Vernalization: cold sensing leading to an epigenetic switch
Vernalization

Acquisition of the *competence* to flower in the spring resulting from exposure to the prolonged cold of winter.
Biennial/winter-annual growth season

- Prevent flowering
- Permit flowering
Time course of cold responses

- Cold Acclimation
- Vernalization
- Bud Dormancy

**Graph:**
- Y-axis: Response
- X-axis: Period of cold (days)
- The graph shows the time course of cold responses with two distinct phases:
  - An initial rapid increase to 100% response within a short period, indicating Cold Acclimation.
  - A gradual increase from 0% to a point, representing Vernalization and Bud Dormancy.

Values:
- 0% at 0 days
- 100% at 10 days
- Gradual increase to 50% around 40 days
Correns, Carl. 1904. Ein typisch spaltender bastard zwischen einer einjährigen und einer Sippe des *Hyoscyamus niger*.
Vernalization Requirement: Natural Variation
(Klaus Napp-Zinn -- FRIGIDA)
*FRI and FLC act synergistically to delay flowering*

*fri/fri; FLC/FLC  FRI/FRI; FLC/FLC  FRI/FRI; flc/flc*

*Loss-of-function mutations in either FRI or FLC eliminate the vernalization requirement.*
Expression of LEAFY in Young Flowers

**LEAFY RNA**

**LEAFY protein**

From D. Weigel
Flowering Pathways in Arabidopsis

Photoperiod and Circadian Clock

CO

Floral Integrators

FT
TSF
?

SOC1
?

Meristem identity

AP1
\downarrow
LFY
Flowering Pathways in Arabidopsis

Photoperiod and Circadian Clock

Floral Integrators

FT
TSF
SOC1
AP1
LFY

Summer/Fall
Winter annual

FRI
FLC
(& relatives)

CO
Rapid-flowering is Derived

Photoperiod and Circadian Clock

CO

Floral Integrators

FT
TSF
?

SOC1
?

AP1

LFY

fri

FLC
Rapid-flowering Arabidopsis is Derived

Photoperiod and Circadian Clock

CO

Floral Integrators

FT

TSF

SOC1

AP1

LFY

flic

FRI
Flowering Pathways in Arabidopsis

Photoperiod and Circadian Clock

CO

Floral Integrators

FT
TSF?

SOC1?

AP1↑↓
LFY

Spring

Vernalization

FLC

FRI

?
Flowering Pathways in Arabidopsis

Photoperiod and Circadian Clock

Floral Integrators

FT
TSF

SOC1

AP1

LFY

Spring

Vernalization

FRI

FLC

CO
Cereals

VRN2

T

Vernalization
Flowering Pathways in Arabidopsis

Photoperiod and Circadian Clock

CO

Floral Integrators

FT
TSF

SOC1

AP1

LFY

Vernalization

Spring
VIN3 is Expressed Only During Prolonged Cold
FRI, FRL1, PAF, EFS, PIE1, etc. 

Fall

Active

VIN3, VRN2, VRN1, etc.

Winter

Initial silenced

Spring

Stable switch

tri-Me on H3K4
Ac on H3K9/K14
PO4 on H3S10
di-Me on H3K9
di-Me on H3K27
Epigenetic Phenomena

**Generationally stable**

Silenced

**Reset each generation**

Silenced

Silenced

Active
Arabidopsis VIN3 gene family (VIN3-Like)

PhD  |  FNIII  |  VID  |  VIN3
PhD  |  FNIII  |  VID  |  VIL1
PhD  |  FNIII  |  VID  |  VIL2
PhD  |  FNIII  |  VID  |  VIL3
        |        |  VID  |  VIL4
Vernalization

Measuring cold

VIN3 induction

Epigenetic switch of target (FLC)

Flowering

Resetting of FLC
Acknowledgements

Past
Ilha Lee
Scott Michaels
Yuehui He

Present
Robert Schmitz
Sibum Sung

Collaborators:
Steve Jacobsen
Koji Goto
Possible similarities?

**Arabidopsis**

- Environmental Cues
- VIN3-Like genes
- Vernalization
- VIN3
- Short Days
- VIL1
- Floral Repressors
- FLC
- FT
- Floral Integrators
- TSF
- SOC1 etc.

**Wheat**

- Vernalization
- TmVIL1
- Short Days
- TmVIL3
- Floral Repressors
- FLM
- TmVRN2
- TmVRN3
- TmVRN1