Hormonal regulation of bud break modulated by light quality

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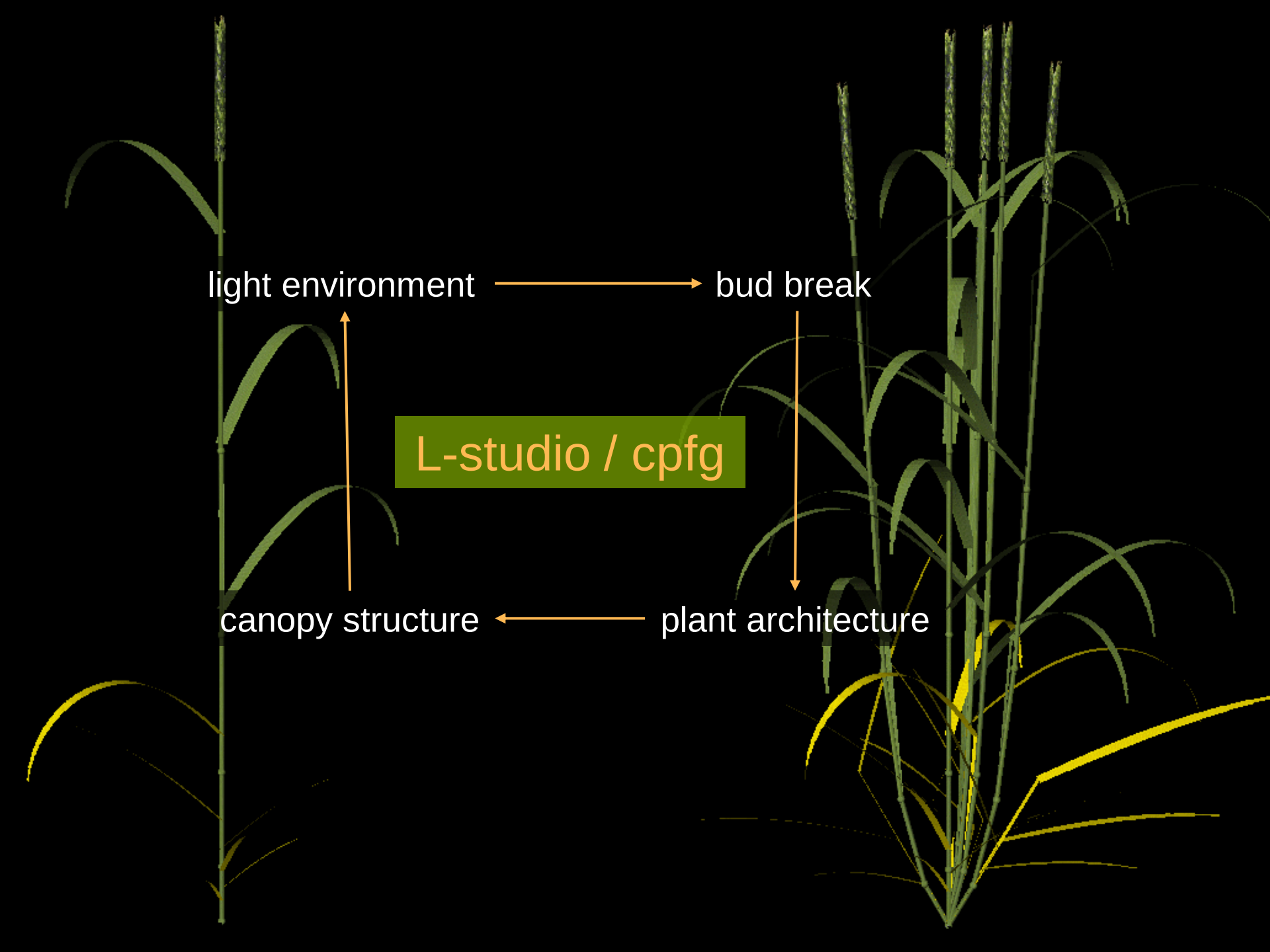
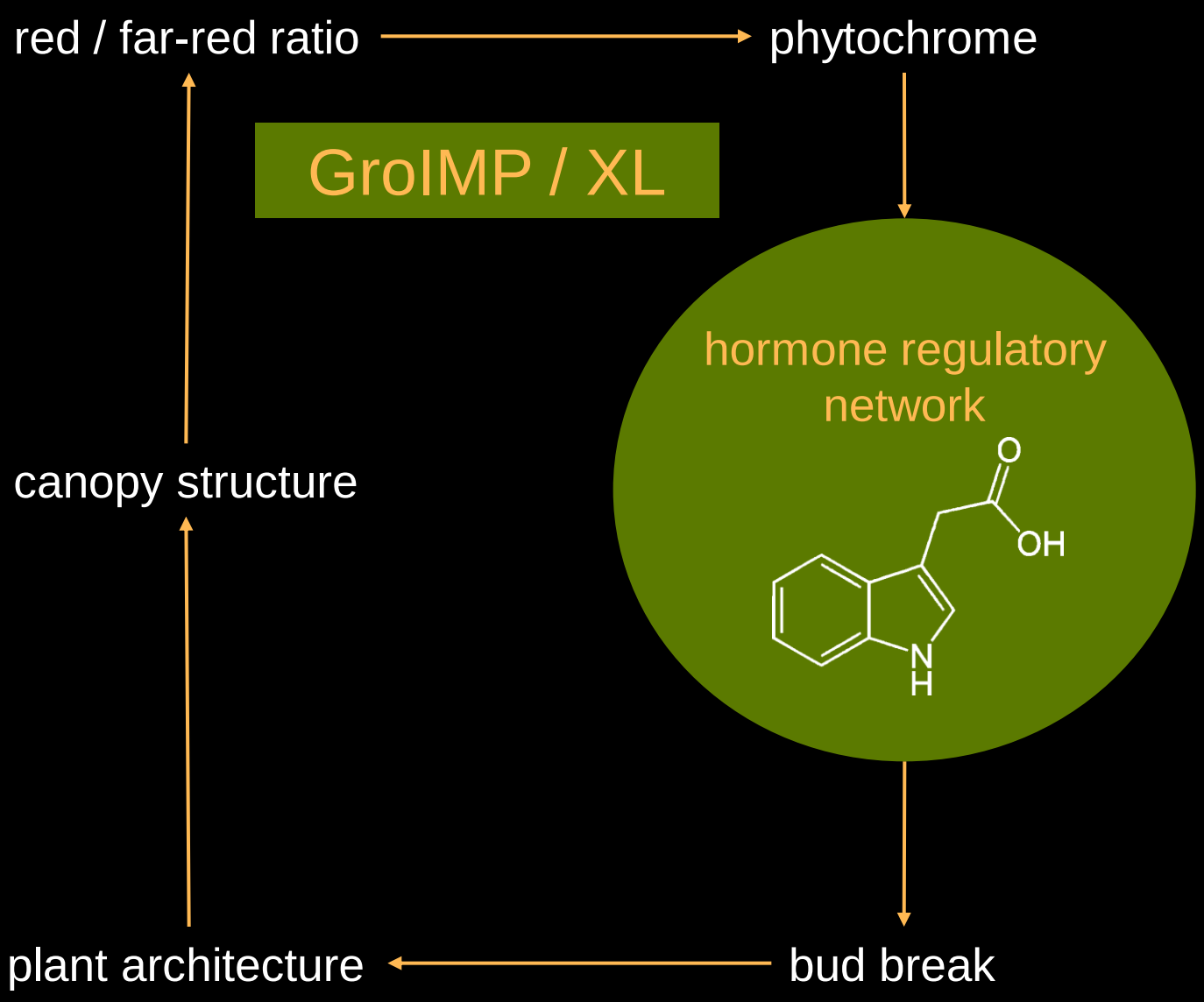
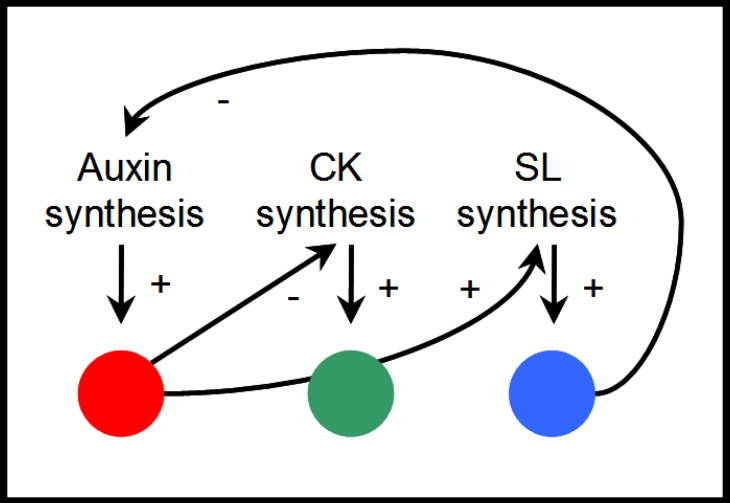

light environment
bud break
L-studio / cpfg
canopy structure
plant architecture


red / far-red ratio
phytochrome
GroIMP / XL
hormone regulatory network
O
OH
N
H
canopy structure
plant architecture
bud break

Photos by Van der Putten & Stomph

Model principles:

- Local hormone synthesis (auxin, cytokinin, strigolactone)
- Mutual influence of hormone levels on synthesis
- Hormone turn-over



Model principles:

- Local hormone synthesis (auxin, cytokinin, strigolactone)
- Mutual influence of hormone levels on synthesis
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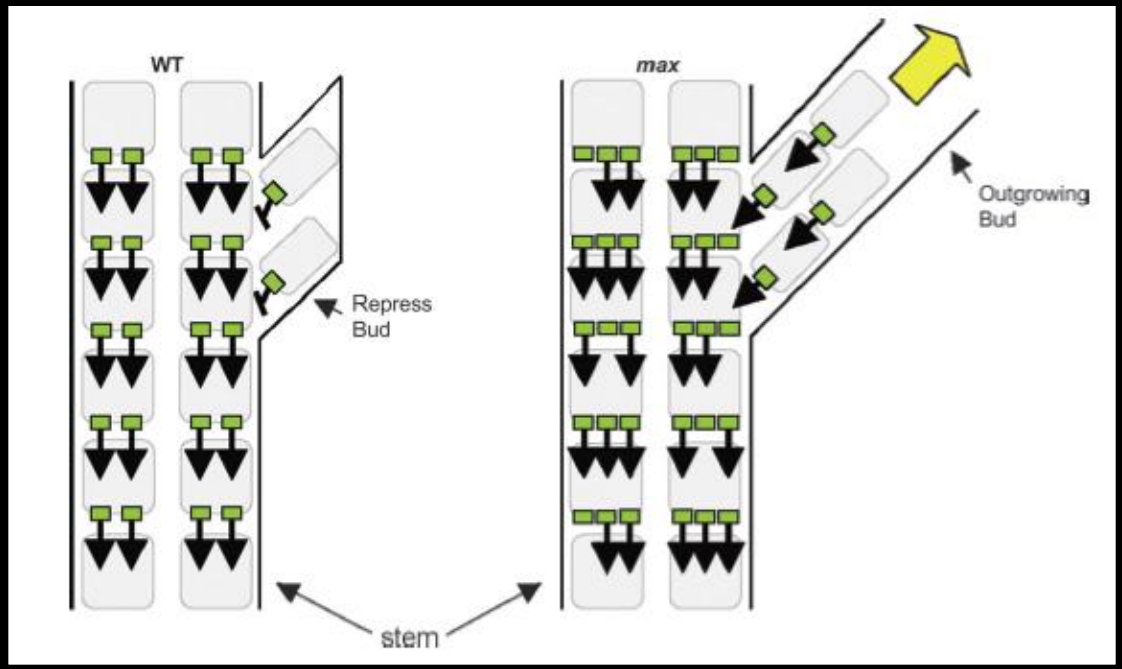
- Directional hormone transport
- Internode transport capacity for auxin, limited by SL level



Ongaro and Leyser (2008)

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- Directional hormone transport
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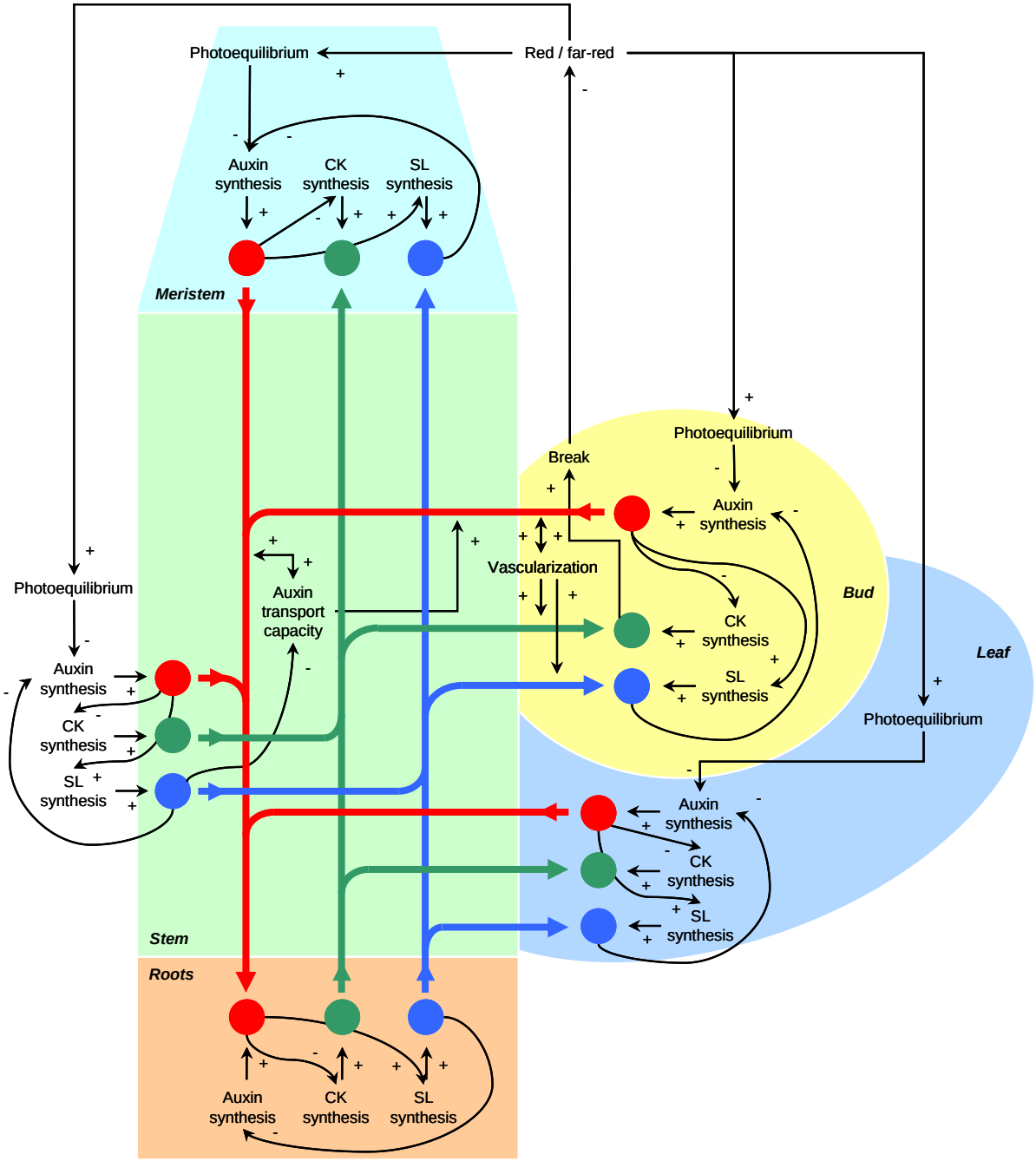
- Bud auxin export at low rate (no vessels) or high rate (vascularised)
- CK and SL import in bud only after vascularisation
- Bud break at sufficiently high bud CK level

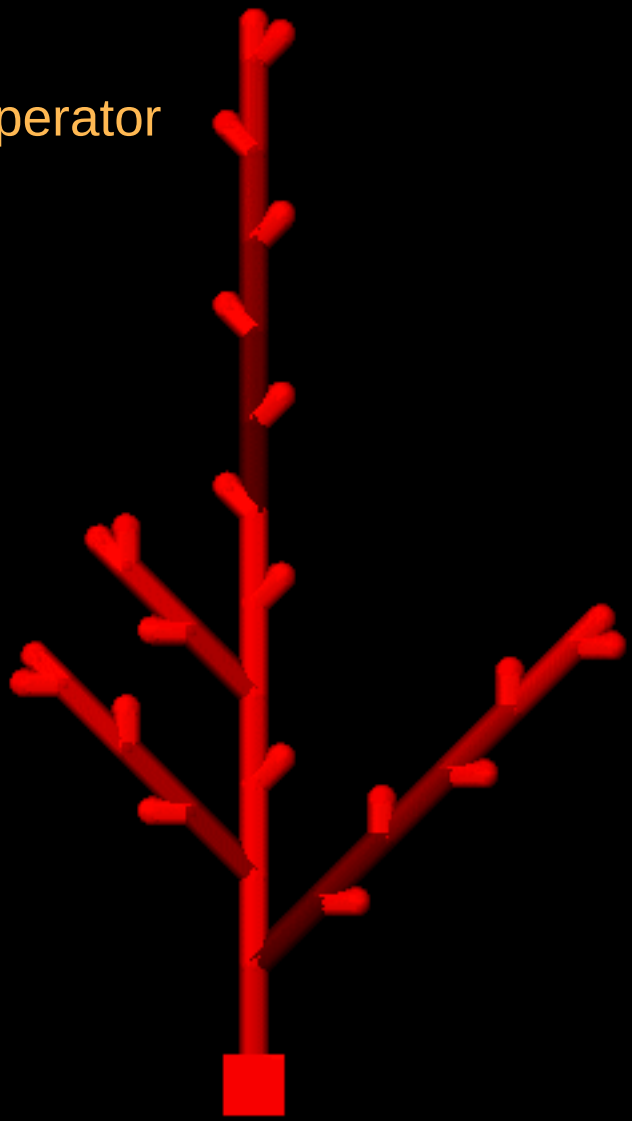

Photoequilibrium
Red / far-red
Auxin synthesis
CK synthesis
SL synthesis
Meristem
Photoequilibrium
Break
Auxin synthesis
Vascularization
Bud
Auxin transport capacity
CK synthesis
SL synthesis
Leaf
Photoequilibrium
Photoequilibrium
Auxin synthesis
CK synthesis
SL synthesis
Auxin synthesis
CK synthesis
SL synthesis
Stem
Roots
Auxin synthesis
CK synthesis
SL synthesis

General implementation

- Two projects:
  - Schematic stick model without light
  - Realistic plant model with light
- *hormone.rgg* – separate file containing ODEs and abstract module Organ

'Stick model' implementation

- Coded in XL (GroIMP)
- ODEs solved using the Rate Assignment Operator
- Considers apex, internodes, buds
- Root system: black box

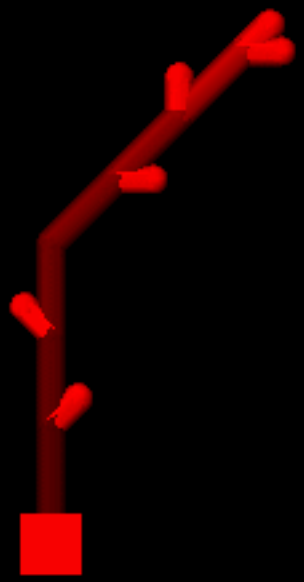


Undisturbed development

max mutant (no SL)

Prusinkiewicz *et al.* (2009)

Decapitation

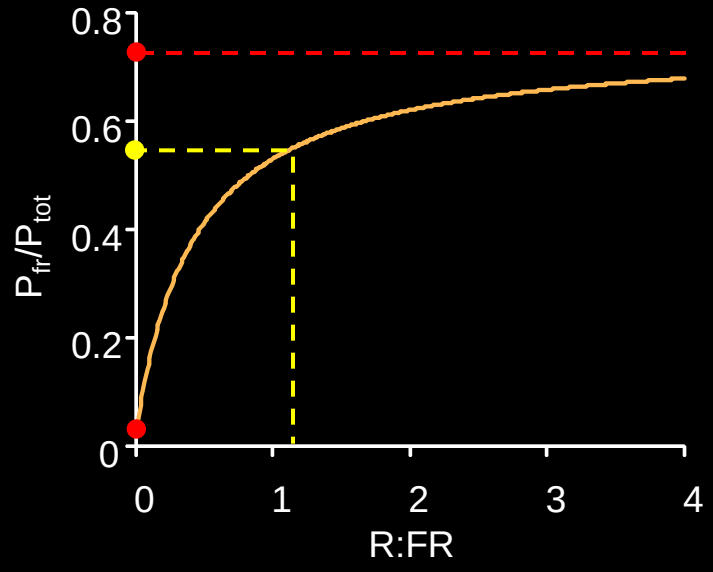


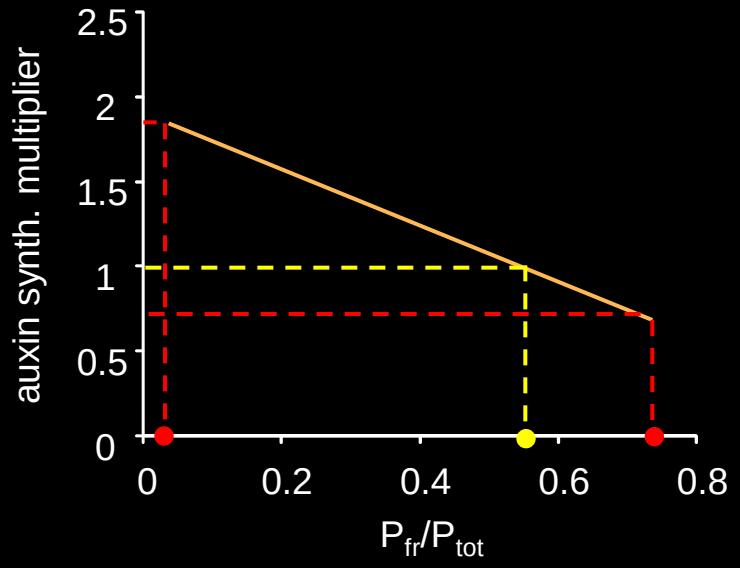
Cline (1996)

Arabidopsis implementation

- Realistic plant architecture
- Red and far-red absorption, reflection and transmission

- Relationship R:FR – phytochrome photoequilibrium
- Relationship phytochrome photoequilibrium – auxin synthesis

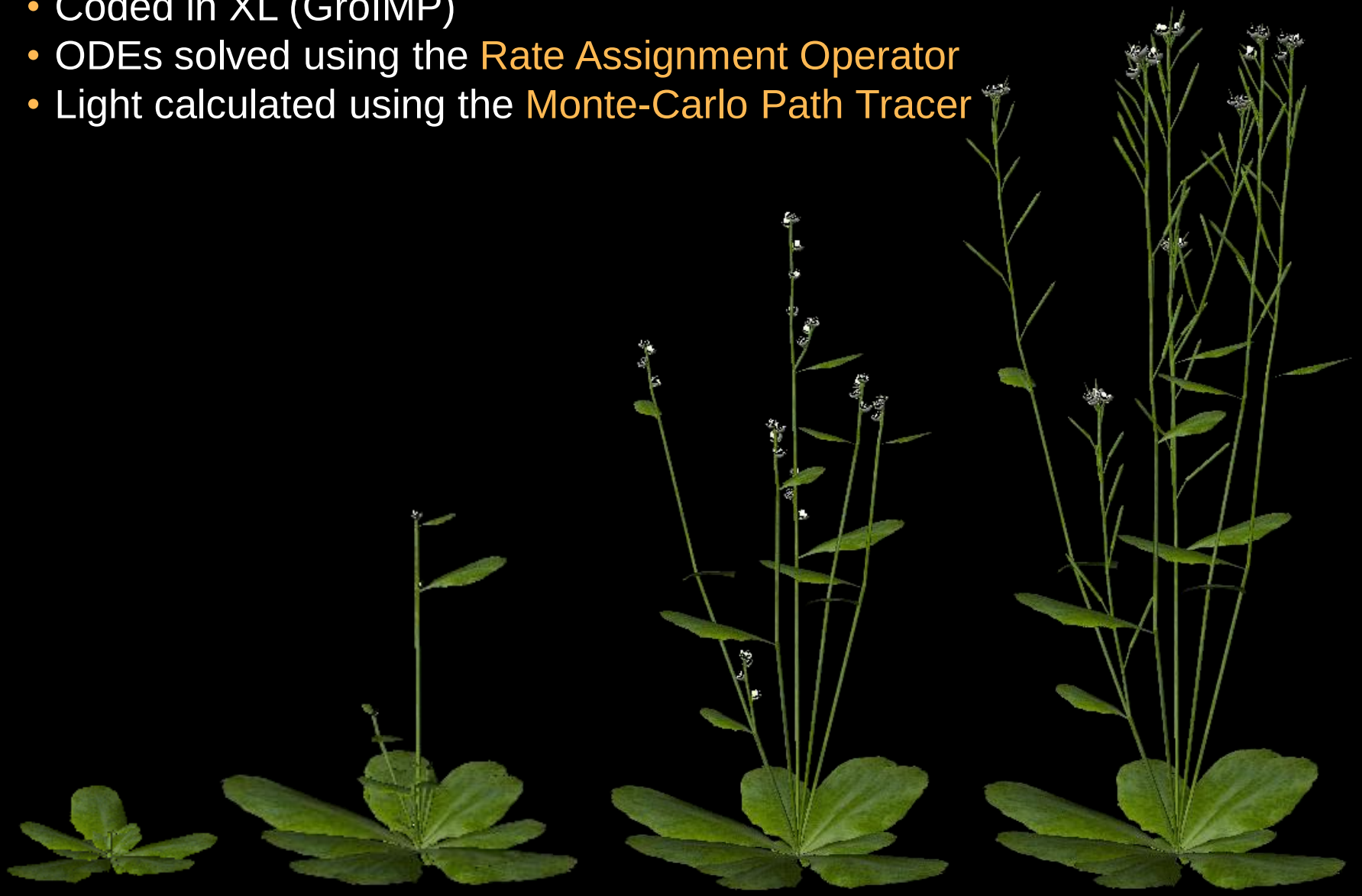


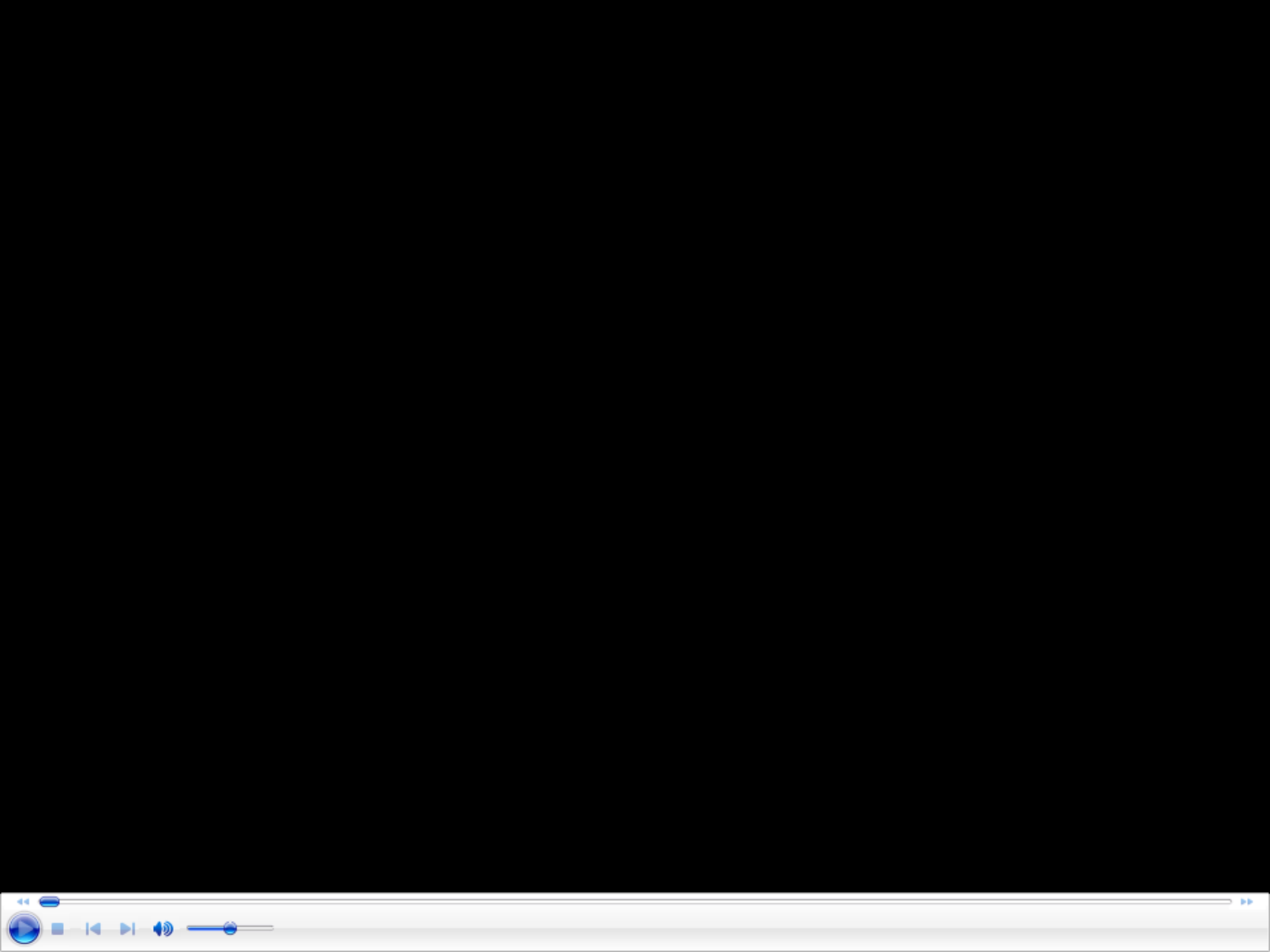


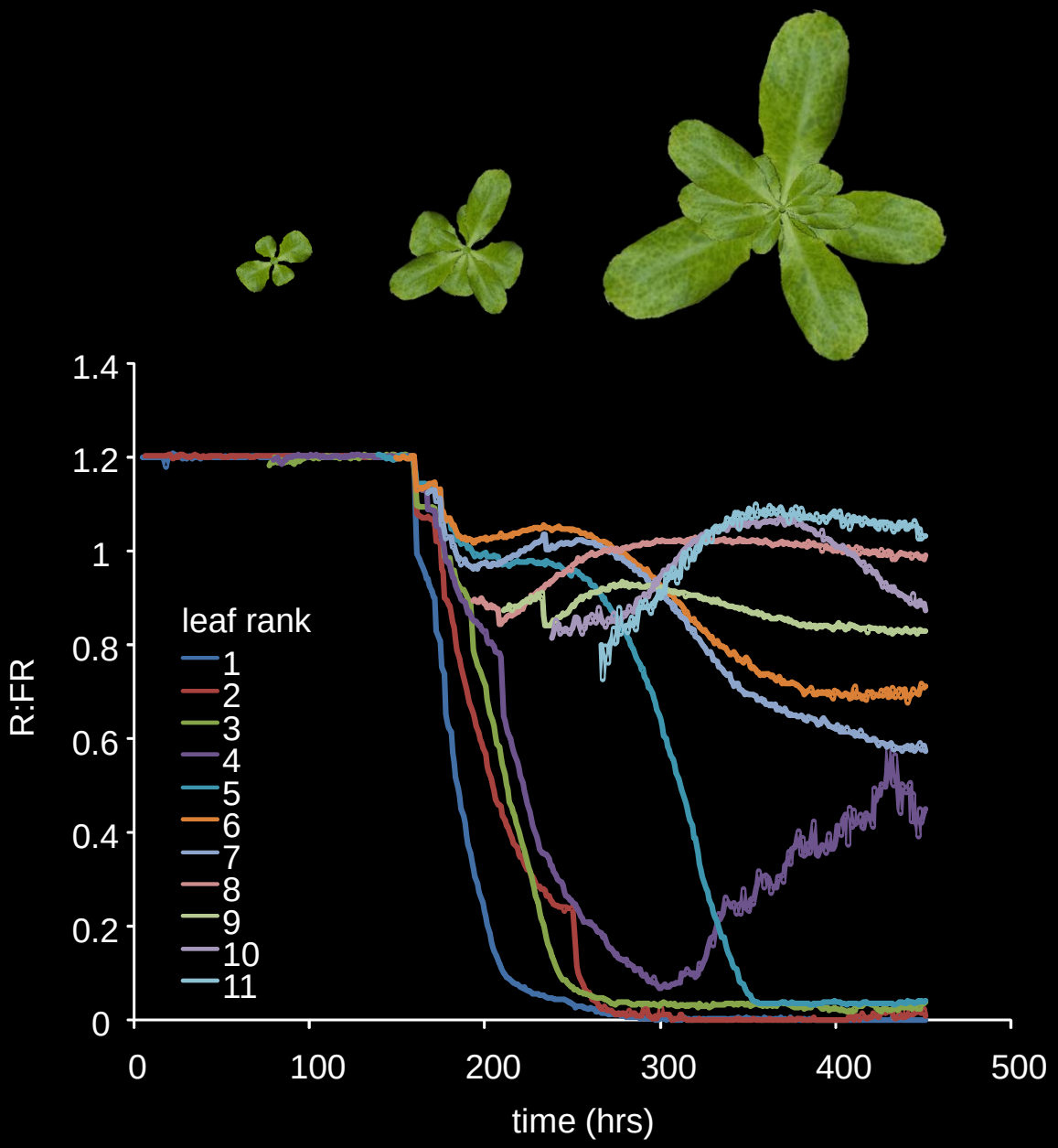
(Burema, 2007)

Arabidopsis implementation

- Coded in XL (GroIMP)
- ODEs solved using the Rate Assignment Operator
- Light calculated using the Monte-Carlo Path Tracer






1.4
1.2
1
0.8
0.6
0.4
0.2
0
R:FR
leaf rank
1
2
3
4
5
6
7
8
9
10
11
0
100
200
300
400
500
time (hrs)

ambient R:FR = 1.2

ambient R:FR = 0.01

Prusinkiewicz *et al.* (2009)

wild-type

max4-mutant

Next steps:

- Improved parameterization of hormone regulatory network model
- Relationship hormone level vs response
- Improved auxin transport model (Prusinkewicz *et al.* 2009)

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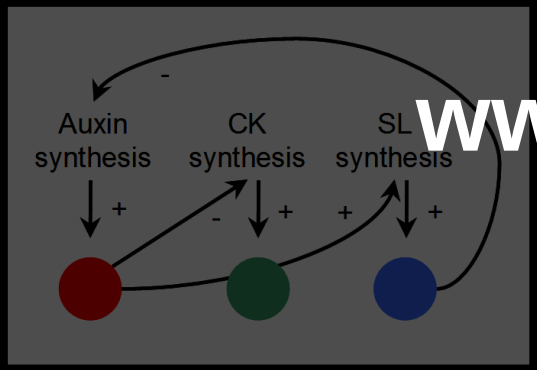
- Analysis of branching of wt and mutants (*brc1, phyB, max*) under low and high R:FR
- Contrasting genotypes of Arabidopsis
- Root architecture & soil nutrient status

- Implementation in crop plant model (*e.g.* rapeseed, rice)
- Community- / field-level

Thanks for your attention!



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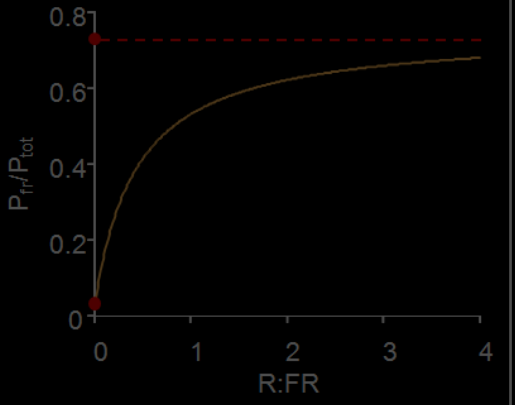

Acknowledgements

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et al…

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