



ABSCISIC ACID



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A tropical beach scene with palm fronds in the foreground, turquoise water, and a clear blue sky. A white rectangular box is overlaid on the right side of the image.


HISTORY

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- In 1940s, scientists isolated a substance from Sycamore leaves called Dormins. (**Hemberg**)
- In the early 1960s, **Eagles** and **Philip Wareing** confirmed that application of a dormin to a bud would induce dormancy
- **F.T. Addicott** (1963) discovered a substance stimulated abscission of cotton fruit. He named this substance as abscisin II
- In 1964, it became evident that the three groups had discovered the same plant hormone.
- Later on the name was changed to abscisic acid (ABA).



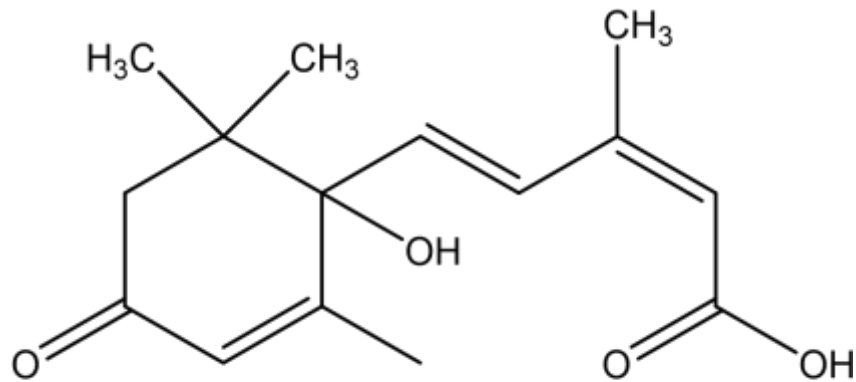
Platanus occidentalis
(Sycamore)



CHEMICAL COMPOSITION

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- ABA is a 15-C Sesquiterpene compound
- Composed of three isoprene residues
- Cyclohexane ring with keto, one hydroxyl group, a side chain with a terminal carboxylic group

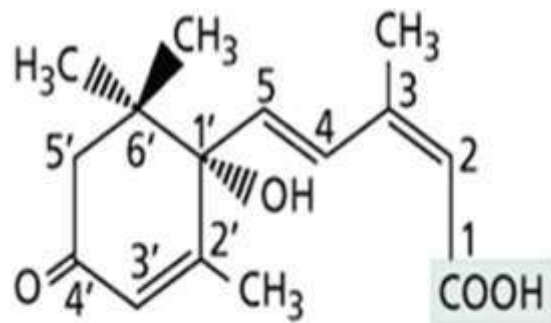


Abscisic Acid

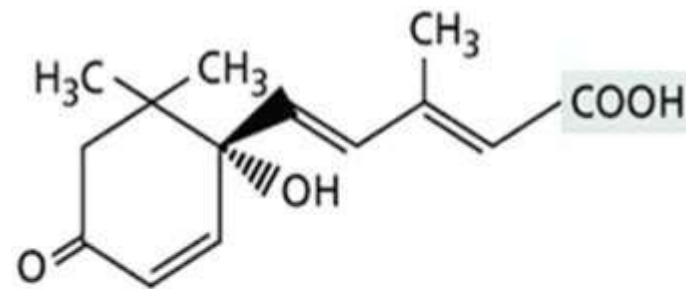


- **Synonyms** 1) ABA 2) Dormin 3) Absicin II
- **Molecular Formula** $C_{15}H_{20}O_4$
- **Molecular Weight** 264.32 g
- **Appearance** White crystals
- **Purity** 98%
- **Melting point** 183-186°C
- **Loss on drying** < 0.5 %
- **Chemical name** Abscisic acid; (2-cis,4-trans)-5-(1-Hydroxy-2,6,6-trimethyl-4-oxo-2-cyclohexen-1-yl)-3-methyl-2,4-pentadienoic acid

- The orientation of carboxylic group at carbon 2 determines the cis and trans isomers of ABA
 - Cis-Absciscic acid (biologically active)
 - Trans-Absciscic acid (biologically inactive)
 Nearly all the naturally occurring ABA is in the cis form



(S)-cis-ABA
(naturally occurring active form)



(S)-2-trans-ABA
(inactive, but interconvertible with active [cis] form)



OCCURRENCE AND DISTRIBUTION



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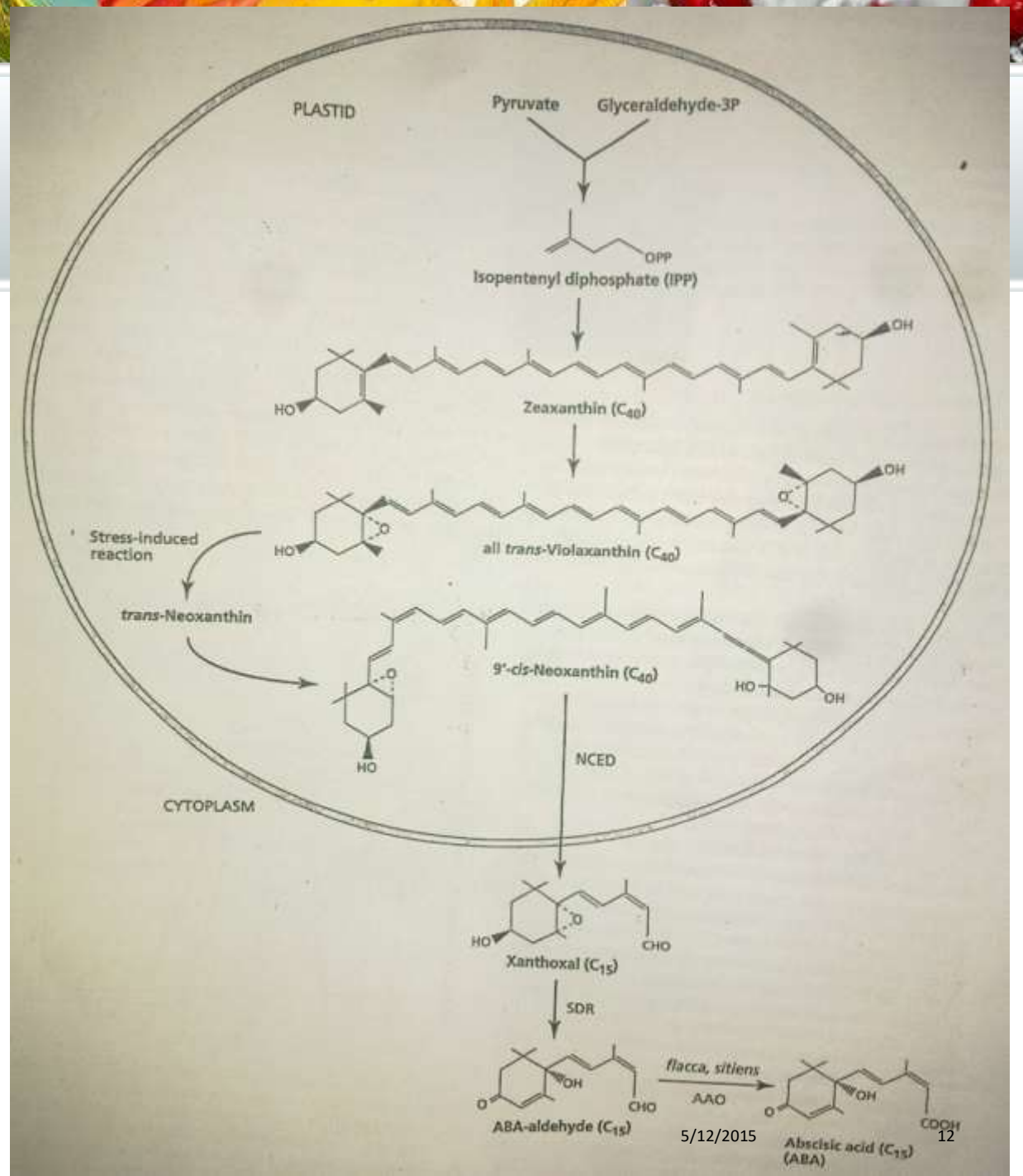
- ABA is a ubiquitous plant hormone in vascular plants
- In bryophytes it has been found in mosses but not in liverworts.
- Some fungi synthesize ABA as secondary metabolite
- A 15-C compound called lunularic acid has been found in algae and liverworts
- ABA is synthesized in all types of cells that contain chloroplasts or other plastids
- It occurs predominantly in mature green leaves
- ABA has been detected in all major organs or living tissues from root caps to apical buds
- Phloem sap, xylem sap and in nectar



BIOSYNTHESIS

BIOSYNTHESIS

- Initial stages occur in the plastids, where isopentenyl diphosphate (IPP) is converted to the C40 xanthophyll zeaxanthin
- Zeaxanthin is further modified to 9-cis-neoxanthin, which is cleaved by the enzyme NCED (9-cis epoxycarotenoid dioxygenase) to form the C15 inhibitor, xanthoxal
- Xanthoxal is then converted to ABA in the cytosol





- Mutants have been isolated that cause defects in the conversion of ABA aldehyde into ABA
- Flacca and Sitiens in *Solanum lycopersicum*
- *nar2a* in *Hordeum vulgare*
- *Aba3* and *aa3* in *Arabidopsis*



ABA TRANSPORT IN PLANT



ABA TRANSPORT IN PLANT

- Externally applied ABA – distributed in all directions
- Cell to cell transport is slow
- ABA synthesized in root cap transported to central vascular tissue
- Transported mostly in its free form
- Transported in a conjugated form as ABA - **β - D-glucosyl ester**
- Redistribution of ABA – pH gradient
- At low pH protonated or un-dissociated form (ABAH)
- At high pH dissociated form (ABA⁻)



ABA SIGNAL TRANSDUCTION PATHWAY



ABA SIGNAL TRANSDUCTION PATHWAY

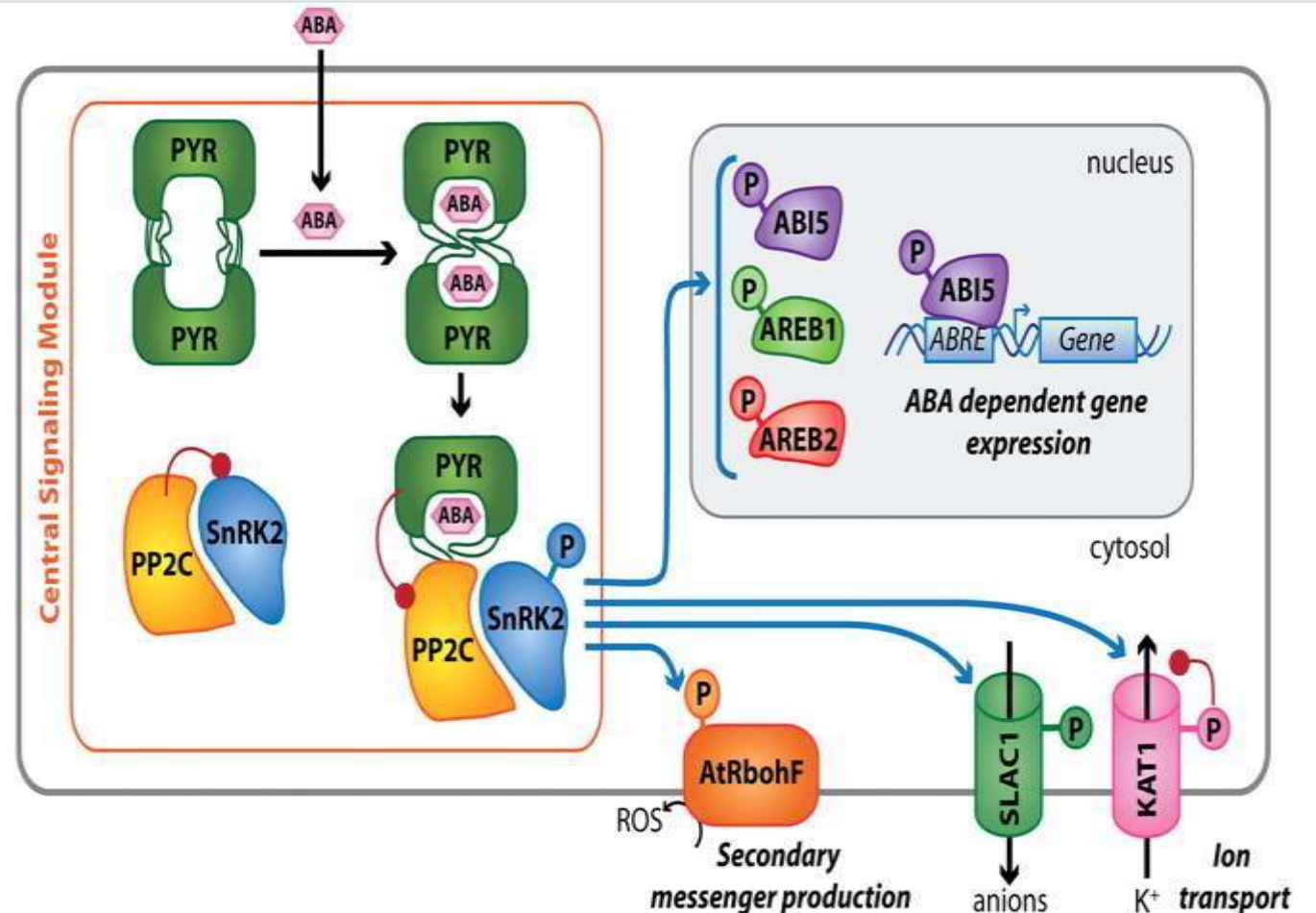
- Abscisic acid elicits two response
 1. Rapid response
 2. Gradual responses
- These fast and slow responses use different receptors
- There are multiple ABA receptors which are soluble and membrane bound
- Three classes of ABA receptors
 1. Plasma membrane localized(G proteins)
 2. Plastid localized enzyme
 3. Cytosolic ligand binding proteins (START domain superfamily)




- **Soluble START proteins** are principle ABA receptors that function in stomatal closing and germination
- First experiment perform in *Arabidopsis*
- PY (pyrabactin) is a synthetic compound similar to ABA
- Genes conferred insensitivity to PY cloned called PYR1
- In *Arabidopsis* PYR and PYL are START domain proteins and ABA dependent inhibitors of one class protein phosphatase type 2(PP2C)
- ABI1 and ABI2 member of PP2C



- In different experimental approach
- Protein- protein interaction
- Using of ABI1 and ABI2 Isolation of PYR1/PYL homologs called RCARs
- PYR1/PYL/RCAR group bind ABA and function as receptor
- These kinases modulate the activity of ion channels like potassium
- Modulate transcription factors like ABFs that regulate the activity of genes containing ABA response elements (ABREs)





DEVELOPMENTAL AND PHYSIOLOGICAL ROLE OF ABA

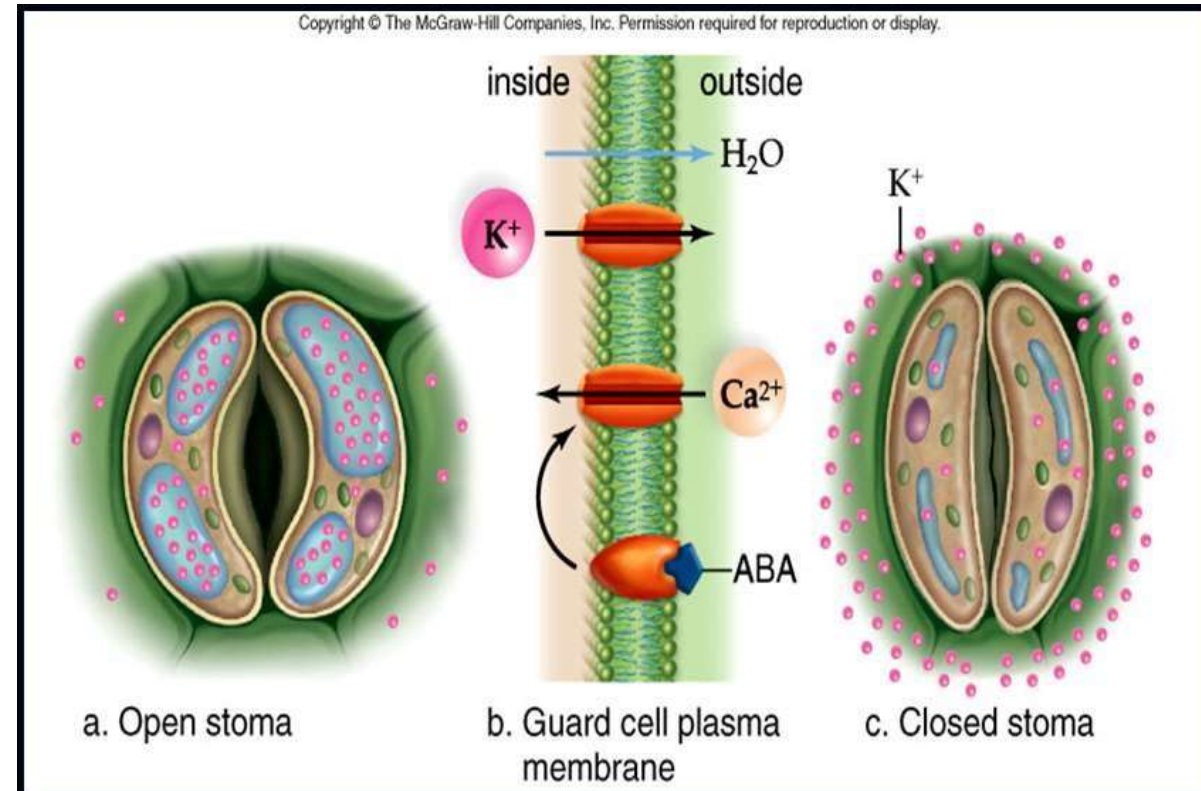


DEVELOPMENTAL AND PHYSIOLOGICAL ROLE OF ABA

- Promotes stomatal closing.
- Induces bud dormancy and seed dormancy.
- Promotes desiccation tolerance in the embryo.
- Inhibits precocious germination and vivipary
- Promotes root growth and inhibits shoot growth in stressed water condition
- Leaf Senescence

PROMOTES STOMATAL CLOSING

- ABA plasma membrane receptor
- Mutants that lack the ability to produce ABA exhibit permanent wilting and are called wilty mutants because of their inability to close their stomata.
- Stomatal closing can also be caused by ABA synthesized in the roots and exported to the shoot



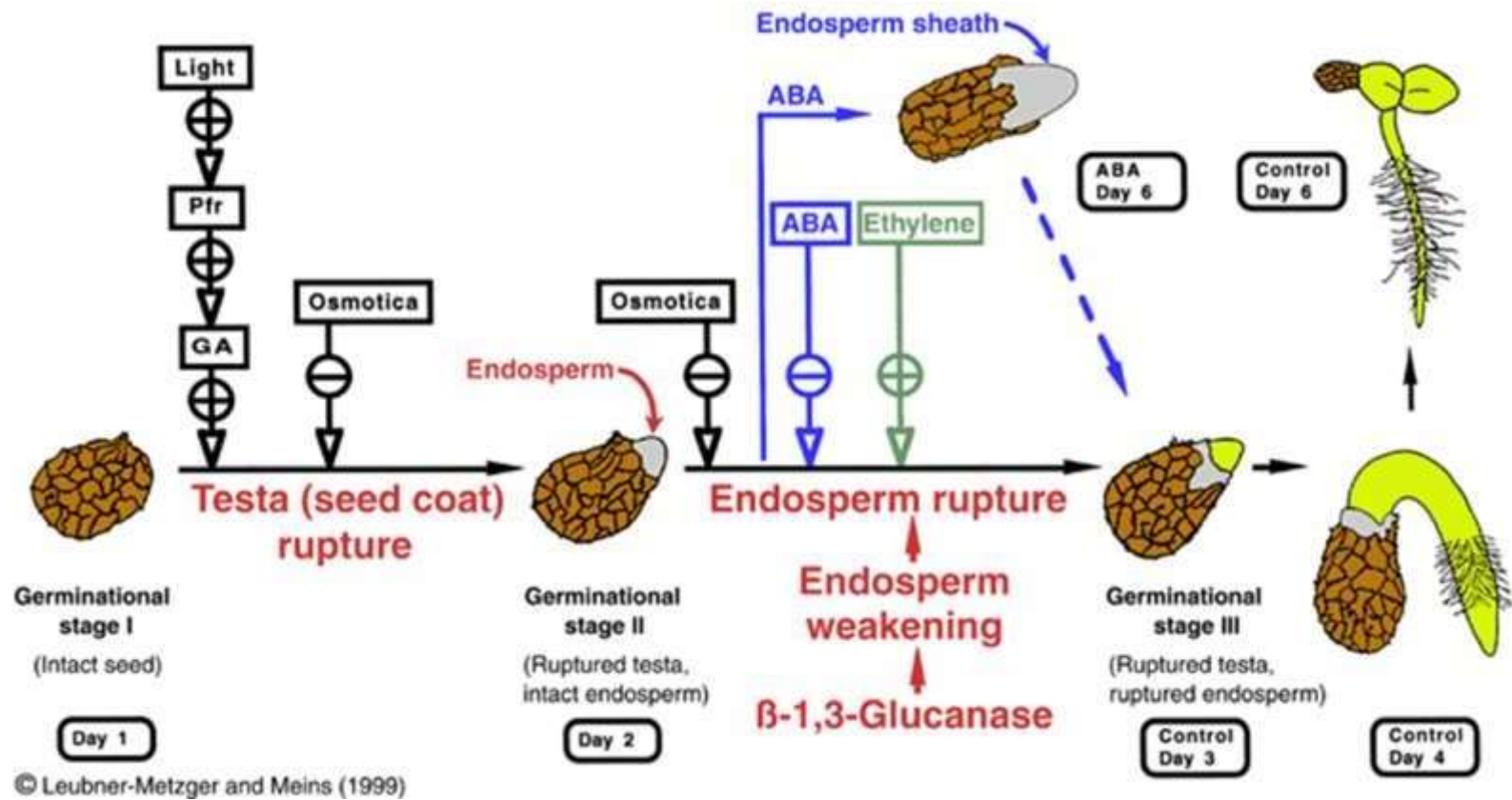


INDUCES SEED DORMANCY

- Growth of the seed suspended -“dormant seeds”.
- Primary dormancy and secondary dormancy
- Controlled by the ratio of ABA to GA
- Embryo dormancy is due to the presence of inhibitors, especially ABA, as well as the absence of growth promoters, such as GA.
- The loss of embryo dormancy is often associated with a sharp drop in the ratio of ABA to GA

WORKING MODEL FOR TOBACCO SEED GERMINATION

- promote (+) or inhibit (-) class I β -1,3-glucanase induction
- GA = gibberellin(s); ABA = abscisic acid; Pfr = Phytochrome

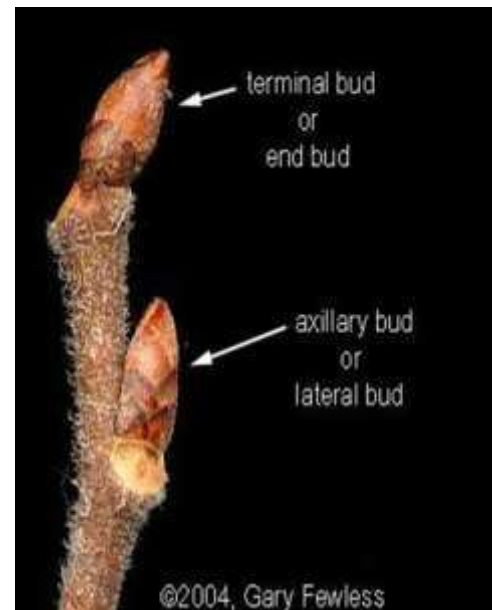


INDUCE DORMANCY OF BUDS

- Dormant bud - shortened internodes and specially modified leaves – “BUD SCALES”
- Most of the trees - buds formed late summer and remain dormant throughout winter.
- Levels of endogenous ABA is high
- Herbaceous plants - eg. Potato



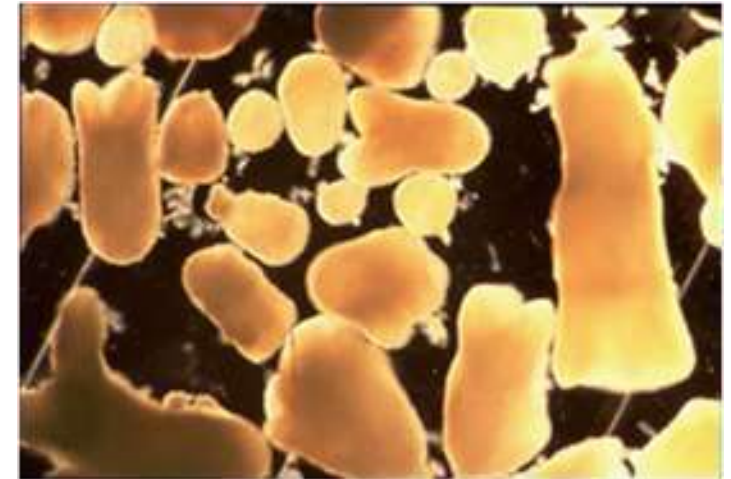
Potato – EYE (bud)



Woody plant Bud

PROMOTES DESICCATION TOLERANCE IN THE EMBRYO

- An important function of ABA -developing seed - desiccation tolerance.
- Levels of ABA in seeds peak during embryogenesis.
- During the mid- to late stages of seed development, specific mRNAs accumulate in embryos.
- These mRNAs encode so-called late-embryogenesis-abundant (LEA) proteins.
- Synthesis of many LEA proteins induced by ABA treatment.





INHIBITS PRECOCIOUS GERMINATION AND VIVIPARY

- When immature embryos are removed from their seeds and placed in culture medium they germinate precociously
- ABA added to the culture medium inhibits precocious germination
- This result, in combination with the fact that the level of endogenous ABA is high during mid- to late seed development, suggests that ABA is the natural constraint that keeps developing embryos in their embryogenic state
- During seed development , embryos of monocot and dicot plants may fail to complete maturation and germinate while the immature seed is still attached to the maternal tissue. This phenomenon is referred to as vivipary or preharvest sprouting



- In maize, several viviparous (vp) mutants have been selected in which the embryos germinate directly on the cob while still attached to the plant
- Vivipary in the ABA-deficient mutants can be partially prevented by treatment with exogenous ABA





SHOOT AND ROOT GROWTH

- ABA has different effects on the growth of roots and shoots, and the effects are strongly dependent on the water status of the plant.
- Maize :
- Two types of seedlings were used
- (1) wild-type seedlings with normal ABA levels
- (2) an ABA-deficient, viviparous mutant
- This suggests that
 - 1. Endogenous ABA promotes shoot growth in well watered plants.
 - 2. Endogenous ABA acts as a signal to reduce shoot growth only under water stressed conditions



LEAF SENESCENCE

- The deteriorative processes that naturally terminate their functional life referred to as “senescence”.
- Expression of senescence associated genes (SAGs) increases
- Hydrolytic enzymes- proteases, ribonucleases, lipases
- ABA involved in “senescence of leaves” but not the abscission of leaves



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