

Académie d'Agriculture
Hommage à Jean Guern
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Signalisation de la dormance des graines médiée par l'acide abscissique

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Dormancy is an adaptive trait

- is defined as the inability of an intact viable seed to complete germination under favourable conditions
- delays germination
- is influenced by environmental conditions
- is released during dry storage

Dormancy impacts on crop seed quality

Preharvest sprouting (germination on the mother plant) may occur when seed dormancy is too low, leading to large economic losses.

Deep dormancy prevents synchronous germination

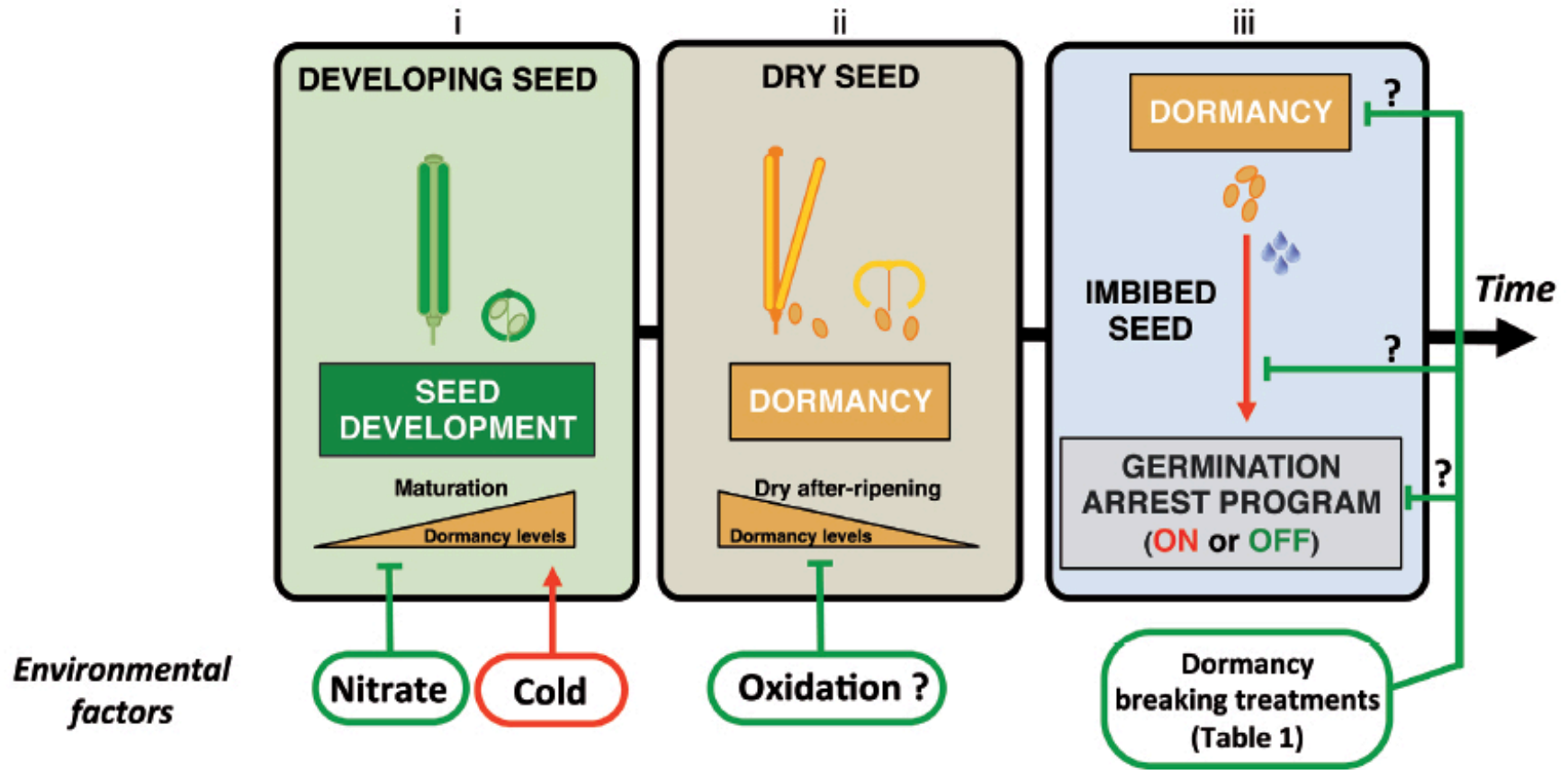


Preharvest sprouting in wheat ears
Holdsworth, Kurup et al., TIPS 2008



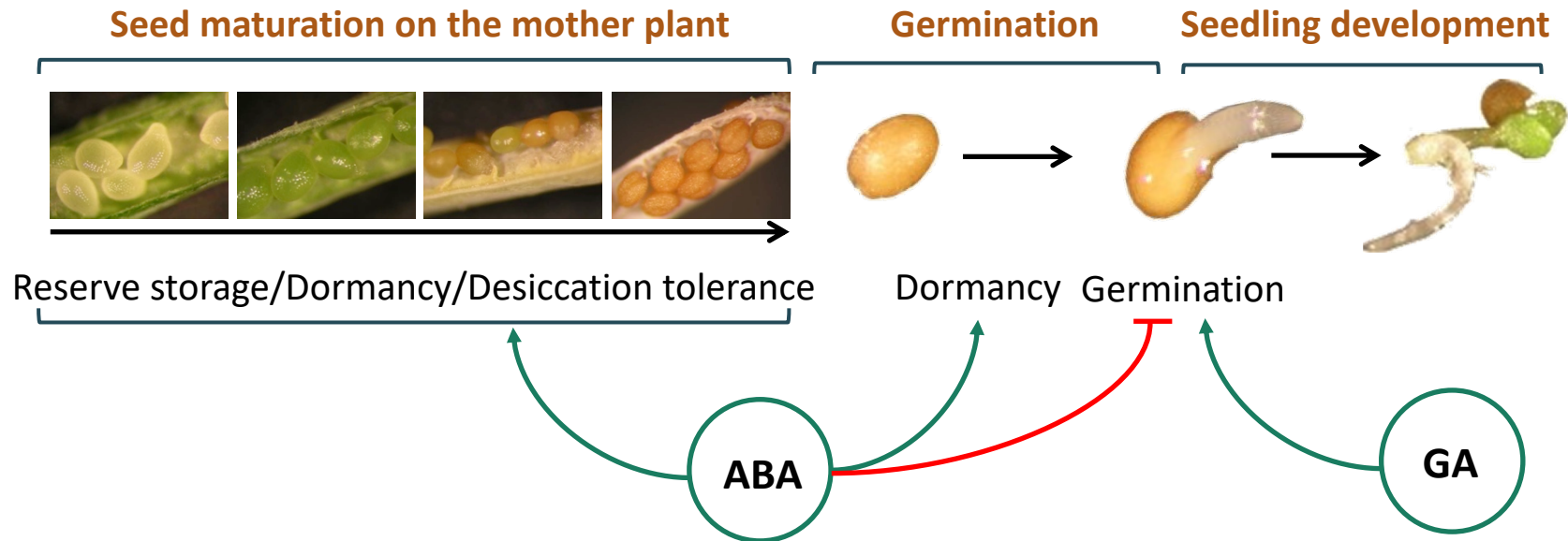
Preharvest sprouting in rapeseed siliques
X. Pinochet

Dormancy is induced during seed development and released upon dry storage



Primary dormancy model

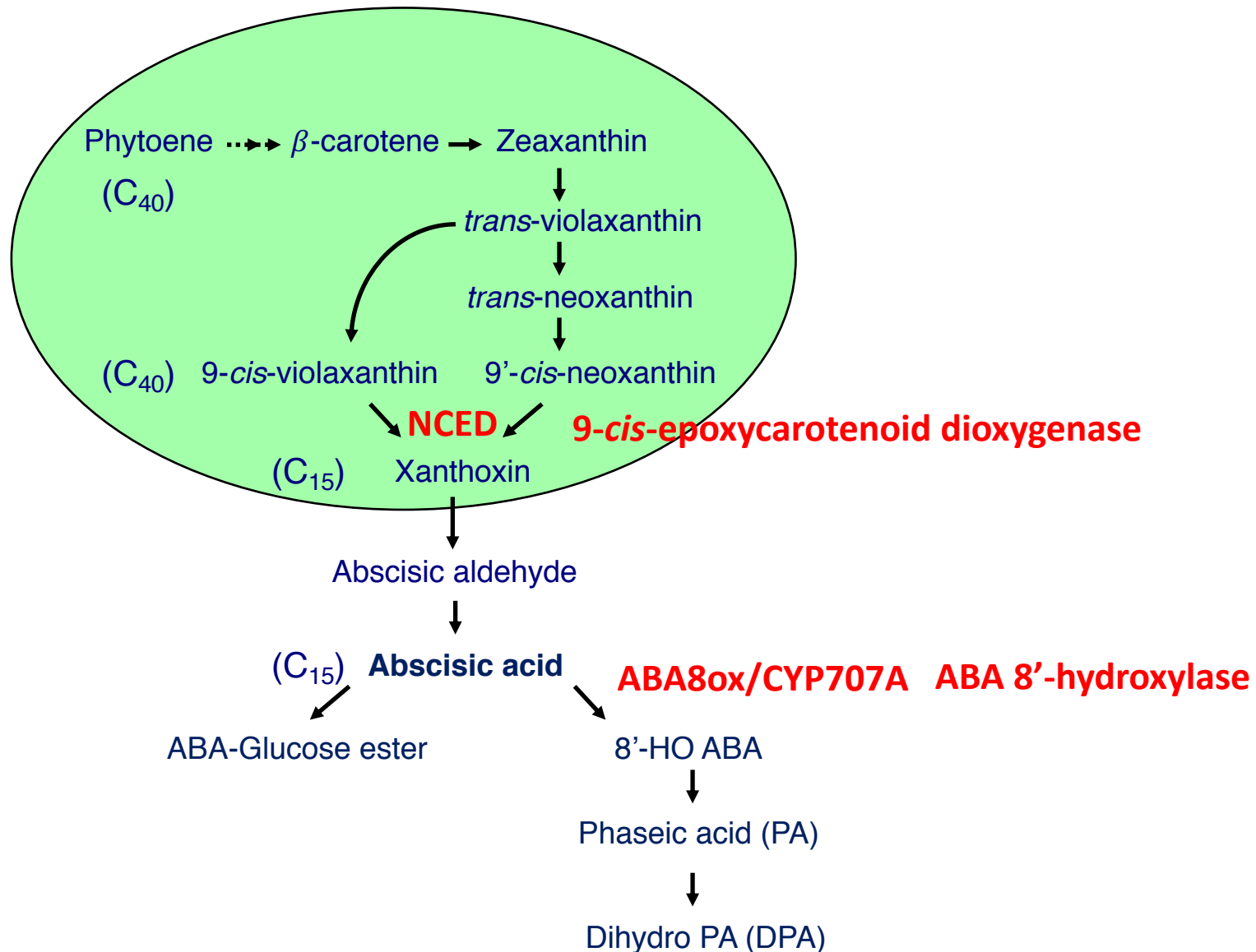
Abscisic acid (ABA) induces dormancy during seed development



ABA synthesis during seed development induces dormancy

ABA degradation upon imbibition allows germination activation by gibberellins (GA)

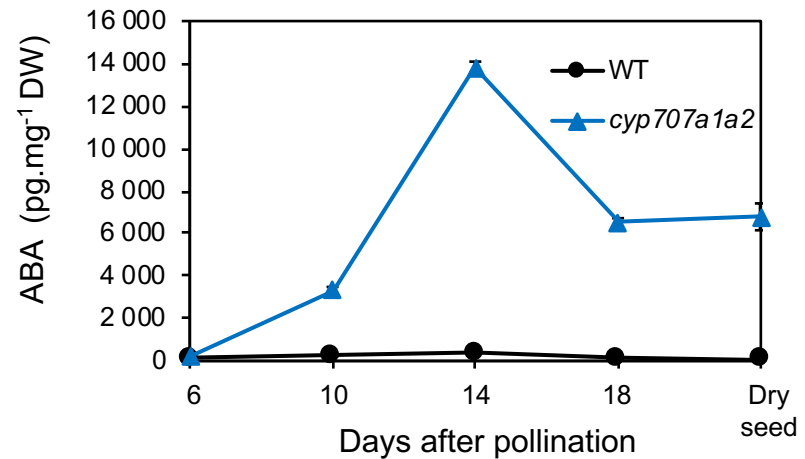
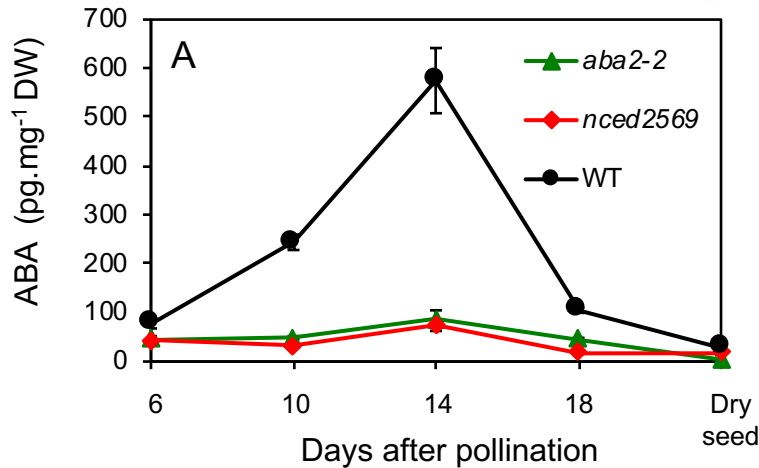
Carotenoid cleavage by NCED and ABA inactivation by CYP707A are key regulatory steps of hormone levels



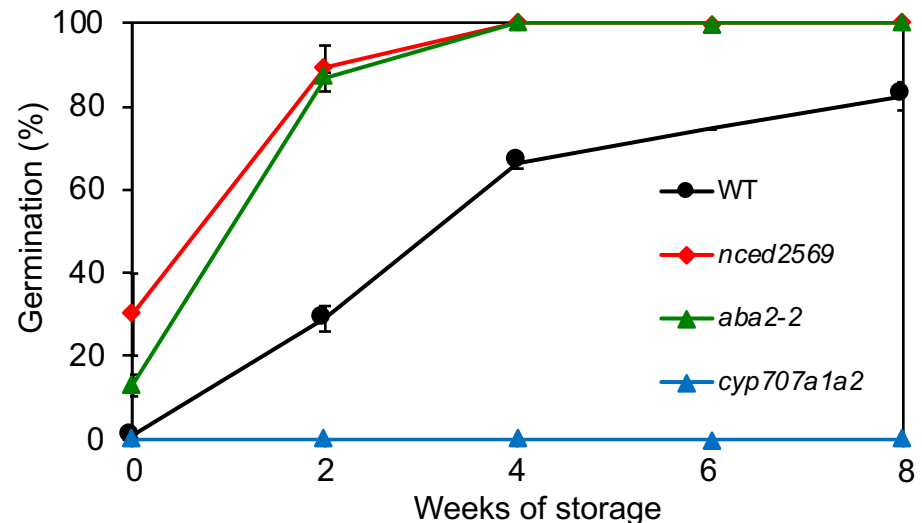
ABA synthesis in developing seeds is required for dormancy induction

Arabidopsis mutants defective in ABA synthesis

in ABA catabolism



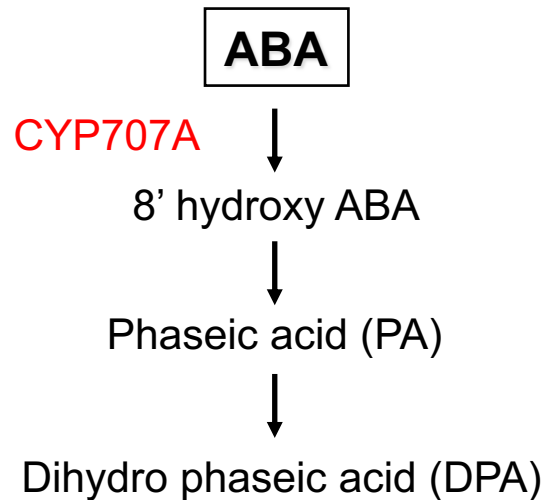
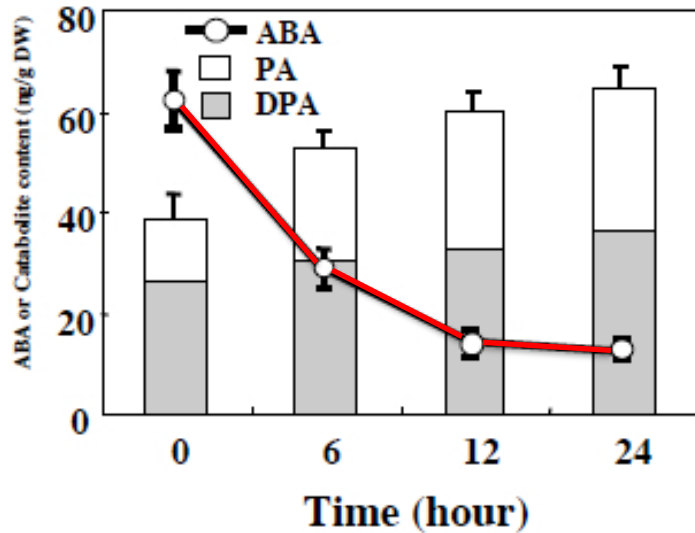
ABA strongly impacts on dormancy depth (after-ripening requirement)



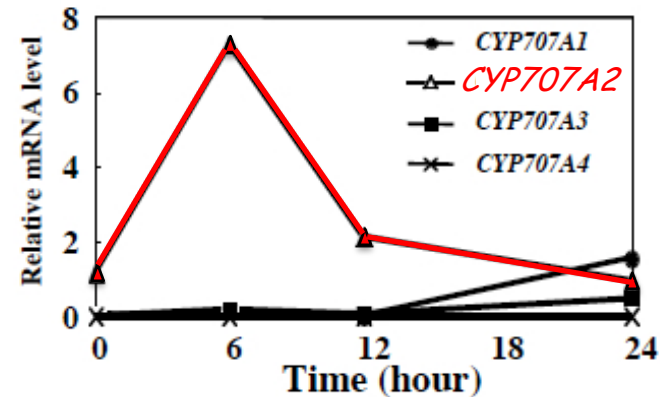
Germination after after-ripening

ABA catabolism precedes seed germination

ABA and catabolites during seed imbibition

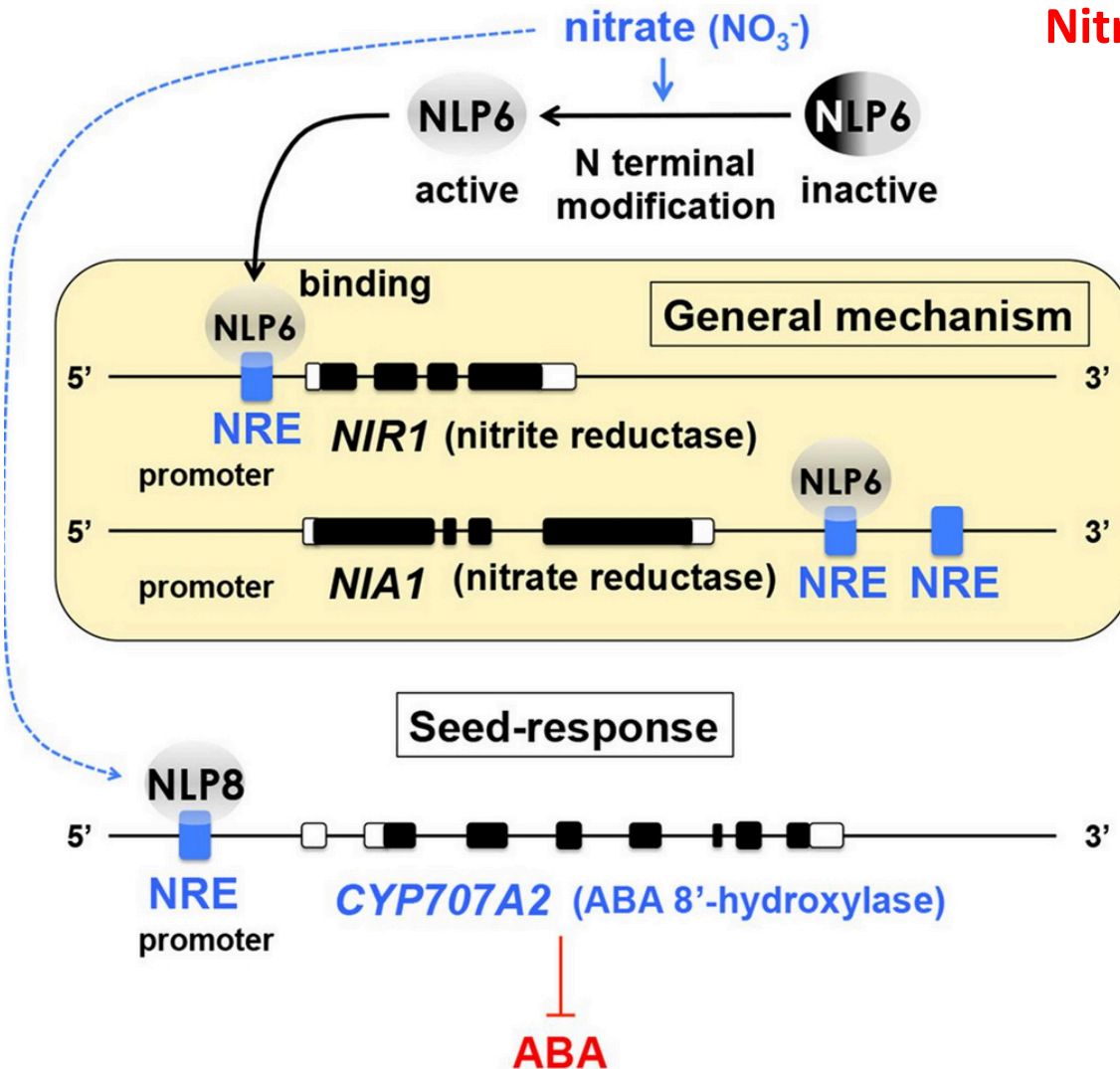


CYP707A gene expression during seed imbibition



ABA degradation upon imbibition allows germination activation by gibberellins (GA)

Dormancy regulation by environmental factors

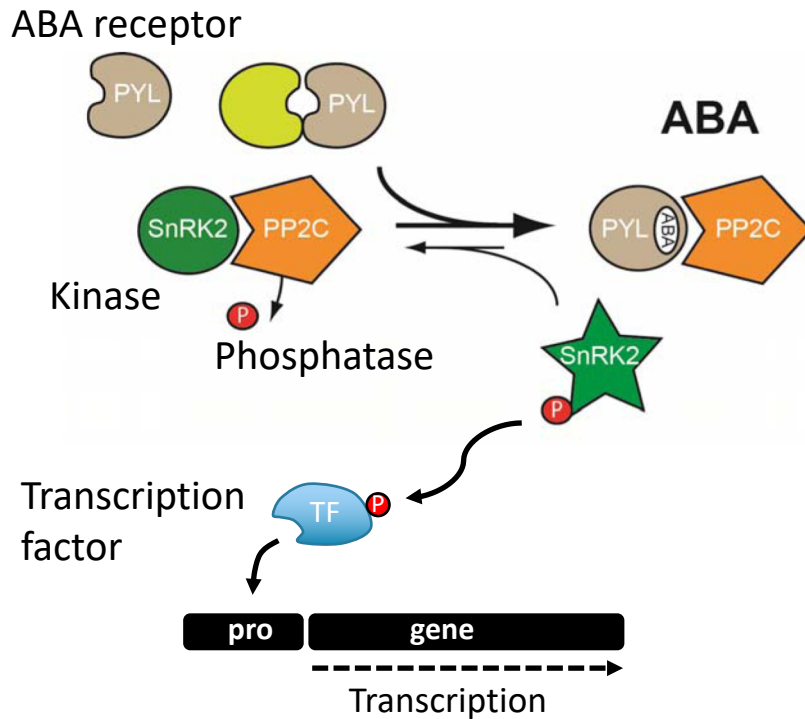


Nitrate activates ABA catabolism

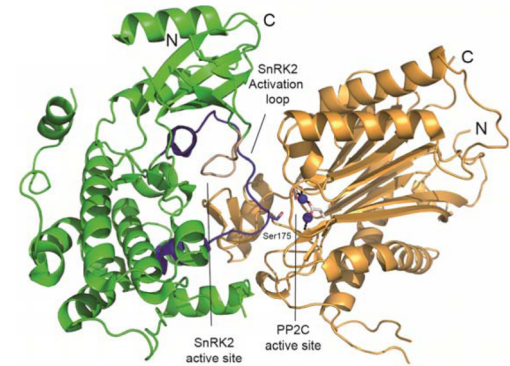
The Nodule Inception (NIN)-like protein NLP6 is activated by nitrate and physically interacts with NREs of *NIR1* and *NIA1*

***CYP707A2* activation by NLP8 upon seed imbibition decreases ABA levels and release seed dormancy**

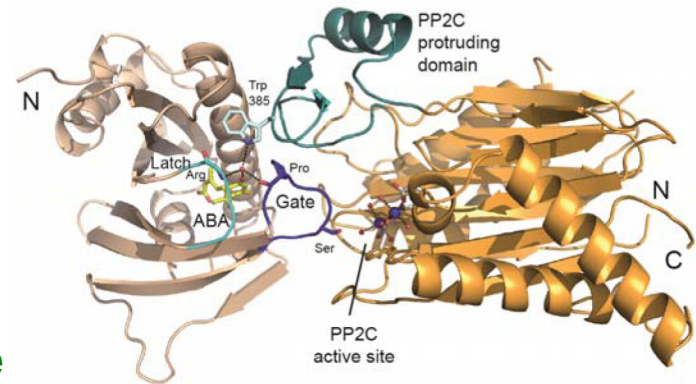
ABA perception and signalling



ABA receptors efficiently compete for the active site of the PP2C with SnRK2



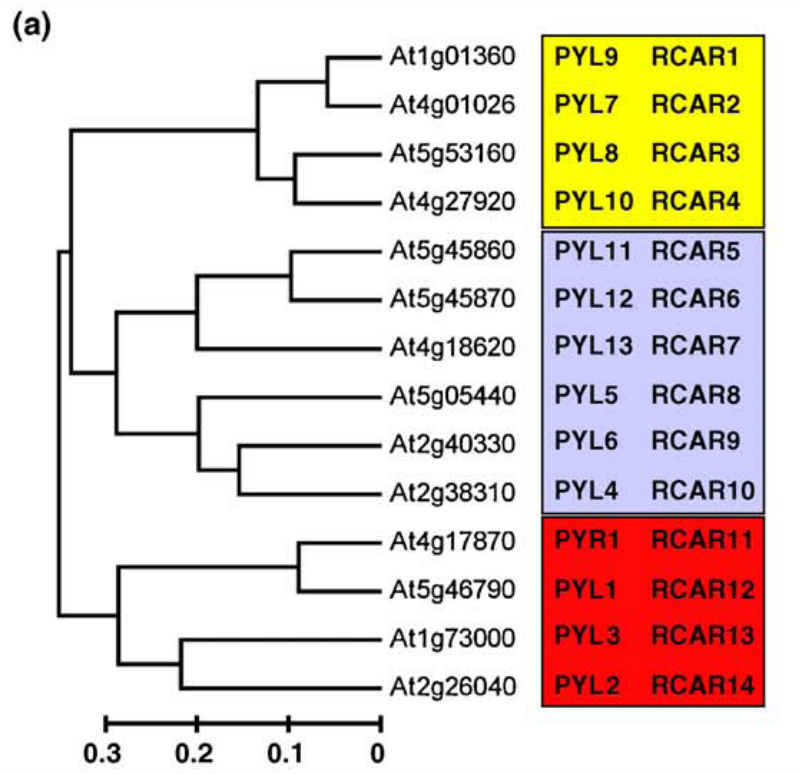
SnRK2-PP2C



Receptor-PP2C

Multigene families encode ABA receptors and PP2Cs

The 14 PYR/PYL/RCARs in Arabidopsis



Common Name	Species	Number of genes
Soybean	<i>Glycine max</i>	23
Corn	<i>Zea mays</i>	20
Western poplar	<i>Populus trichocarpa</i>	14
Rice	<i>Oryza sativa</i>	11
Grape	<i>Vitis vinifera</i>	8
Sorghum	<i>Sorghum bicolor</i>	8
Barrel medic (a model legume)	<i>Medicago truncatula</i>	6
Arabidopsis	<i>Arabidopsis thaliana</i>	14

Klingler, J.P., Batelli, G., and Zhu, J.-K. ABA receptors: the START of a new paradigm in phytohormone signalling. *J. Exp.Bot.* 61: [3199-3210](#) by permission of Oxford University Press; Raghuvaran, A.S., Gougen, V.K., Christmann, A., and Grill, E. (2010) ABA perception and signalling. *Trends Plant Sci.* 15: [395-401](#).

Dormancy regulation by ABA involves the PYL/PP2C/SnRK2 signaling pathway

Three SnRK2 are involved in ABA responses

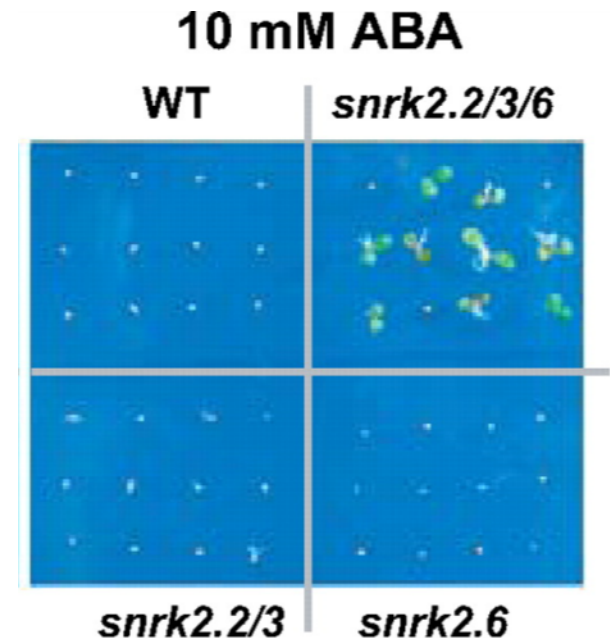


WT *snrk2.2/3* *2/3/6*

Lack of dormancy in triple mutants

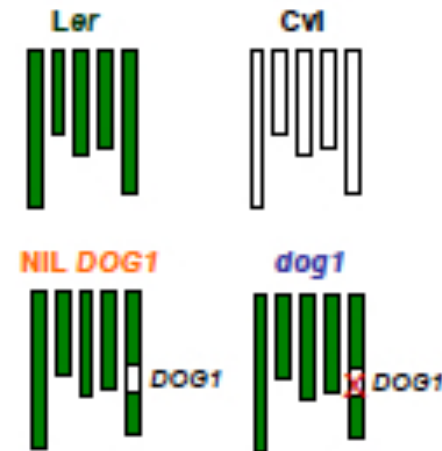
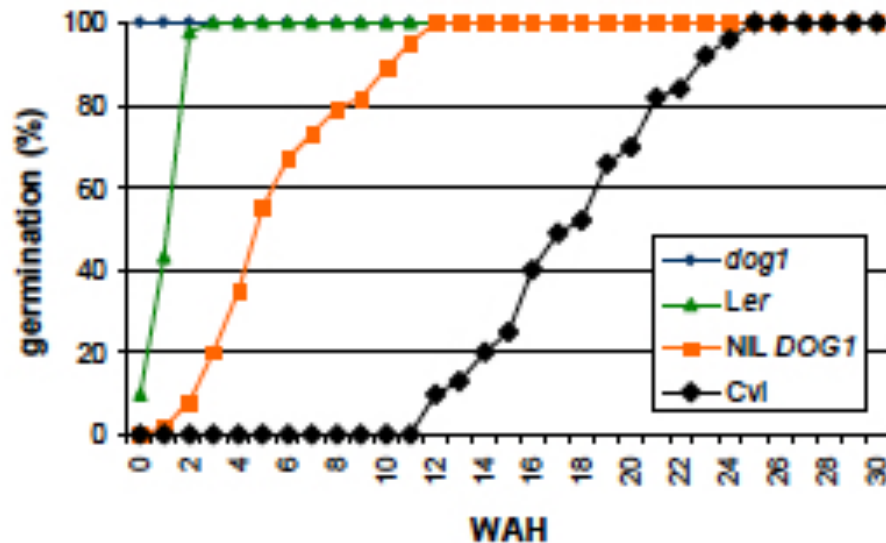
Under 100% humidity, triple *snrk2* mutants are viviparous

The triple mutant is ABA insensitive
in its germination response



DOG1 is a key factor in dormancy induction

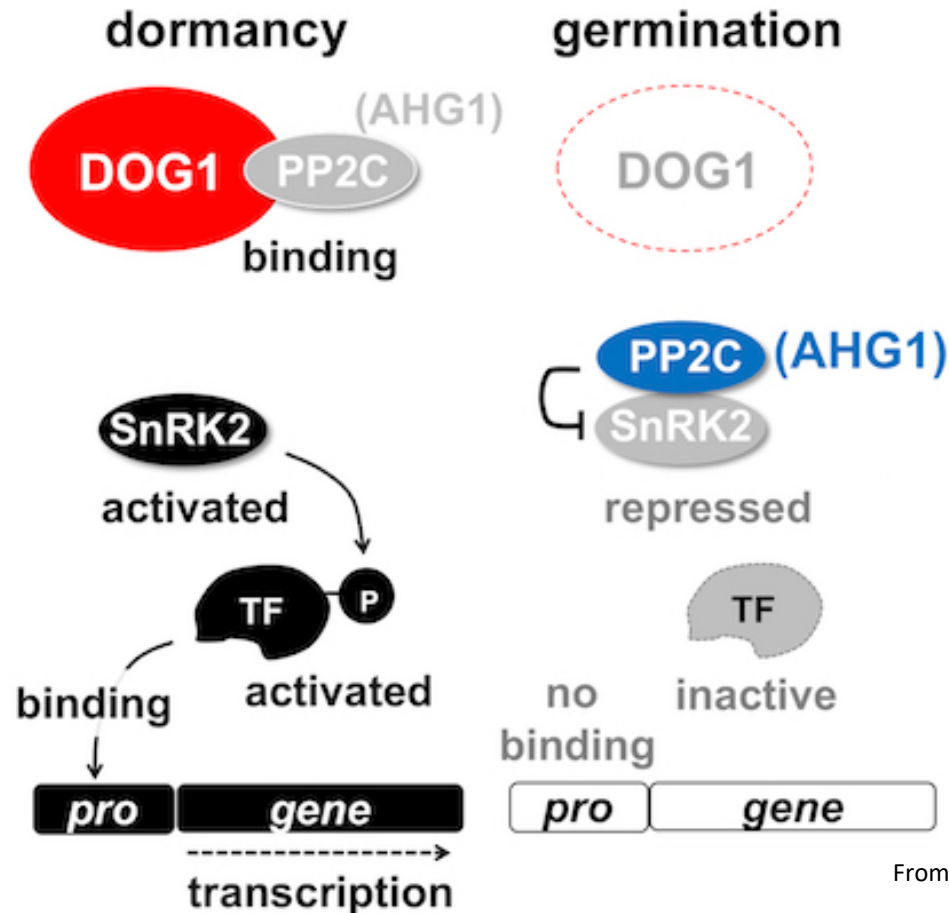
- DOG1 (DELAY OF GERMINATION1) identified by QTL analysis
- Deep dormancy of Arabidopsis seeds from Cape Verde Islands (Cvi accession)
- Dormancy increase by introgression of DOG1 (NIL DOG1) in Landsberg erecta accession (Ler)



Germination after several weeks of dry storage

DOG1 is a heme-binding protein which molecular function is unknown

DOG1 interacts with a subset of PP2C proteins



From Nonogaki, Adv Bot Res 2019

- DOG1 protein sequesters the AHG1 and AHG3 PP2Cs to establish seed dormancy

ABA and DOG1 are central regulators of seed dormancy and integrators of environmental cues

- Essential role of PP2C in crosstalk between ABA and DOG1 signaling
- Several factors in signaling networks (ethylene, cold...) upstream of ABA and DOG1 have been identified
- Increasing evidence for dormancy regulation by epigenetic mechanisms
- The understanding of the complexity of signaling networks and crosstalks remains a important challenge

