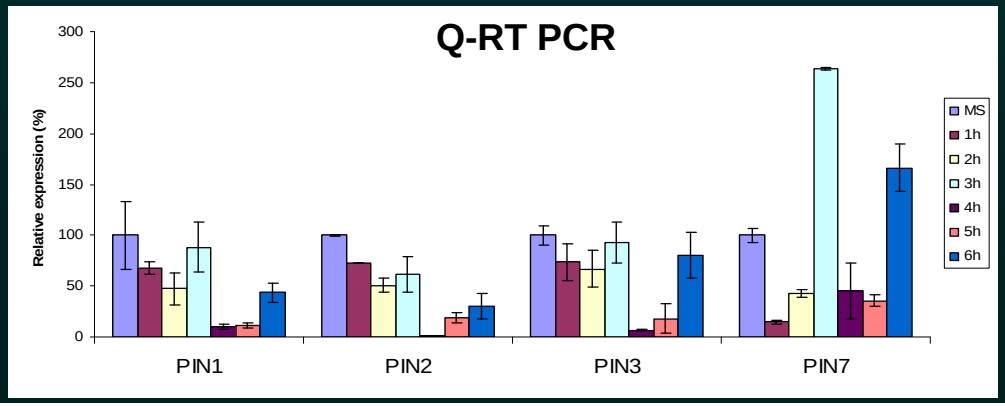
PIN3:GFP (24h)





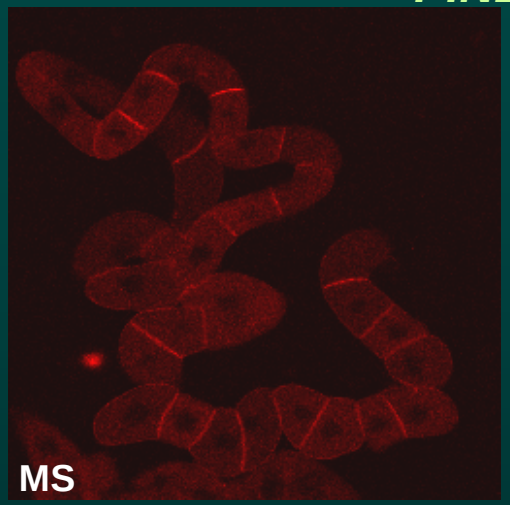
PIN7:GFP (24h)

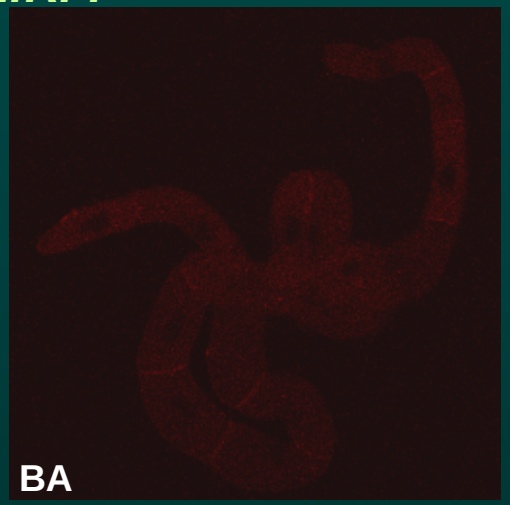


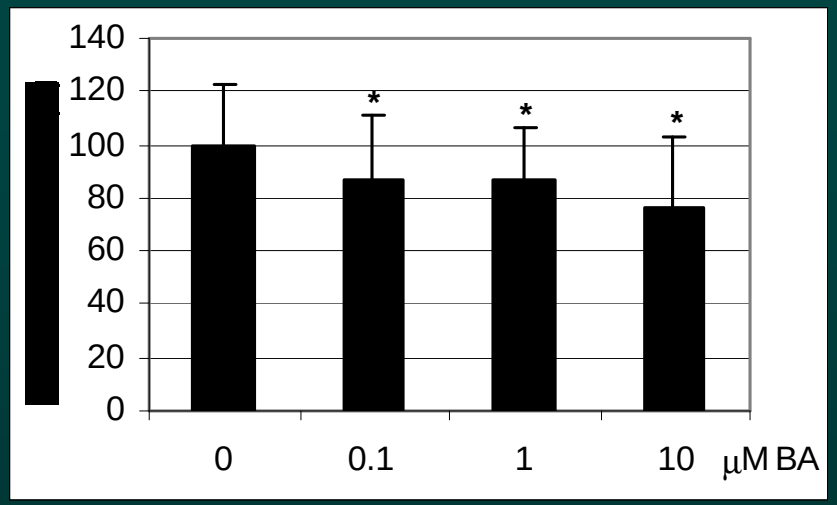


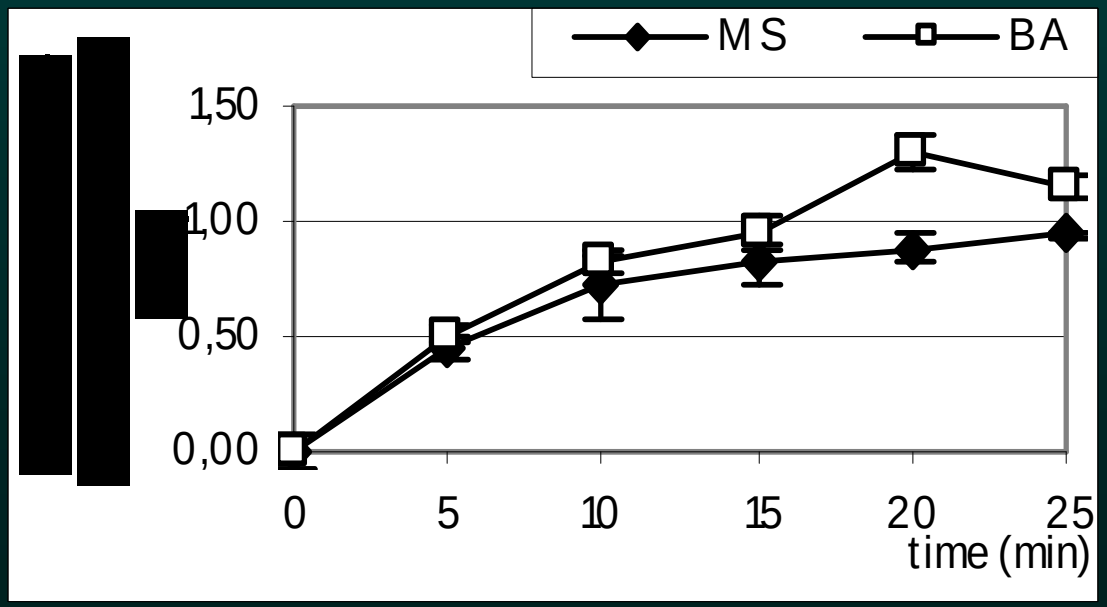
Cytokinin reduces auxin efflux in tobacco BY2 cells

PIN1:RFP



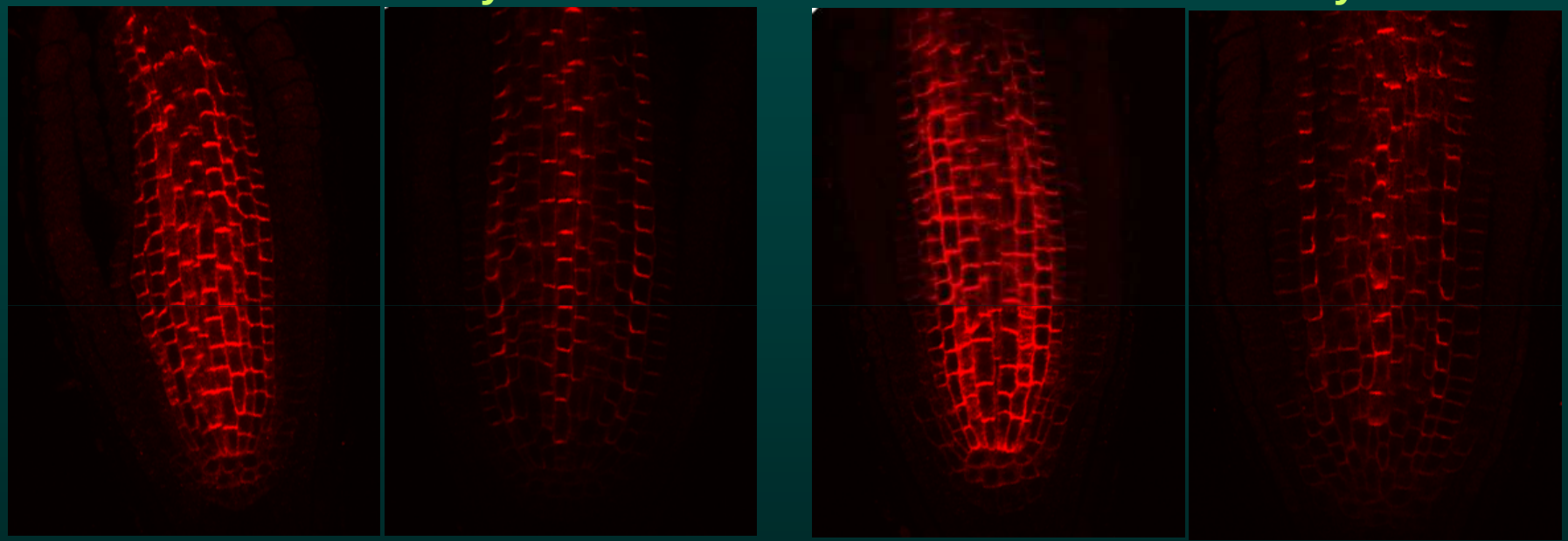






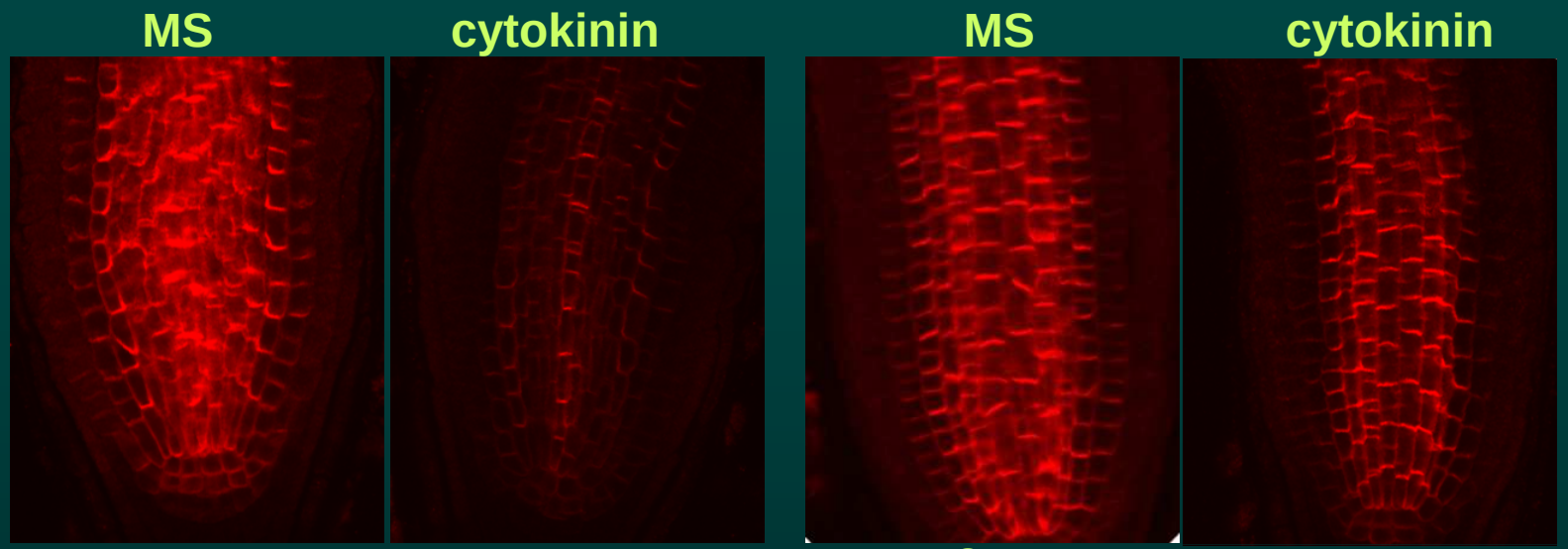
Cytokinin inhibitory effect on PIN1 is ethylene independent

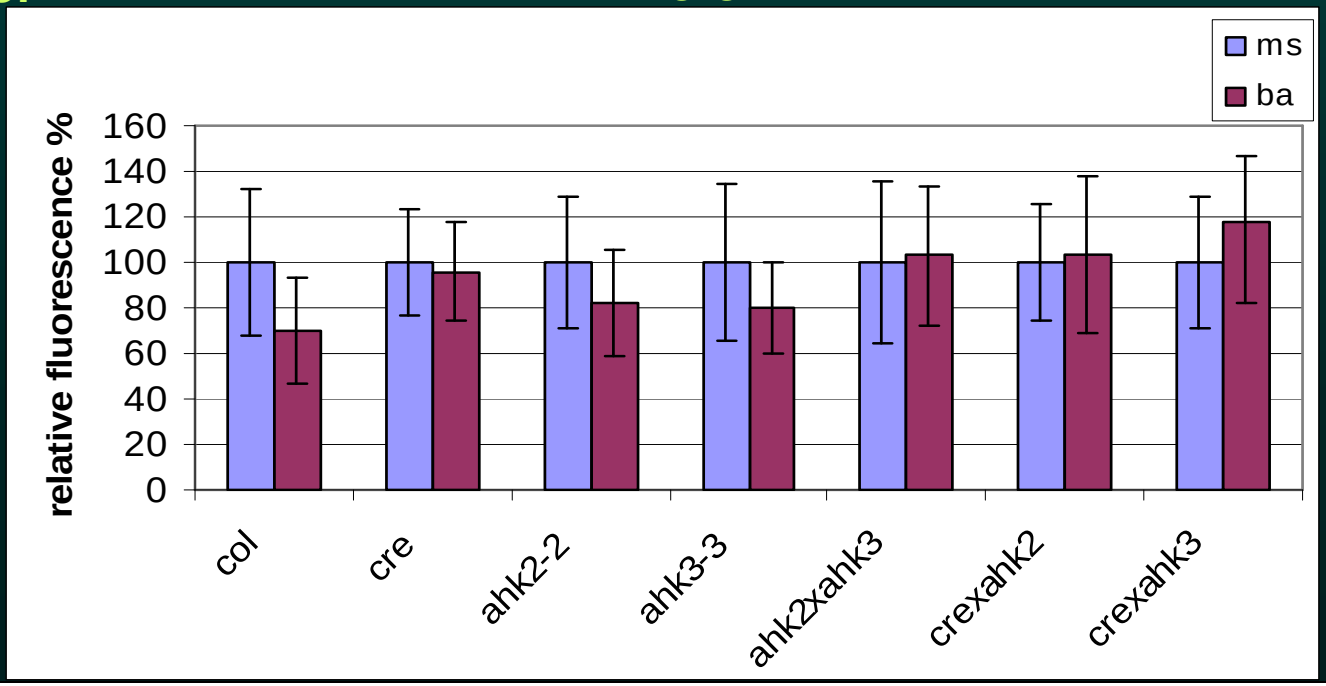
MS cytokinin MS cytokinin



etr1-3 *ein2*

Cytokinin inhibitory effect on PIN1 requires CK perception





Conclusions:

1. **Cytokinin regulates root meristem growth in ethylene independent manner**

2. **Cytokinin antagonizes auxin regulated root meristem growth.**

3. **Modulation in auxin distribution might result in reduced root meristem size**