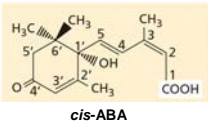


Lecture 13: Abscisic acid (ABA)



Discovery

Biosynthesis

Physiological effects

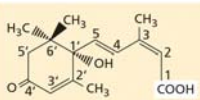
Signal transduction



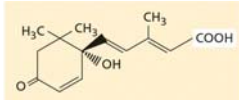
Platanus occidentalis
(Sycamore)

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ABA structures and occurrence



Naturally occurring active form



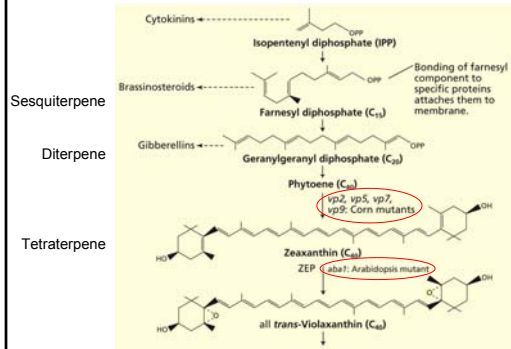
Inactive, but interconvertible with active (*cis*) form

- ABA ubiquitous in vascular plants; detected in mosses, but absent in liverworts
- ABA present in every major organ or living tissue from root cap to apical bud
- ABA synthesized in almost all cells that contain chloroplasts and amyloplasts

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ABA biosynthesis

... via the terpenoid pathway in chloroplasts and other plastids
... from a carotenoid intermediate



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ABA biosynthesis cont.

NCED: 9-cis-epoxy-carotenoid dioxygenase;
its synthesis is rapidly induced by water stress;
localized on thylakoids

ABA-aldehyde (C₁₅)

Abscisic acid (C₁₅)

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Vivipary in ABA-deficient seeds

Vivipary (preharvest sprouting)
= the precocious germination of seeds in the fruit while still attached to the plant

Vivipary is a feature of many ABA-deficient seeds

ABA-deficient vp14 mutant of maize

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ABA concentration and distribution in tissue

ABA biosynthesis and concentrations fluctuate during

- development
- in response to changing environmental conditions

Examples:

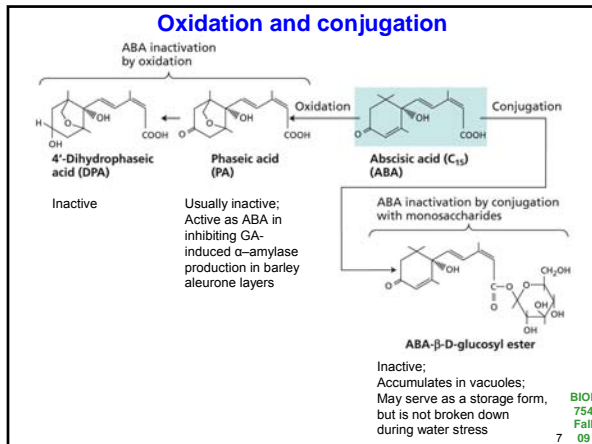
- in developing seeds, ABA levels increase 100-fold within a few days and decline as maturation proceeds
- under drought stress, ABA levels in leaves increase 50-fold within 4-8 hrs; upon re-watering, ABA level declines to normal level in same amount of time

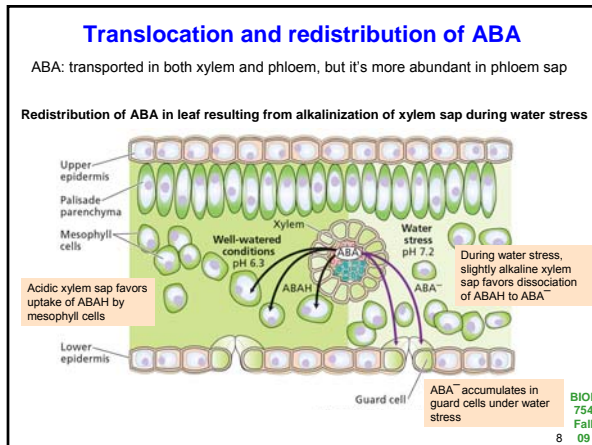
ABA concentrations in tissue regulated by:

- biosynthesis
- other plant hormones
- degradation
- compartmentation
- conjugation
- transport

Example: cytosolic ABA increases during water stress as result of synthesis in leaf, redistribution within the mesophyll cell, import from roots and recirculation ion from other leaves;
After re-watering, concentration of ABA declines because of degradation and export from leaf and decreased synthesis rate

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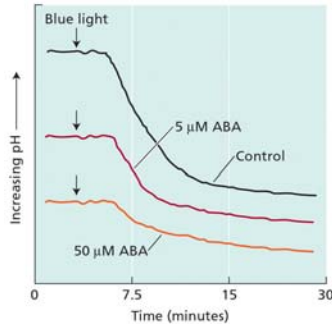


Developmental and physiological effects of ABA

- ABA levels in seeds peak during embryogenesis
- ABA promotes desiccation tolerance in the embryo
- ABA promotes accumulation of seed storage protein during embryogenesis
- Seed dormancy may be imposed by the seed coat or the embryo (environmental factors control the release from seed dormancy)
- Seed dormancy is controlled by the ABA:GA ratio
- ABA inhibits precocious germination and vivipary
- ABA accumulates in dormant buds
- ABA inhibits GA-induced enzyme production
- ABA promotes root growth and inhibits growth at low water potentials
- ABA closes stomata in response to water stress
- ABA promotes leaf senescence independently of ethylene

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ABA inhibits blue light-stimulated proton pumping by guard cell protoplasts



1. A pulse of blue light activates the plasma membrane H⁺-ATPase, which pumps protons into the external medium and lowers the pH.
2. Addition of ABA to the medium inhibits acidification by 40%.
3. Results demonstrate that ABA induces changes in the cell that inhibit the plasma membrane H⁺-ATPase.

(The starting pH was the same in all cases.)

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Factors involved in ABA signal transduction

ABA stimulates phospholipid metabolism

- In bean (*Vicia faba*), ABA stimulates phosphoinositide metabolism and the release of IP₃ (inositol triphosphate), serving as a secondary messenger
- In Arabidopsis, antisense DNA experiments that block expression of an ABA-induced phospholipase C showed that this enzyme is required for ABA effects on germination, growth, gene expression

Protein kinases and phosphatases

- Evidence for ABA-activated protein kinase (AAPK) in bean; AAPK is an autophosphorylating kinase that either forms part of a Ca²⁺-independent signal transduction pathway for ABA, or acts further downstream

ABI protein phosphatases are negative regulators of the ABA response

- *ABI1* and *ABI2* (*ABA INSENSITIVE*) encode serine/threonine protein phosphatases
- *abi1-1* and *abi2-1* mutants show decreased response to ABA
- wild-type function of these phosphatases is to inhibit the ABA response

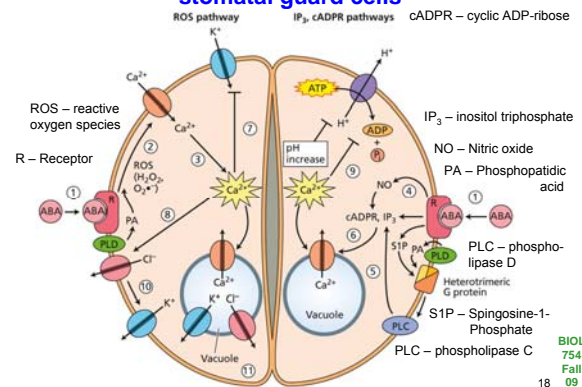
ABA signaling also involves Ca²⁺-independent pathways

- ABA can utilize cytosolic pH as a signaling intermediate (resulting in activation of outward K⁺ channels (*aba1* mutation renders these channels insensitive to pH))

ABA regulation of gene expression is regulated by transcription factors

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Simplified model for ABA signaling in stomatal guard cells



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