Plant hormones--- Abscisic acid (ABA) and ethylene
(植物荷爾蒙-離層酸和乙烯)

Wan-Hsing Cheng (鄭萬興)

Institute of Plant and Microbial Biology
Academia Sinica

植物暨微生物學研究所

Mar 8, 2025

Plant hormone-abscisic acid and ethylene (植物的荷爾蒙-離層酸和乙烯)

Definition of Plant Hormone (phytohormone)

Substances that influence plant growth and development at low concentration. Major classes are abscisic acid, auxin, ethylene, cytokinin, and gibberellin.

植物激素，又稱植物荷爾蒙，是一些在植物體內合成，可以從產生部位輸送至作用部位，微量濃度(nM)即可對植物體產生某種生理作用的活性有機物。植物激素能由產生部位運輸至作用部位，並調節特定細胞的細胞代謝。

Plant hormones

Abscisic acid (ABA,離層酸): seed maturation and stress-response hormone

Gibberellins (GA,激勃素): regulators of plant height and seed germination

Ethylene (C2H4;乙烯**); :** the gaseous hormone

Auxin (植物生長激素): the first discovered plant growth hormone

Cytokinins (細胞分裂素): regulators of cell division

Brassinosteroid (菜籽類固醇): regulators of cell expansion and development

Salicylic acid (SA;水楊酸**):** plant defense

Jasmonic acid (JA;茉莉酸**):** plant defense

Strigolactone (獨角金內酯): shoot branching hormone

Small peptides

Introduction

Abscisic acid (ABA): 離層酸; 脫落酸

＊1950s: β-inhibitor complex reported by Thomas Bennet-Clark and Ned Kefford; oat coleoptile (燕麥葉鞘)

＊1960s: abscisin II (離層素), an abscission-accelerating compound (young cotton fruit).

dormin (休眠素), a dormancy-inducing factor (sycamore leaves,楓樹)

＊1965: abscisin II = dormin discovered by Frederick Addicott's group in US.

Crozier et al., 2000 in Biochemistry and Molecular Biology in Plants

Introduction

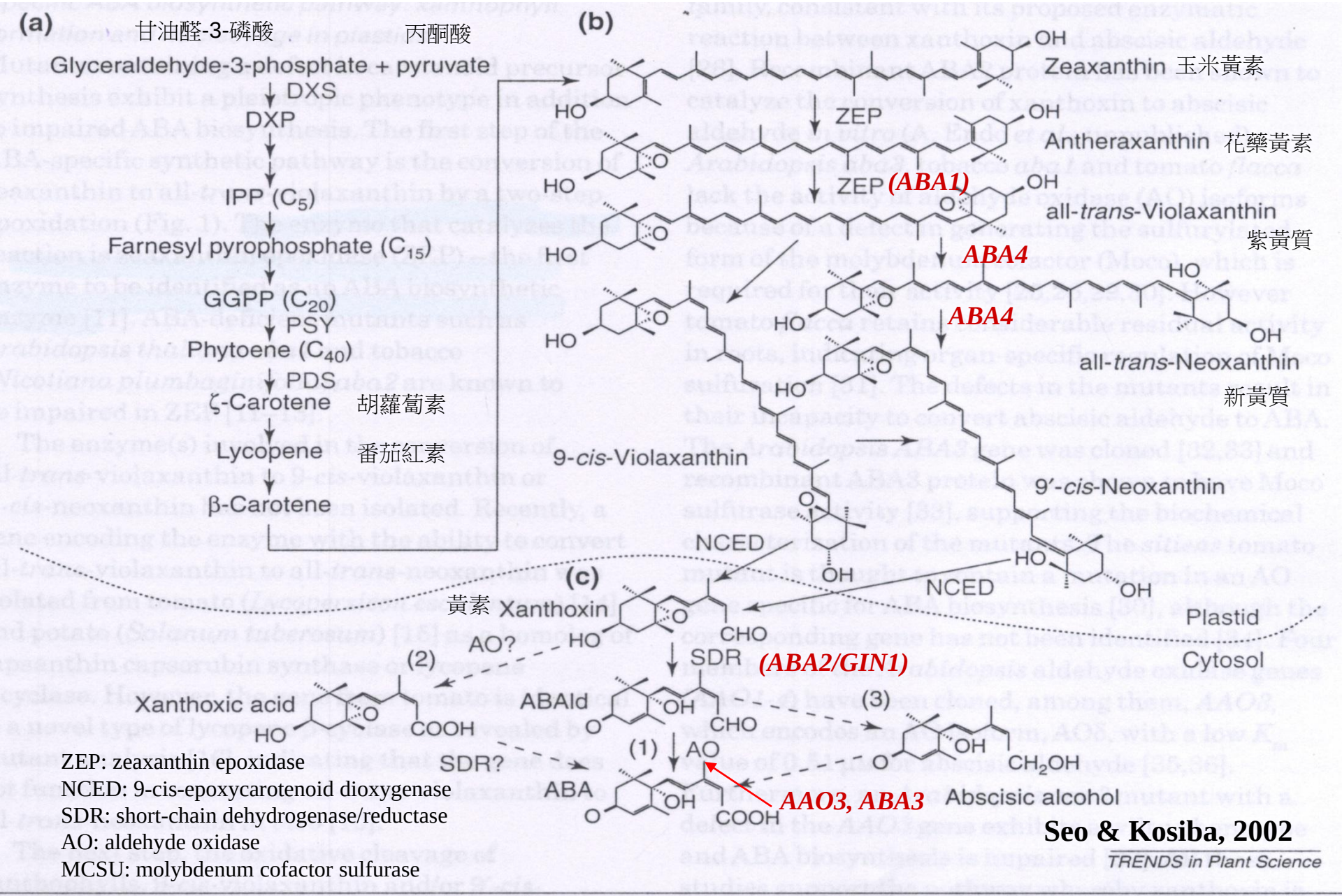
Contrary to its name, ABA does not induce abscission (離層).

Abscission is more related to ethylene(乙烯).

vp14: ABA-deficient mutant causes viviparous(熟前萌芽) phenotype in maize.

Susuki et al., 2006; Plant J 45

ABA Biosynthetic Pathway(生合成路徑)

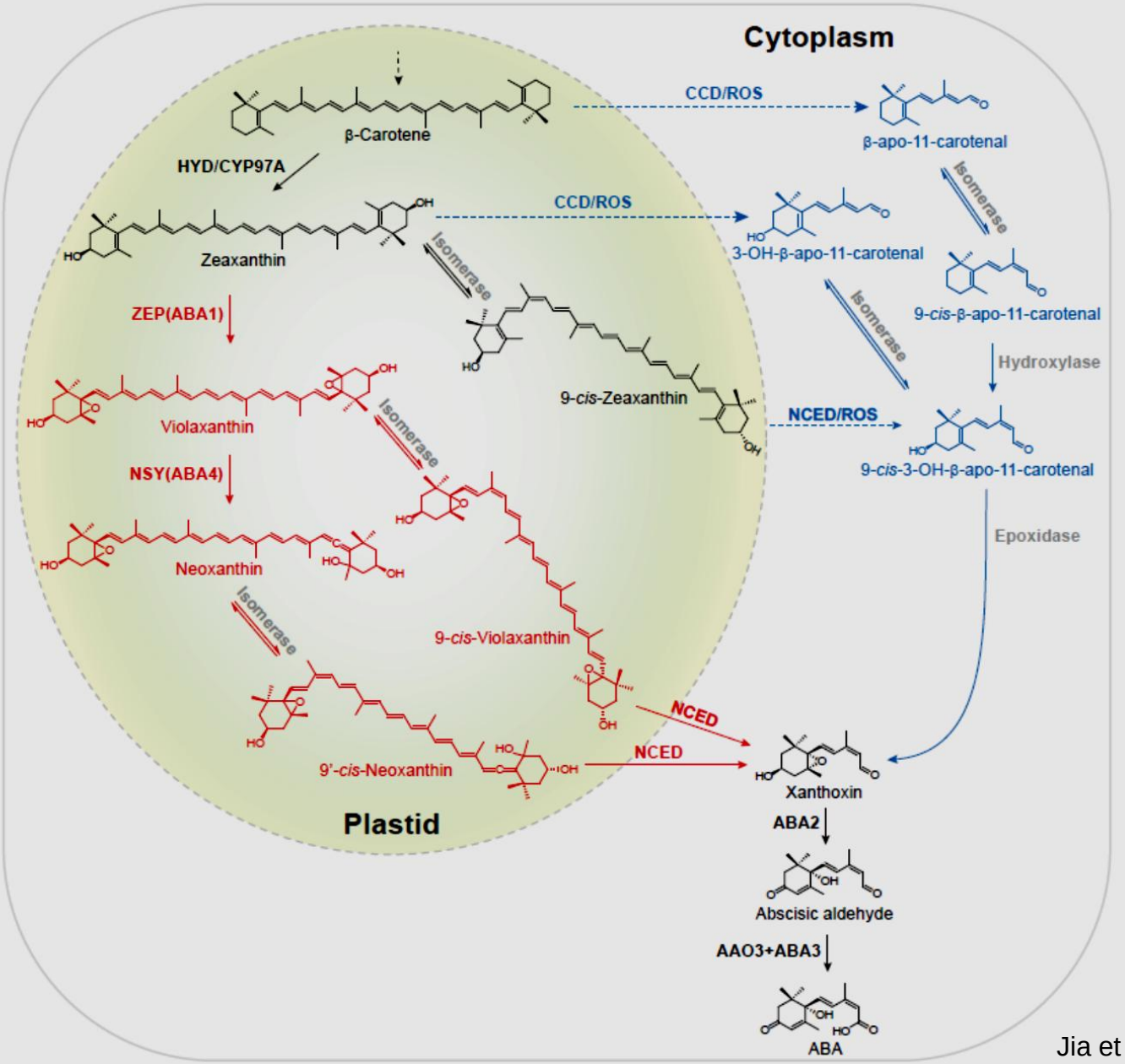


ZEP: zeaxanthin epoxidase
NCED: 9-cis-epoxycarotenoid dioxygenase
SDR: short-chain dehydrogenase/reductase
AO: aldehyde oxidase
MCSU: molybdenum cofactor sulfurase

Seo & Kosiba, 2002

TRENDS in Plant Science

A novel plant ABA biosynthetic route

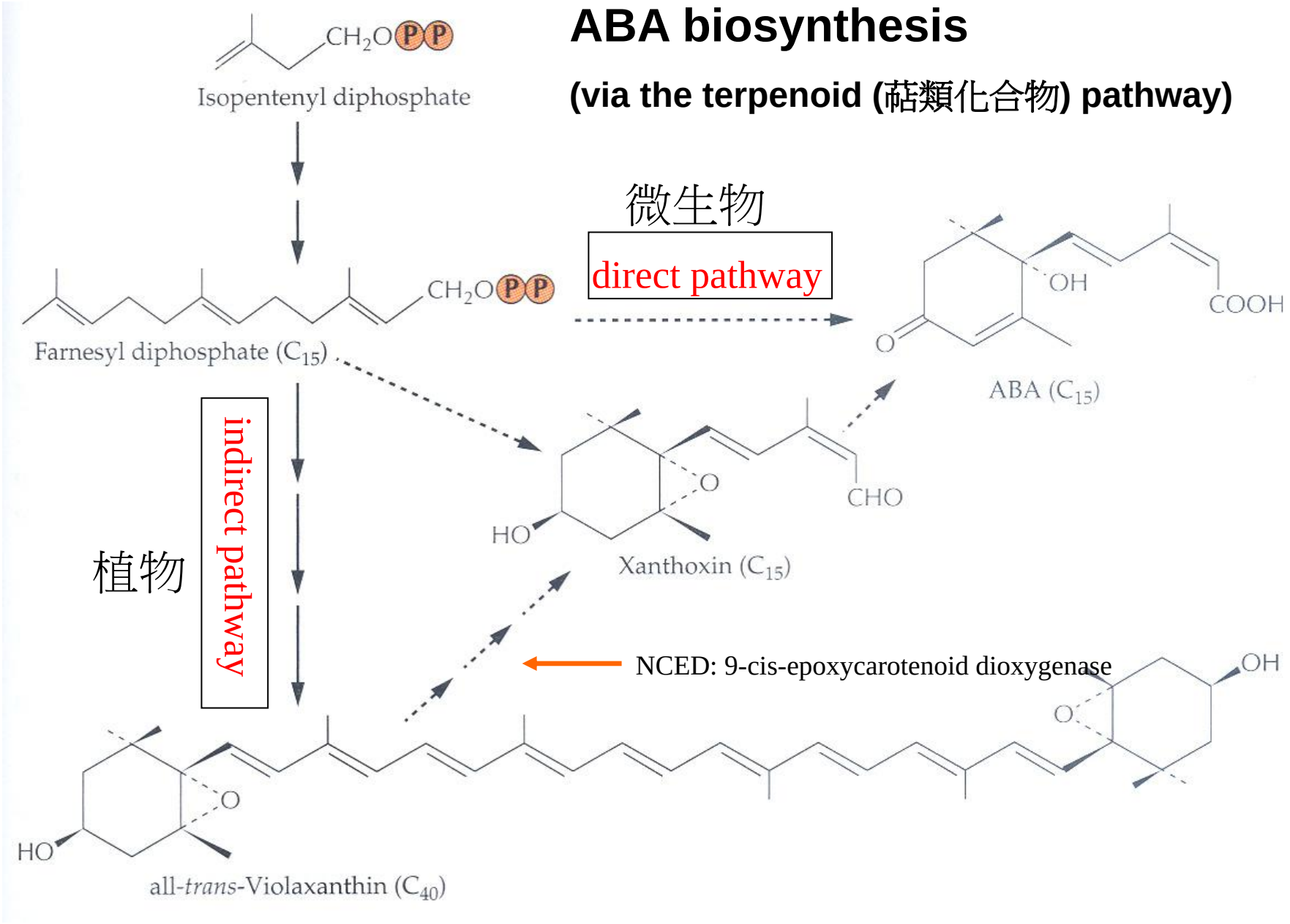


Jia et al., 2022; Mol Plant

Figure 7. Schematic representation of the classic ABA biosynthetic pathway and the alternative, ABA1-independent ABA biosynthetic pathway.

ABA biosynthesis

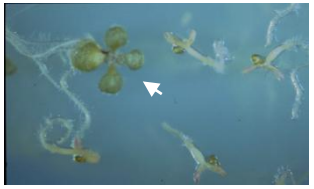
(via the terpenoid (萜類化合物) pathway)

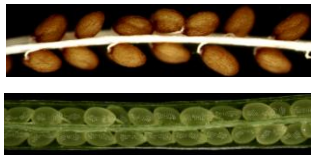


Crozier et al., 2000 in Biochemistry and Molecular Biology in Plants

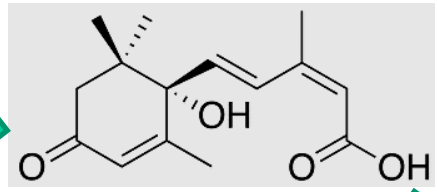
ABA affects plant growth and development

Seed dormancy and germination (種子休眠和發芽)





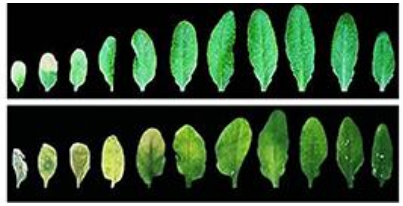
Seed development and maturation (種子發育與成熟)



Abscisic acid (ABA)

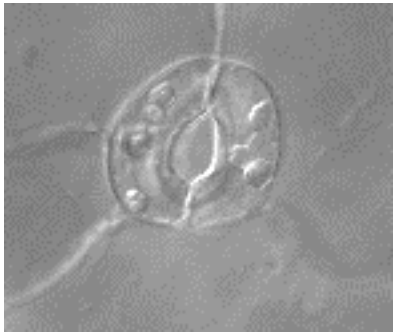
Vegetative growth (營養生長)

Senescence (老化)

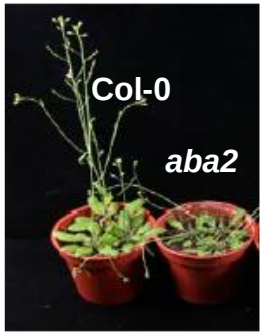


Song et al., 2016

Biotic stress (生物性逆境)



Stomatal closure (氣孔關閉)



Abiotic stress (非生物性逆境)

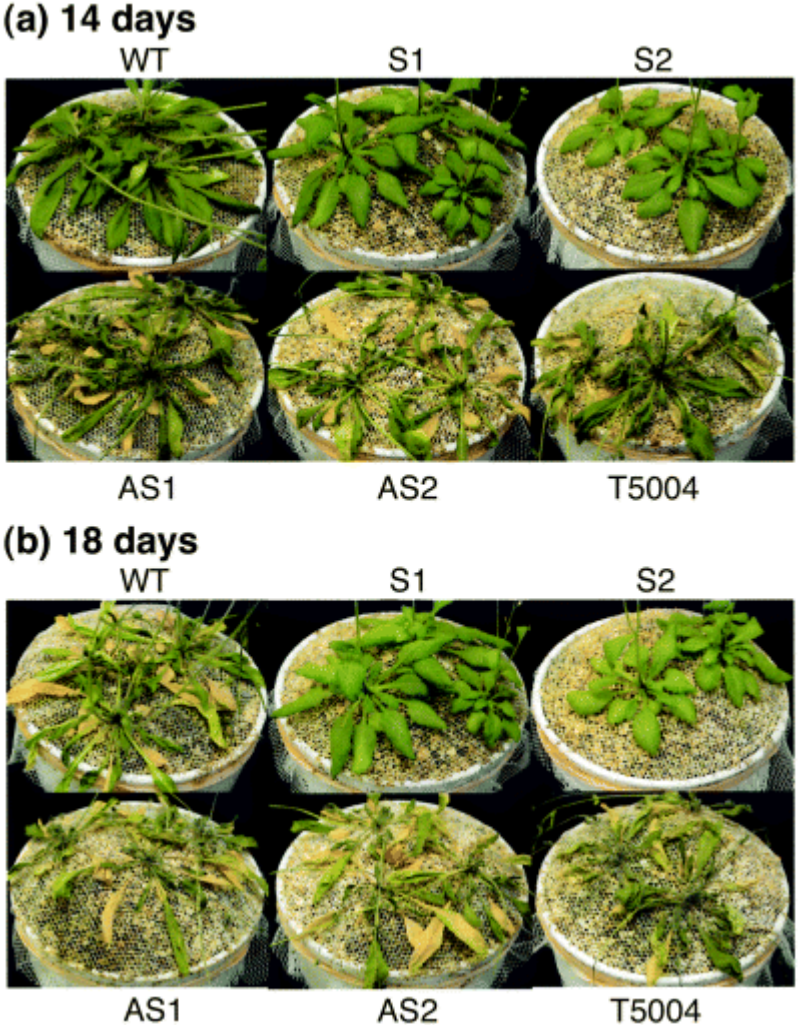
阿拉伯芥NCED3過度表現，增加ABA含量和提高乾旱耐性

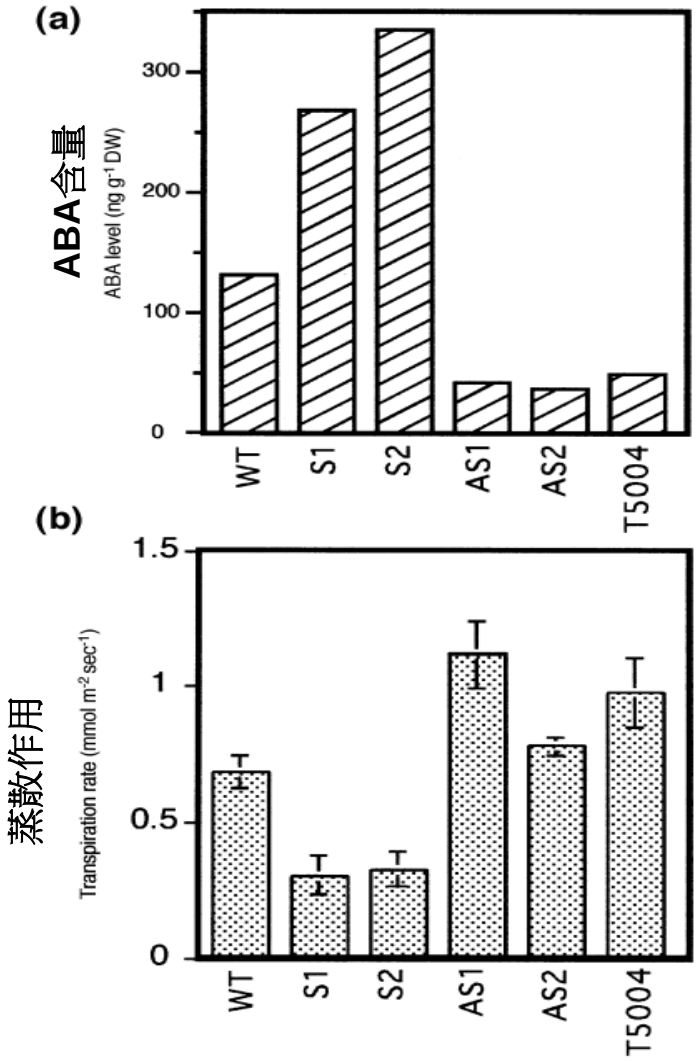
WT: wild type, 野生型正常株

S1, S2:過度表現株

AS1, AS2, T5004 :基因靜默株

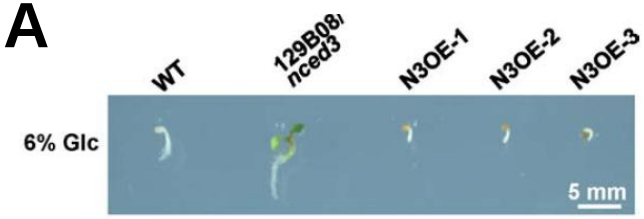
乾旱耐性試驗

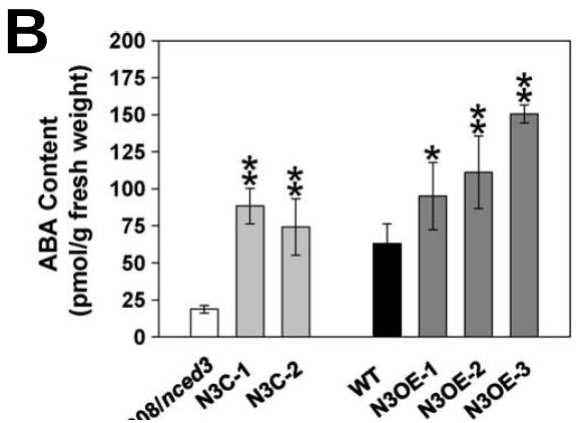




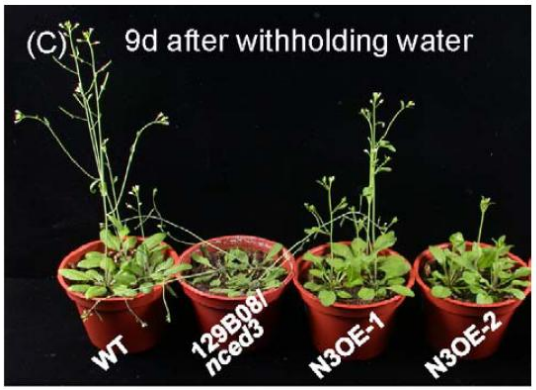
Iuchi et al., 2001; Plant J 27: 325-333

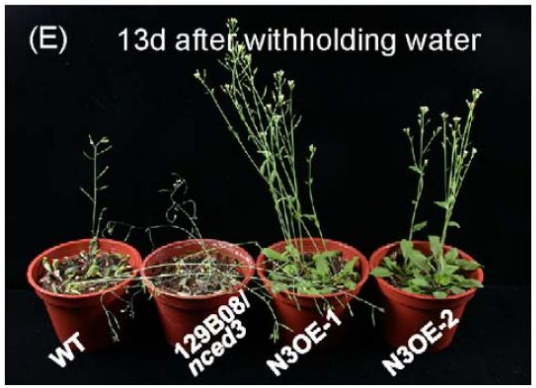
水稻NCED3過度表現，增加ABA含量和提高乾旱耐性





129B08/nced3:NCED3突變株
N3OE:水稻NCED3過度表現株
N3C:NCED3互補株





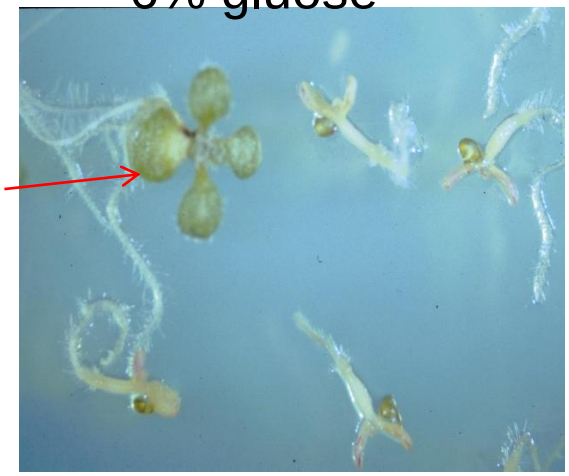
35S::OsNCED3

Hwang et al., 2010; Plant Science
Chen et al., 2011; Plant Cell Physiol

ABA2: short-chain dehydrogenase/reductase(SDR 短鏈去氫還原酶)

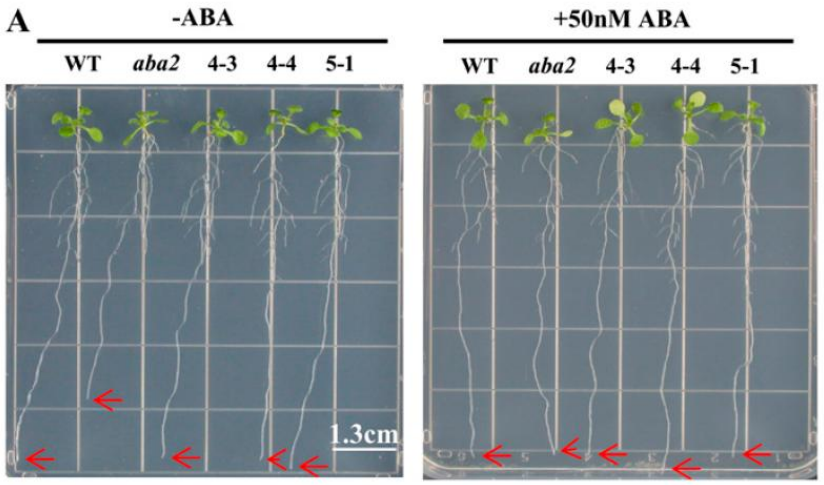
6% gluose

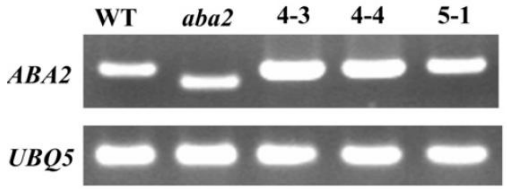
aba2
突變株

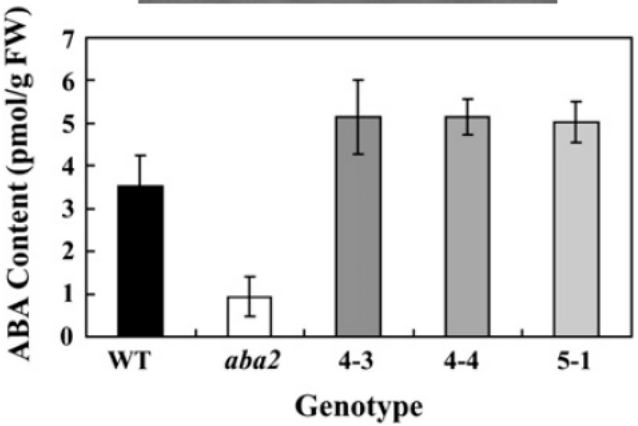


正常株　突變株　互補株

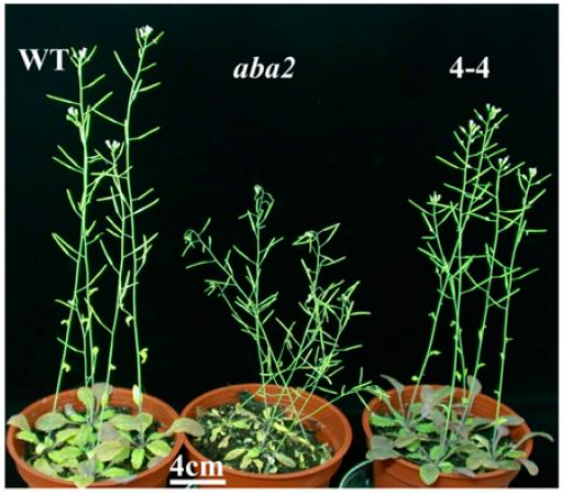
ABA2過度表現株提高ABA含量和鹽類抗性







鹽處理16天

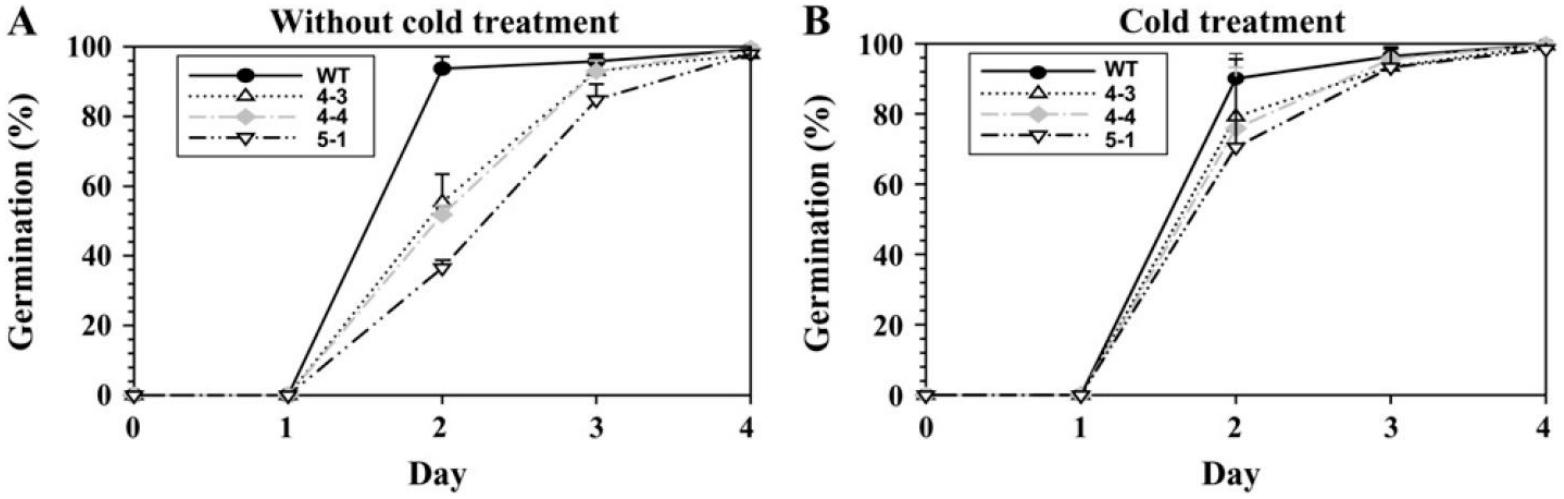


4-3, 4-4, 5-1: ABA2過度表現株

Lin et al., 2007; Plant Physiol

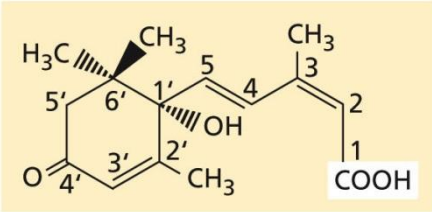
Over-expression of *ABA2* promotes seed dormancy

ABA2過度表現株促進種子休眠



(Lin et al., 2007; Plant Physiol)

Physiological effects of abscisic acid (ABA)



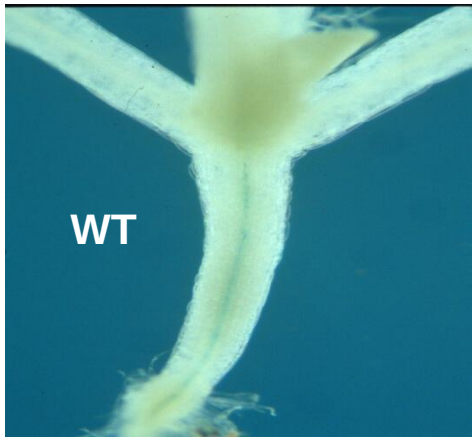
(*S*)-*cis*-ABA
(naturally occurring
active form)

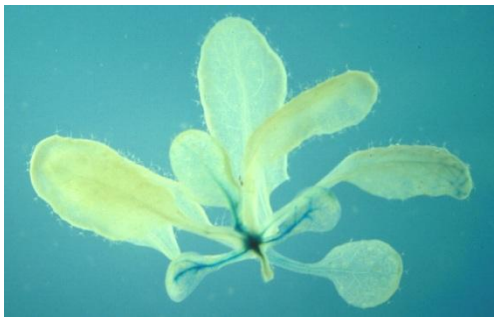
1. Seed development and maturation
2. Seed dormancy
3. Stomatal regulation
4. Adaptation to stress
5. Plant size
6. Root growth

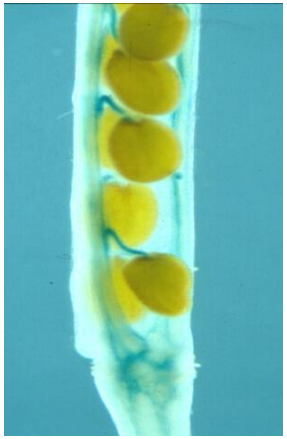
ABA2 的組織表現

Gene: Promoter + coding sequences
基因: 起動子 + 編碼區

ABA2::GUS　　GUS:β-glucouronidase



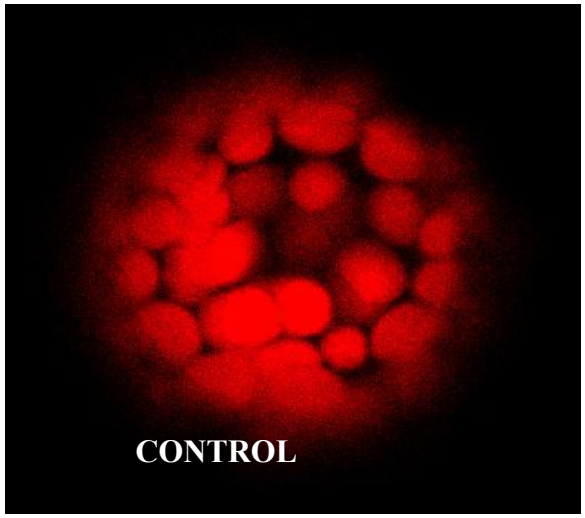


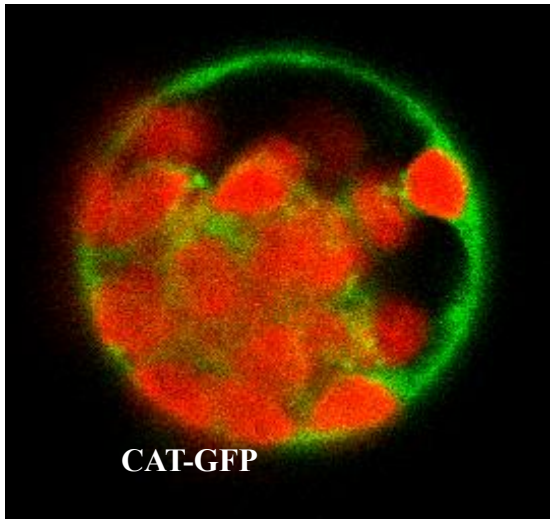


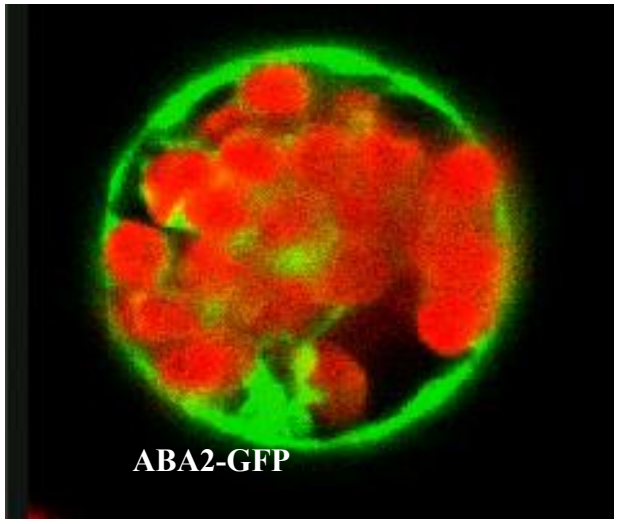
***ABA2*表現於維管束組織，但並不在ABA作用的位置上，如氣孔和種子內，此結果暗示ABA運送可能經由中間產物或結合物(ABA-conjugate)。**

Subcellular localization of ABA2 (ABA2蛋白質於細胞內的位置)

35S::ABA2-GFP
the cauliflower mosaic virus 35S promoter







CAT:光合作用的基因

Conclusion :

-*ABA2*-overexpressed transgenic plants with elevated ABA levels promote seed dormancy and salt tolerance.

轉殖株過度表現**NCED3** 或***ABA2***基因會產生較多的**ABA**，促進種子休眠和對乾旱或鹽逆境的抗性。

-The basal levels of ABA are essential for maintaining normal primary root elongation and plant size.

基本**ABA**含量對於根部生長和植株大小的發育是必要的。

Heterophylly (異型葉): two different leaf shapes in a plant.

-**Aquatic plants** (水生植物)display heterophylly leaves, submerged leaves (水生葉)and aerial leaves(水上葉).

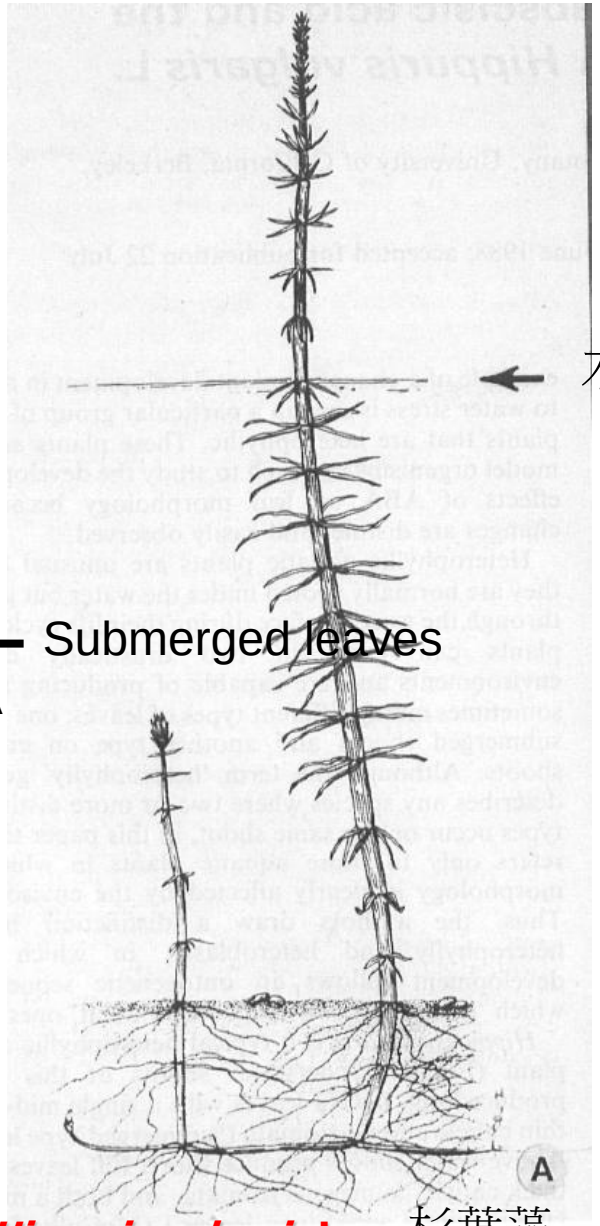
Submerged leaves(水生葉): longer, thinner, more dissected, few or no stomata

Aerial leaves(水上葉): shorter, thicker and broader, stomata

-**Environmental factors** (環境因素)for heterophylly: osmotic stress, CO_2 Conc., high temp., water depth, light quality----.

-**Plant hormones** associated with heterophylly: ABA(離層酸), ethylene(乙烯)

Aerial leaves ← ACC

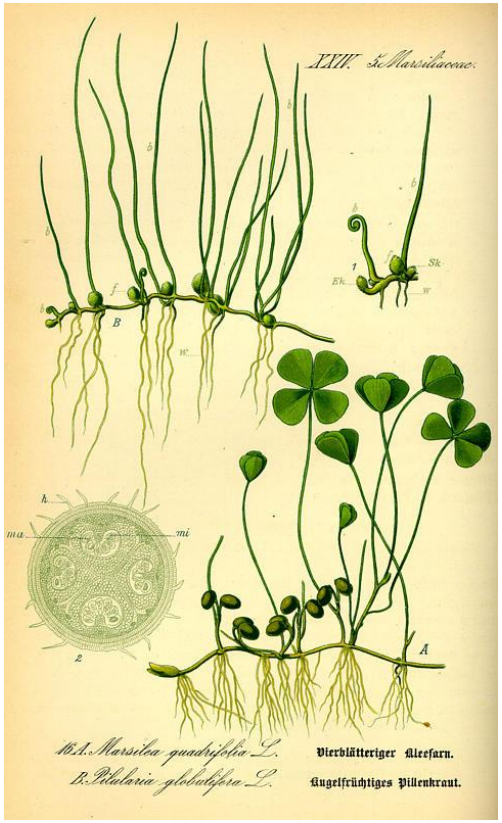


← 水平面

← Submerged leaves

ABA

***Hippuris vulgaris* L.** 杉葉藻



Marsilea quadrifolia

(Lin and Yang, 1999)

四葉草

(田字草)

terrestrial leaves

submerged leaves

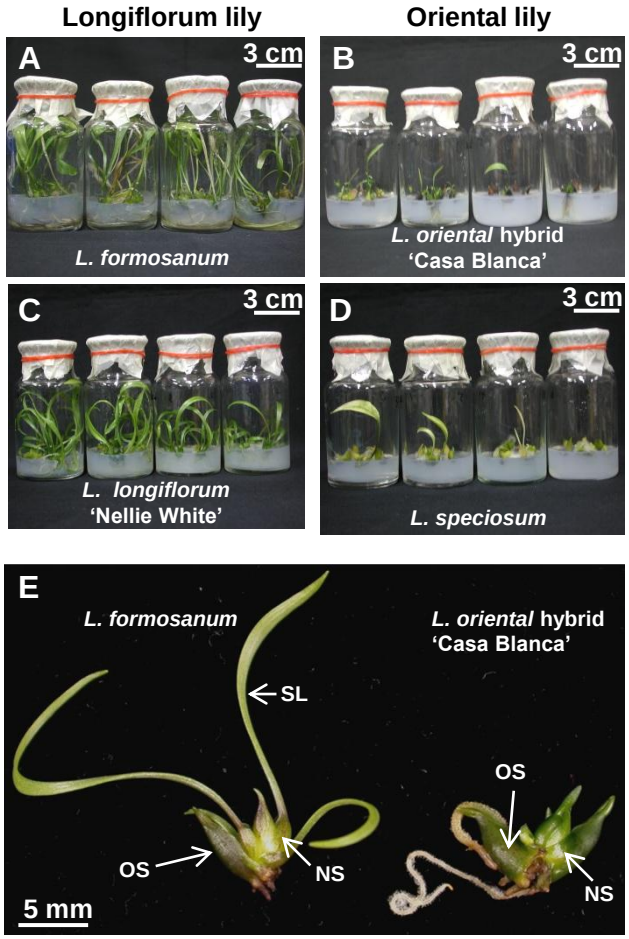
Heterophylly : aquatic(水生), semi-aquatic, land plants(陸生), and geophytic plants (地下芽植物，如百合)

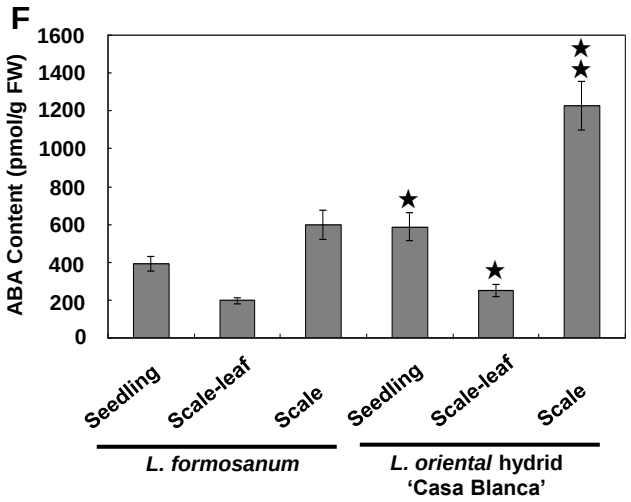
Heterophylly has been proposed as a survival strategy that allows plants to adapt to environmental change during their life cycle by evolving developmental plasticity in leaves.

異型葉可能為植物適應環境所產生的策略。

Comparison of heterophyllous rosette leaves and ABA contents between Longiflorum and Oriental lilies

喇叭型百合(鐵炮百合) 東方型百合

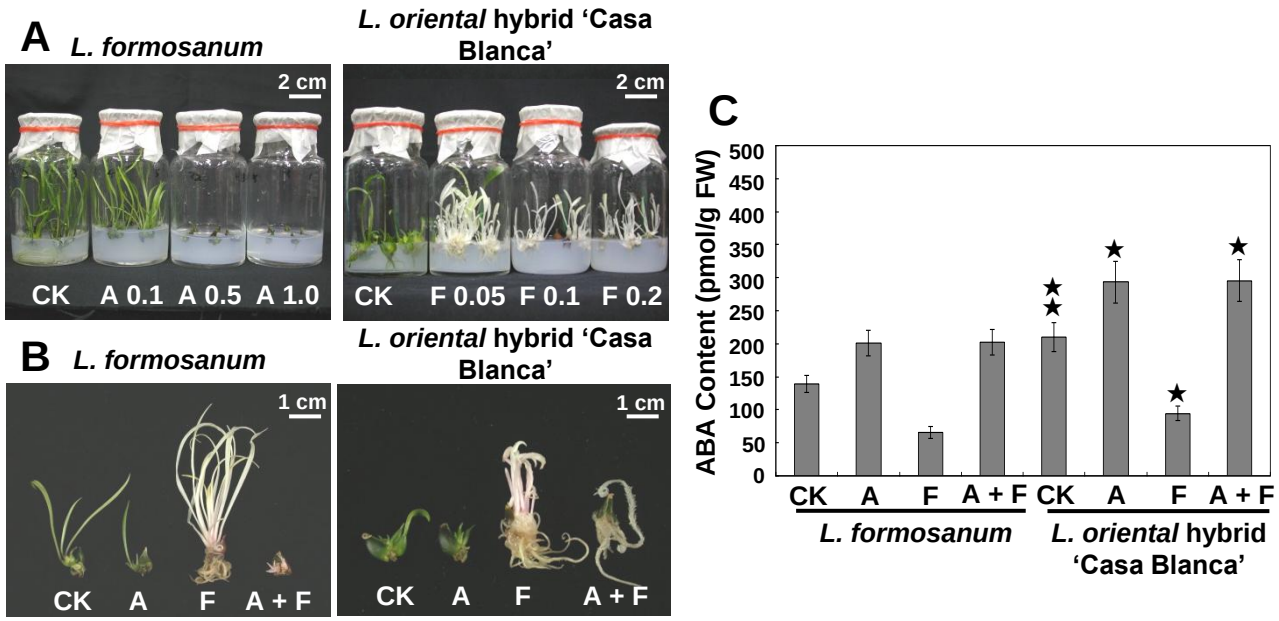




Scale-leaf growth pattern

Scale growth pattern

Heterophyllous rosette leaves are regulated by ABA



A: ABA

F: fluridone

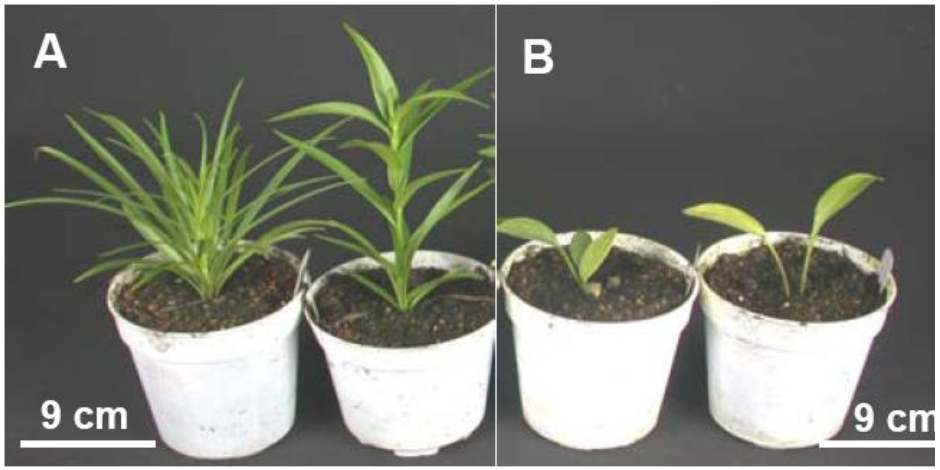
Morphological comparison of Longiflorum and Oriental lilies

台灣百合 *L. formosanum*

復活節百合 *L. longiflorum* 'Nellie White'

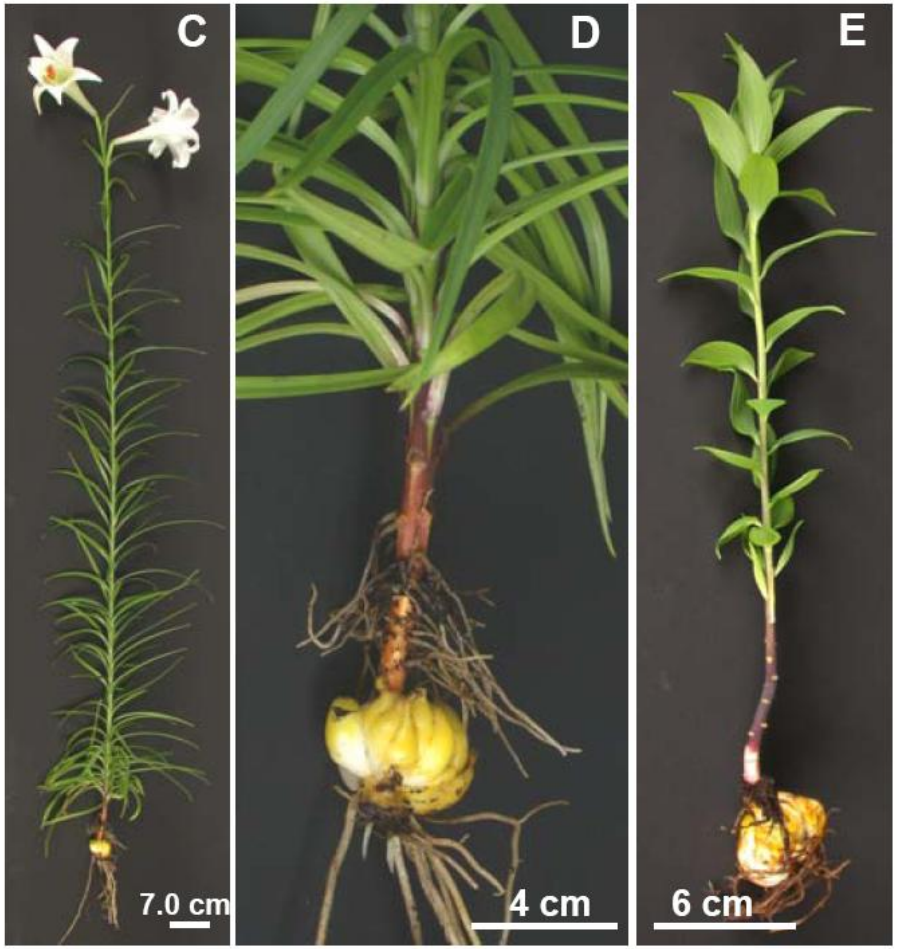
L. oriental hybrid 'Casa Blanca' 東方百合

L. speciosum 鹿子百合



台灣百合

香水百合



台灣百合

Abscisic Acid: A Novel Nutraceutical 營養品 for Glycemic Control (穩定血糖)

Elena Zocchi[1], Raquel Hontecillas[2,3]*, Andrew Leber[2], Alexandra Einerhand[2], Adria Carbo[2], Santina Bruzzone[1], Nuria Tubau-Juni[3], Noah Philipson[2], Victoria Zoccoli-Rodriguez[2], Laura Sturla[1] and Josep Bassaganya-Riera[2,3]*

Frontiers in Nutrition 4: 24 (2017)

Abscisic Acid Standardized Fig (*Ficus carica*) Extracts Ameliorate Postprandial Glycemic and Insulinemic Responses in Healthy Adults

Fiona S. Atkinson [1,*], Agusti Villar [2], Anna Mulà [2], Andrea Zangara [2,3,*], Ester Risco [2], Carsten R. Smidt [4], Raquel Hontecillas [5], Andrew Leber [5] and Josep Bassaganya-Riera [5]

Nutrients **2019**, *11*, 1757; doi:10.3390/nu11081757

https://zh.wikipedia.org/wiki

-台灣超過2百萬人罹糖尿病！40歲以下患者有增加趨勢

-It is estimated that 34% of adults in the U.S. have metabolic syndrome.

-About 28.3 million Americans have type 2 diabetes (T2D) and over 20% of middle-aged adults have prediabetes.

ABA Levels in Common Foods

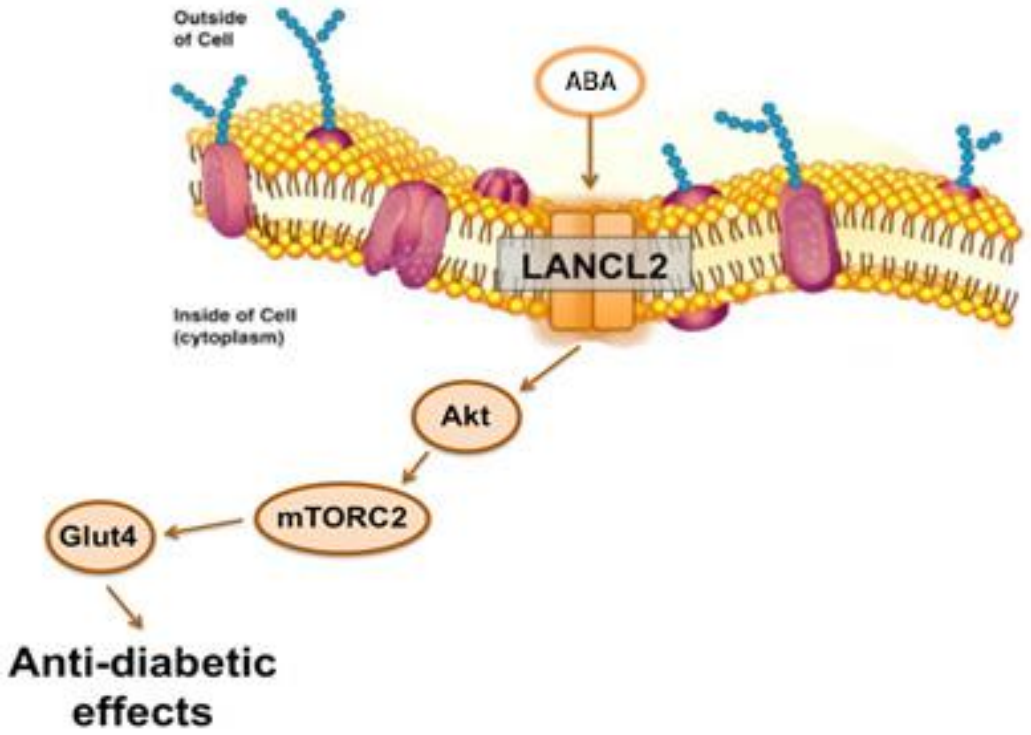
Food	Part	ABA, µg/g	Reference
Eureka lemon	Dried peel 果皮乾	6.5 優利卡檸檬	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Lisbon lemon	Dried peel	7.8 里斯本檸檬	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Red blush grapefruit	Dried peel	3.6 紅寶石葡萄柚	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Marsh white grapefruit	Dried peel	3.7 馬什白葡萄柚	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Washington Navel Orange	Dried peel	6.4 臍橙	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Washington Navel Orange	Dried peel	8.3	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Tall Satsuma mandarin	Dried peel	2.9 溫州蜜柑	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Dwarf Satsuma mandarin	Dried peel	8.3	J. Exp. Bot., 1991, 42 (241), 1083-1088.
Orange	Rind	1.1	Planta 1983, 157, 371-375
Avocado	Mesocarp	7.6 酪梨	Planta 1983, 157, 371-375
Bean	Leaves	0.08	Planta 1983, 157, 371-375
Fig	Whole	0.73 無花果	Magnone, The FASEB Journal fj.15-277731.
Bilberry	Whole	0.4 歐洲藍莓	Magnone, The FASEB Journal fj.15-277731.
Apricot	Whole	0.32 杏仁果	Magnone, The FASEB Journal fj.15-277731.
Banana	Whole	0.22	Magnone, The FASEB Journal fj.15-277731.
Potato	Whole	0.03	Magnone, The FASEB Journal fj.15-277731.
Soy milk	Whole	0.03 豆漿	Magnone, The FASEB Journal fj.15-277731.
Apple	Whole	0.024	Magnone, The FASEB Journal fj.15-277731.
Olive	Whole	0.016 橄欖	Magnone, The FASEB Journal fj.15-277731.

biotherapeutics
1800 Kraft Dr., Suite 200, Blacksburg , VA , 24060

Innovative Pathway - LANCL2

- ABA binds to lanthionine synthetase C-like 2 (LANCL2) and signals through Akt/mTORC2.
- Exerts anti-diabetic actions by up-regulating glucose transporter Glut4.

lanthionine synthetase: 羊毛硫氨酸合成酶



Abscisic acid enriched fig extract promotes insulin sensitivity by decreasing systemic inflammation and activating LANCL2 in skeletal muscle

Andrew Leber, Raquel Hontecillas, Nuria Tubau-Juni, Victoria Zoccoli-Rodriguez, Bret Goodpaster & Josep Bassaganya-Riera

Scientific Reports | (2020) 10:10463 | https://doi.org/10.1038/s41598-020-67300-2

biotherapeutics

1800 Kraft Dr., Suite 200, Blacksburg , VA , 24060


Thank You