Lecture 9: Auxin III

Physiological effects

- Apical dominance
- Lateral and adventitious root development
- Flower and fruit development
- Vascular differentiation

Signal transduction

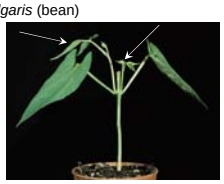
Summary on auxin

Auxin regulates apical dominance

Apical dominance = the growing apical bud inhibits the growth of lateral (axillary) buds

Phaseolus vulgaris (bean)

Axillary buds are suppressed because of apical dominance



Removal of apical/ terminal bud induces growth of axillary buds

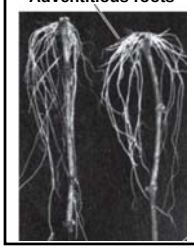
Applying IAA to cut surface prevents outgrowth of axillary buds

Auxin promotes the formation of lateral and adventitious roots

Lateral roots

- Found above the elongation zone
- Originate from cells in the pericycle
- Auxin stimulates the cells to divide
- Dividing cells gradually form into a root apex
- Lateral root grows through the root cortex and epidermis

Adventitious roots

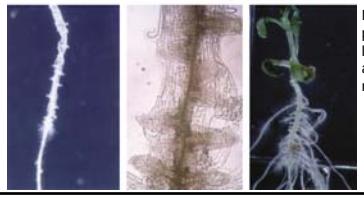


- Originating from non-root tissue
- From clusters of mature cells that renew their cell division activity
- Dividing cells develop into root apical meristem similar to lateral roots
- Auxin stimulation of adventitious roots useful for propagation of plants by cuttings

Auxin promotes the formation of lateral and adventitious roots

WT

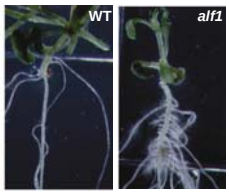
alf1
***a**berrant **l**ateral root **f**ormation*



Extreme proliferation of lateral and adventitious roots

Genes involved in regulating lateral root formation

ALF1



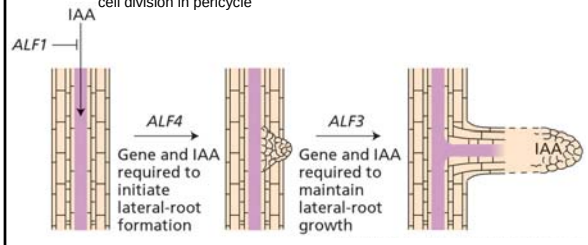
ALF3

Defective in development of lateral-root primordia into mature lateral roots

ALF4

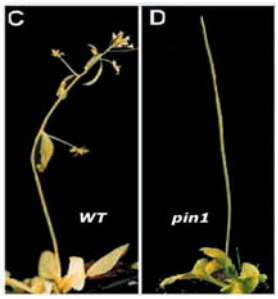
A model of lateral root formation

IAA transported acropetally (toward the tip) in stele is required to initiate cell division in pericycle



IAA is required to promote cell division and maintain cell viability in developing lateral root

Auxin transport regulates floral bud development

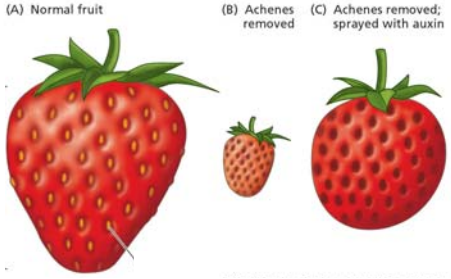


Treatment of plants with auxin inhibitor NPA causes abnormal floral development (similar to *pin1* mutant).

Floral meristem depends on auxin being transported to it from subapical tissue.

In absence of efflux carrier, meristem is starved for auxin and normal phyllotaxis and floral development are disrupted.

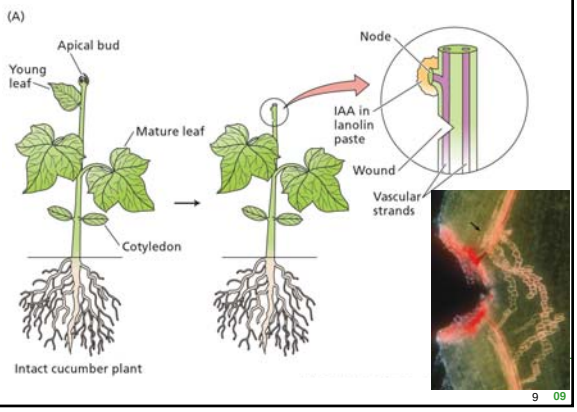
Auxin promotes fruit development



Auxin is produced in pollen, endosperm, and embryo of developing seeds.

Growth of "fruit" is regulated by auxin produced by "seeds", the achenes.

Auxin induces vascular differentiation



Auxin signal transduction pathway

ABP1 = AUXIN BINDING PROTEIN; *abp1* knockout mutants are lethal; primarily localized on ER, small amount present on plasma membrane Remains to be determined whether ABP57 from rice is involved in signal transduction

TIR1 = TRANSPORT INHIBITOR RESPONSE1, breakthrough discovery: (Dharmasiri et al. 2005 Nature 435: 441, Kepinski and Leyser 2005 Nature 435: 446) **binds auxin; F-Box protein involved in ubiquitin-mediated protein degradation**

Additional receptors?

Auxin Response Factors (ARF) = transcriptional activators by binding to the auxin response element TGTCTC present in the promoters of auxin response proteins

Calcium – may be involved, as auxin increases free level of calcium in cell

pH – auxin induces decrease in cytoplasmatic pH

MAP kinases – phosphorylating proteins that ultimately activate transcription factors
- auxin stimulates cell cycle activity by stimulating synthesis of the major cyclin-dependent protein kinase CDC2 (cell division cycle 2)

Auxin signal transduction pathways – Genes regulated by auxin

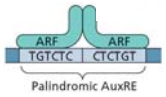
Genes involved in auxin-regulated growth and development

AUX/IAA gene family (short-lived transcription factors)

SAUR gene family (gravitropism)

GH3 gene family (auxin response proteins, ARF, containing auxin response element TGTCTC)

ARFs form dimers by binding to response element arranged in a palindrome



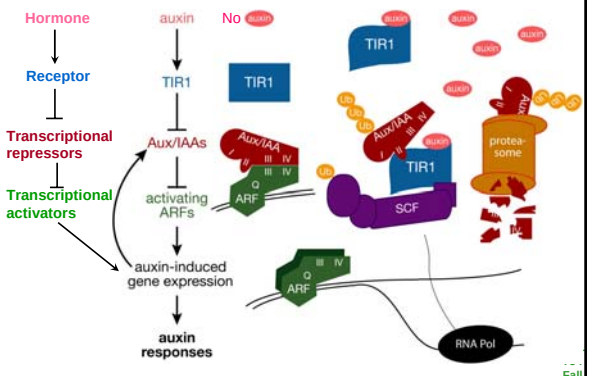
Stress response genes

Genes encoding glutathione S-transferase (***GST***s)

Genes encoding 1-aminocyclopropane-1-carboxylic acid (***ACC***) synthase, the key enzyme in ethylene biosynthesis

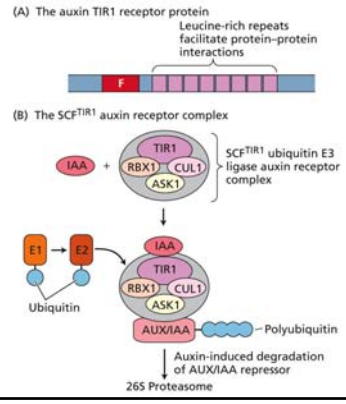
Early auxin-responsive genes
- activated by pre-existing transcription factors
- Cannot be blocked by protein synthesis inhibitors
- may encode proteins that regulate transcription of secondary response genes

Auxin signal transduction pathway – current model

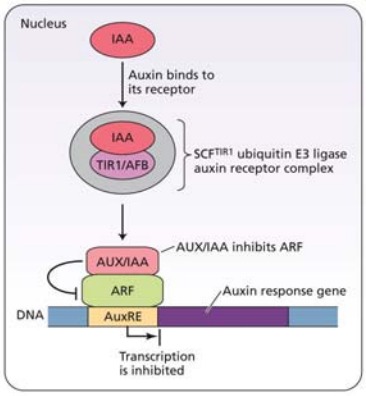


Woodward and Bartel 2005 Plant Cell 17: 2425

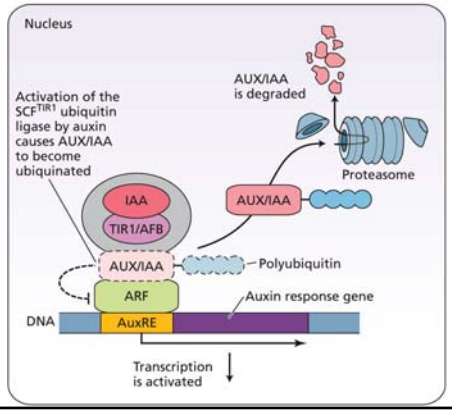
The auxin receptor



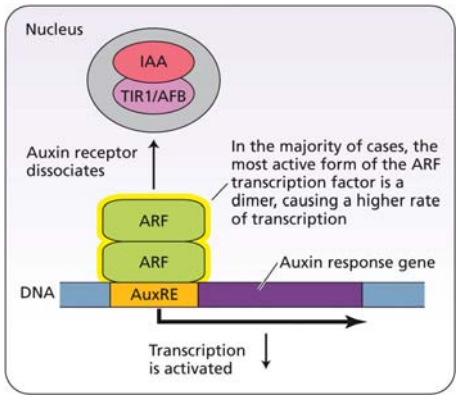
Auxin signal transduction - Repression



Auxin signal transduction - Activation



Auxin signal transduction - Potentiation



Summary AUXIN

What is auxin?

How and where is auxin synthesized?

How is auxin transported in the plant?
What experiments could you run to show auxin transport?
What are important components (proteins) of auxin transport?

How do cells grow?

How do plants respond to light?

How do plants respond to gravity?

Which developmental processes are affected by auxin?

What is our current understanding of auxin signal transduction?

Reading assignment I

Objectives of the reading assignment are:

- Make you familiar with the primary literature in the field.

- Review the publication and identify novel aspects of the research presented in the paper. The paper should deal with developmental processes and must not use Arabidopsis as a research object.

- How does this paper advance our understanding of plant developmental processes?

1. Reading assignment:
- Present the major findings of the paper in class in form of a short presentation (15 + 5 min discussion) and discuss the results in class.
  - Summarize the main results of the paper and discuss whether they support the authors' hypotheses.
  - Are the conclusions justified?
  - Emphasize interesting techniques used to answer the questions raised in the paper.
  - Your suggestions for improvements and/or other approaches.