



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Shoot Development: Organogenesis

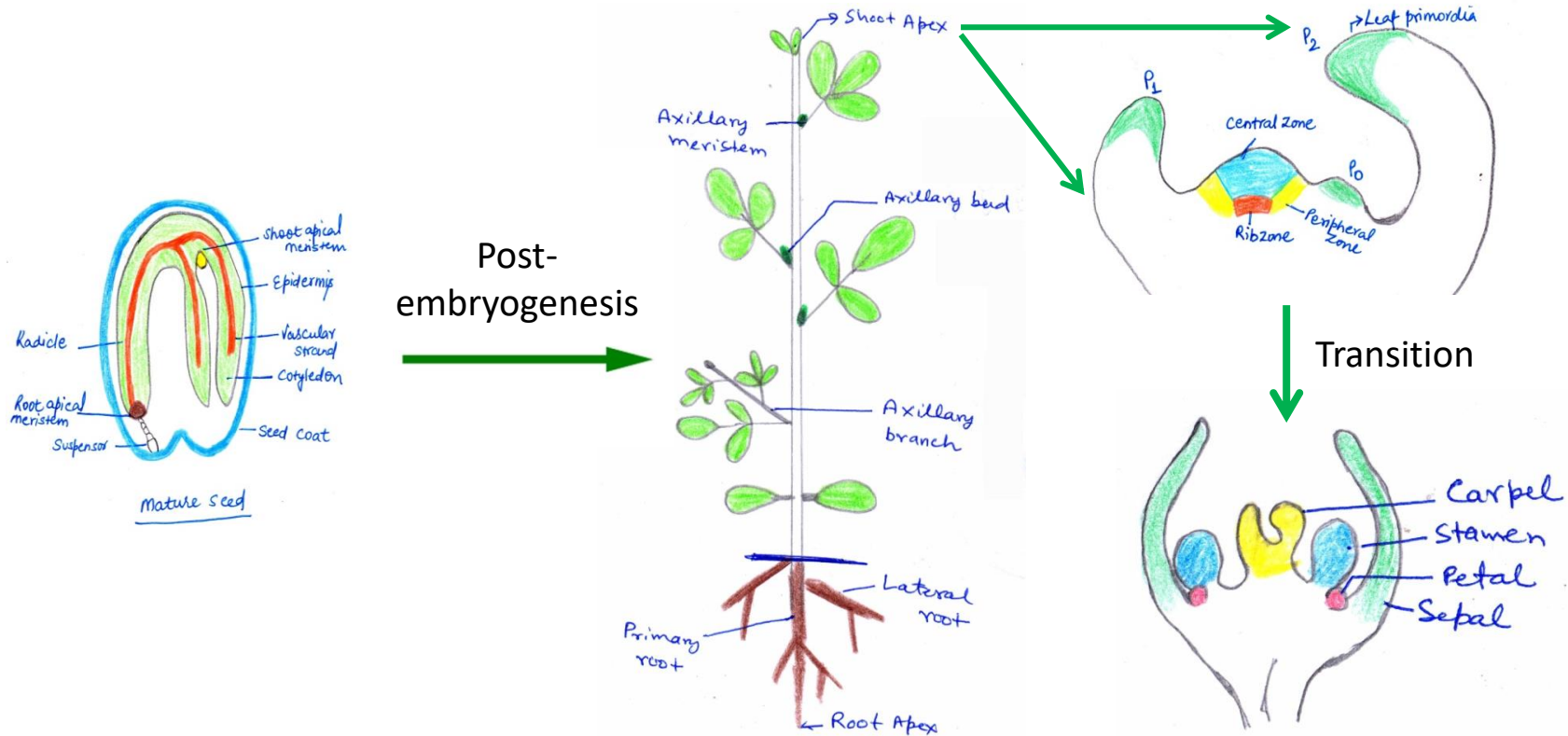
Dr. Shri Ram Yadav

Department of Biotechnology

Indian Institute of Technology, Roorkee



Shoot System Architecture



Shoot Apical Meristem Organization

a Shoot apical meristem

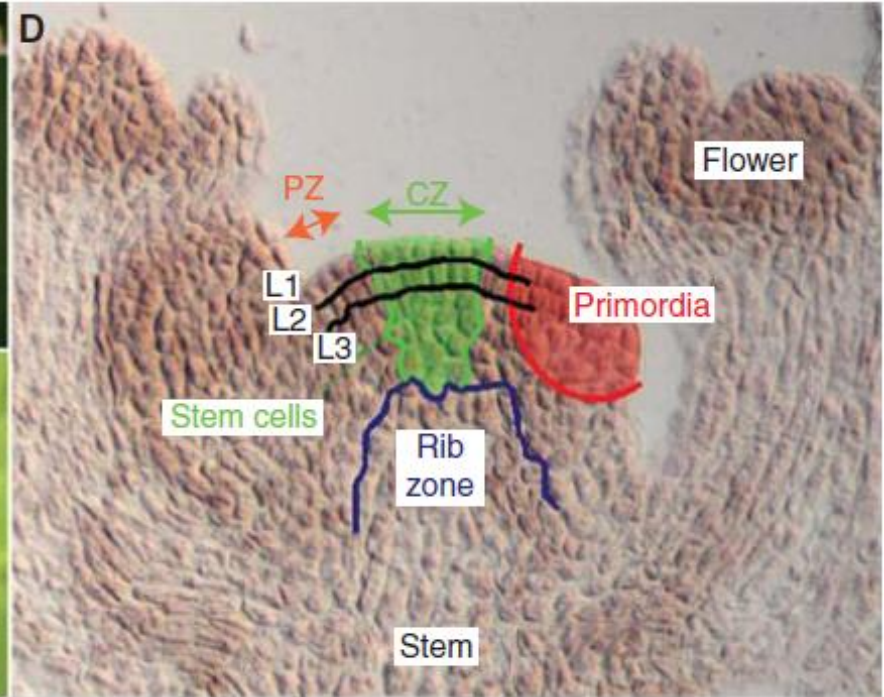
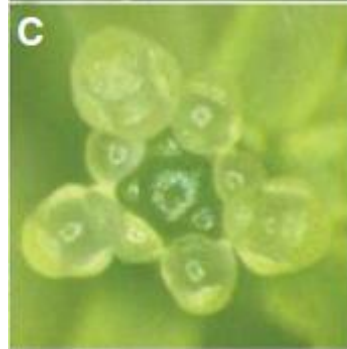
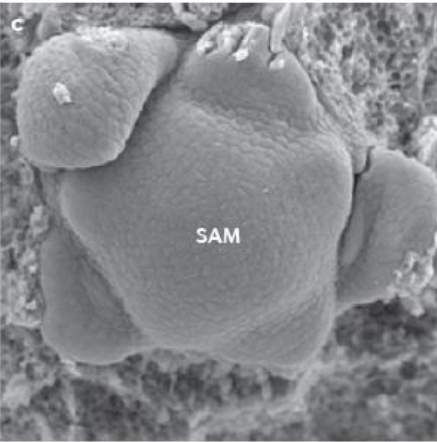
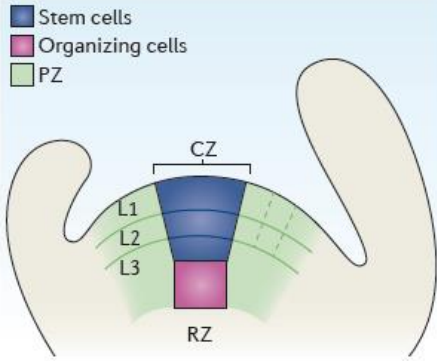


Image Source: Vernoux et al. (2010), Cold Spring Harb Perspect Biol., 2:a001487.
Heidstra and Sabatini (2014), Nat Rev Mol Cell Biol., 15, 301-12.

Phyllotaxis at Inflorescence Meristem

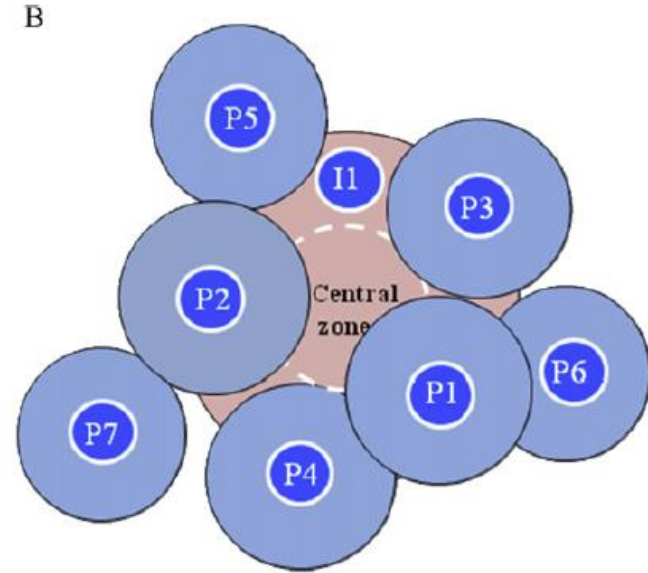
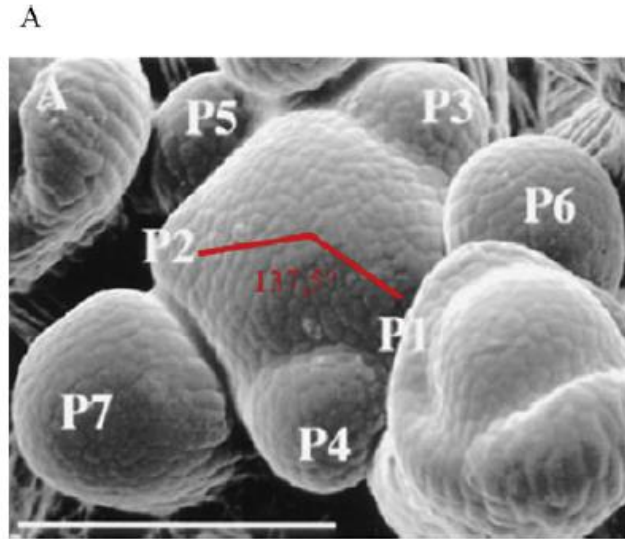
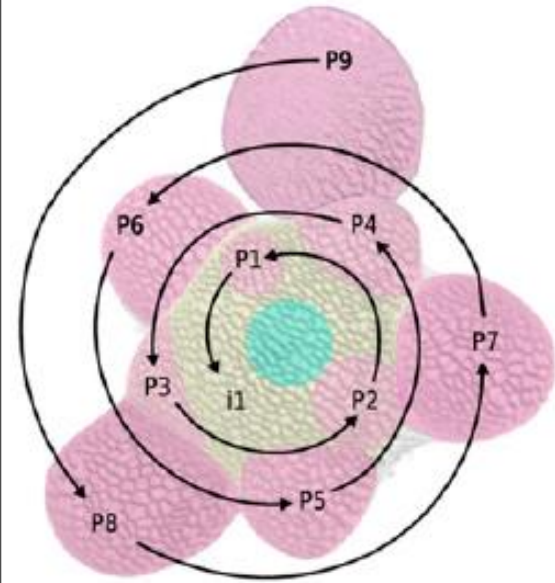


Image Source: Murray et al. (2012) *Plant Cell*, 24, 3907–919.
Bohn-Courseau, I (2010), *C. R. Biologies*, 333, 290–96.

Phylotaxis at SAM

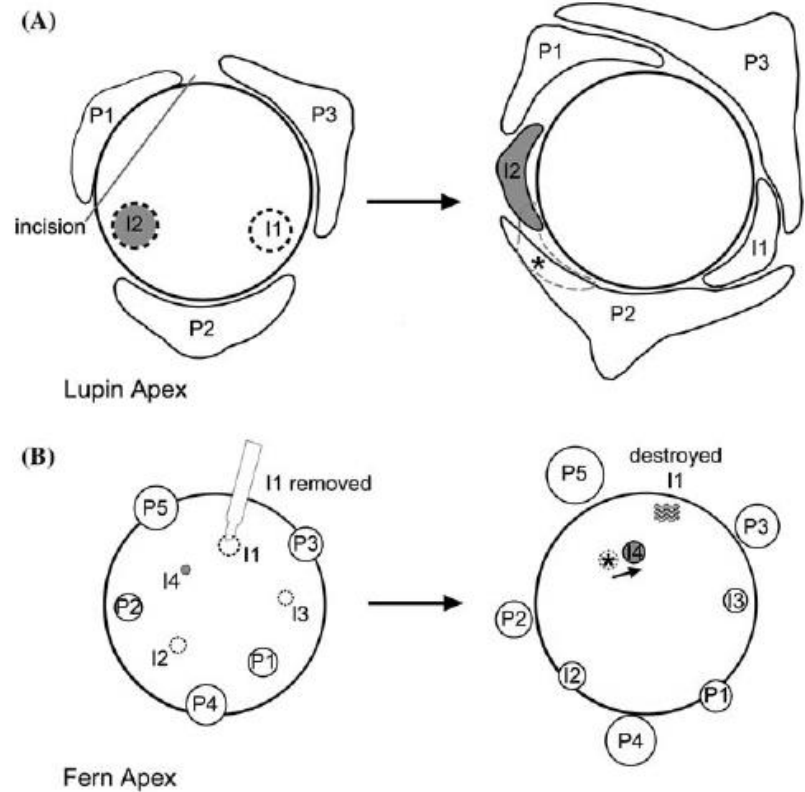
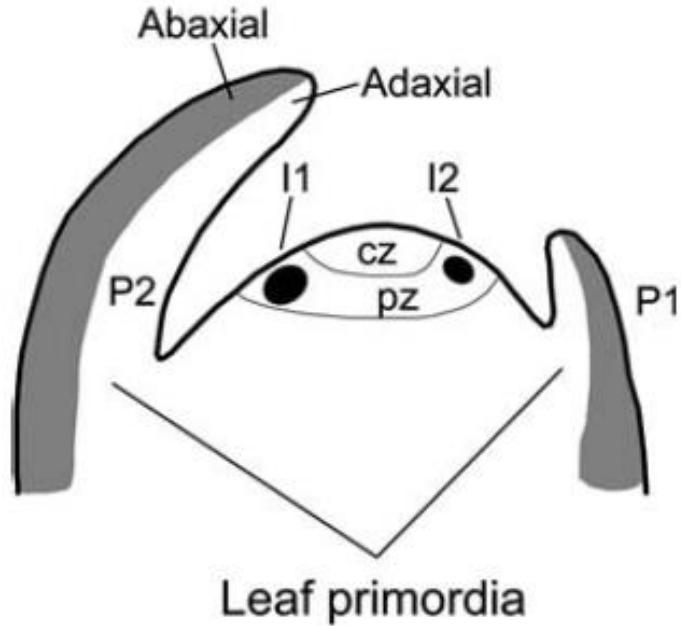


Image Source: Golz, J. F. (2006), Plant Mol Biol., 60, 889-903.

Auxin Regulates Organogenesis



CZ:
high KNOX expression
high CK
low GA
stiff tissue- variable stiffness
frequent microtubule reorientation
slow growth

P0:
low KNOX expression
ANT
YABBY
low CK response?
high GA
auxin maximum
soft tissue
circumferent microtubule orientation
fast growth

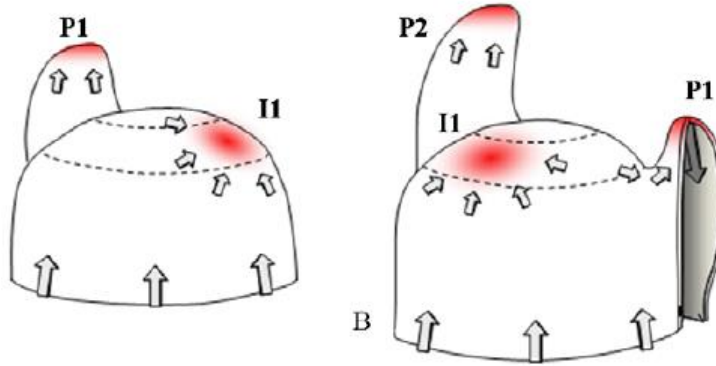
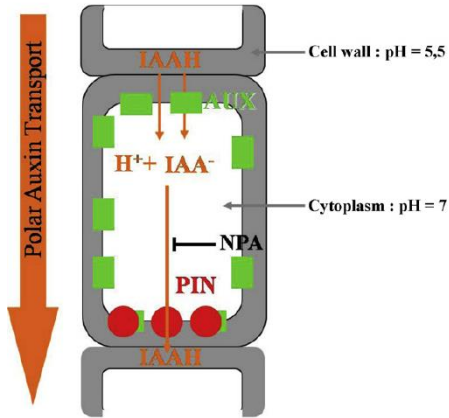
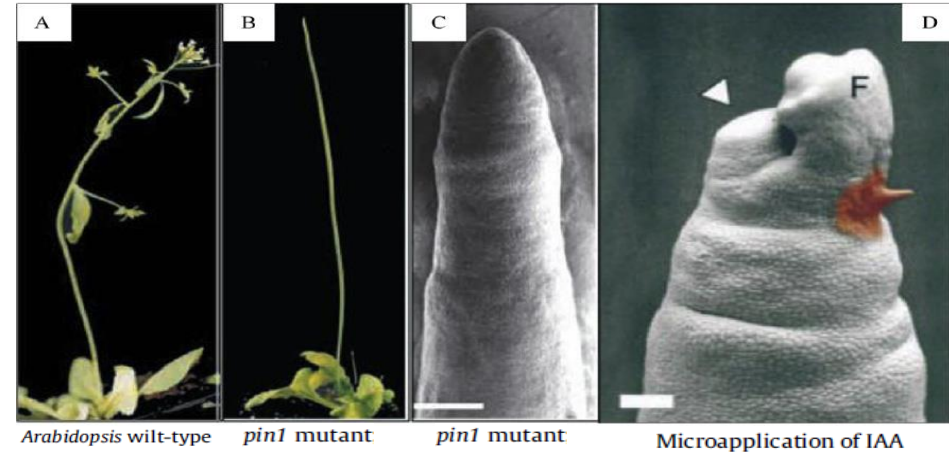
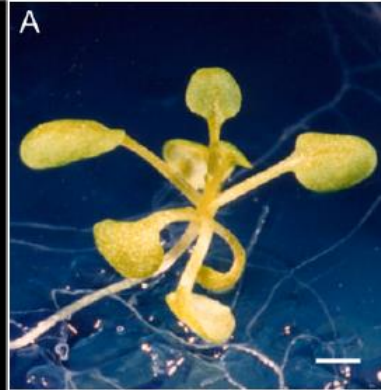
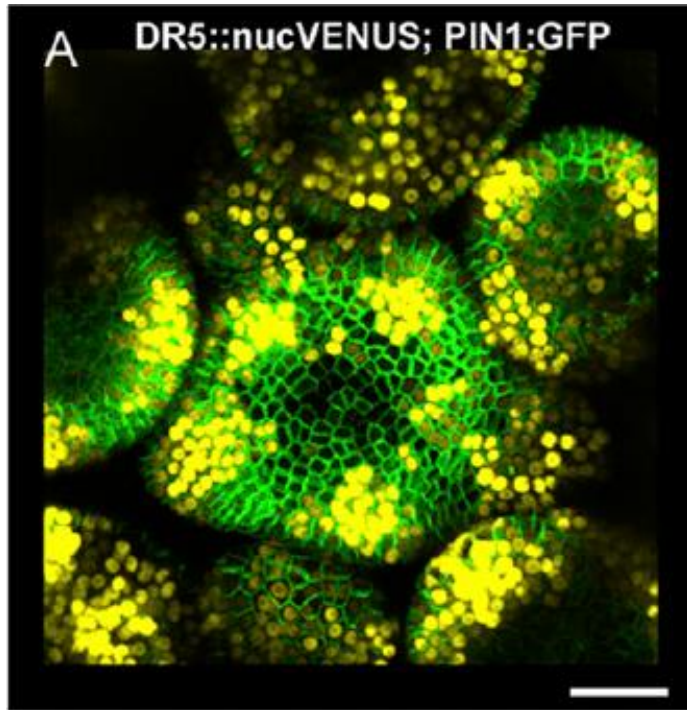
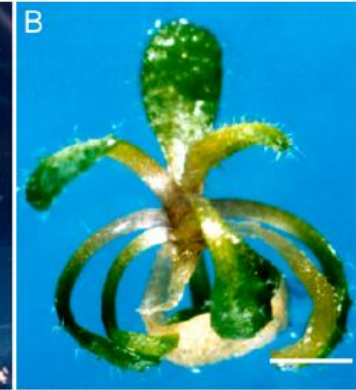


Image Source: Bohn-Courseau, I (2010),
C. R. Biologies, 333, 290–96.
Smith et al. (2006), PNAS, 103, 1301-6.
Bar & Ori (2014) Development 141,
4219-30.

Auxin Regulates Organogenesis



Wild-type



mp



mp pin1

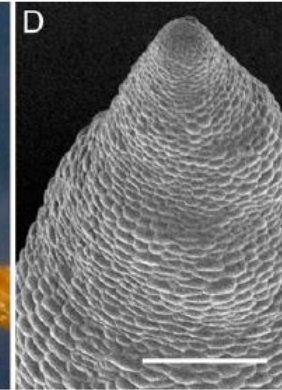


Image Source: Pinon et al. (2013), PNAS, 110, 1107–12.
Schuetz et al. (2008), Plant Physiology, 148, 870–80.

Auxin Regulates Organogenesis

PIN1 efflux carrier

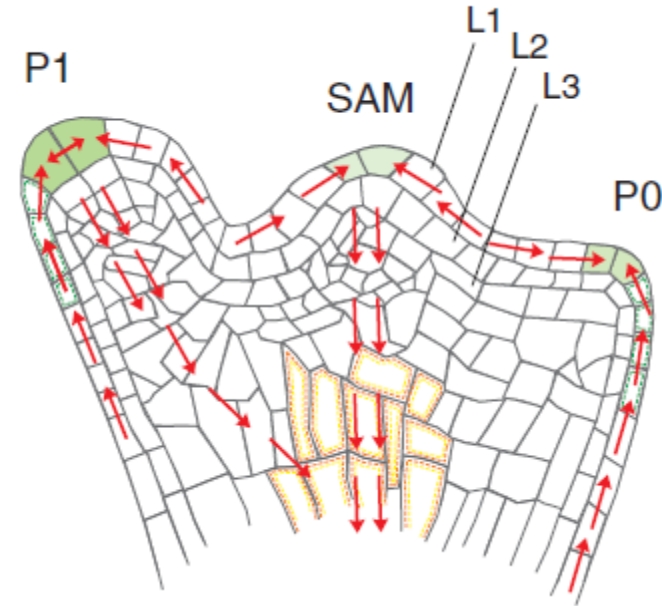
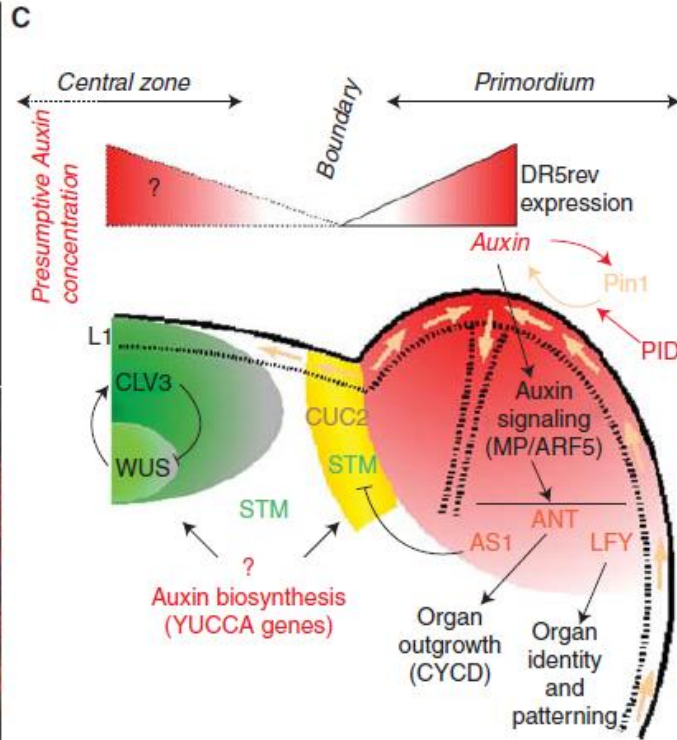
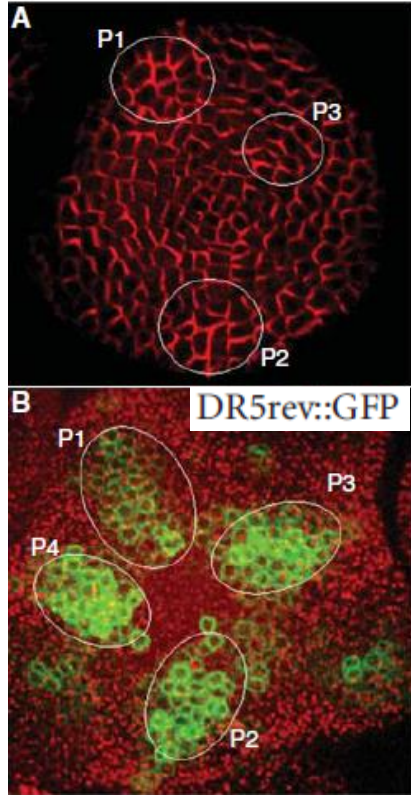


Image Source: Vernoux et al. (2010), Cold Spring Harb Perspect Biol., 2, a001487.
Petrášek & Friml (2009), Development, 136, 2675-88.

Feedback from Lateral Organs Controls Shoot Apical Meristem Growth by Modulating Auxin Transport

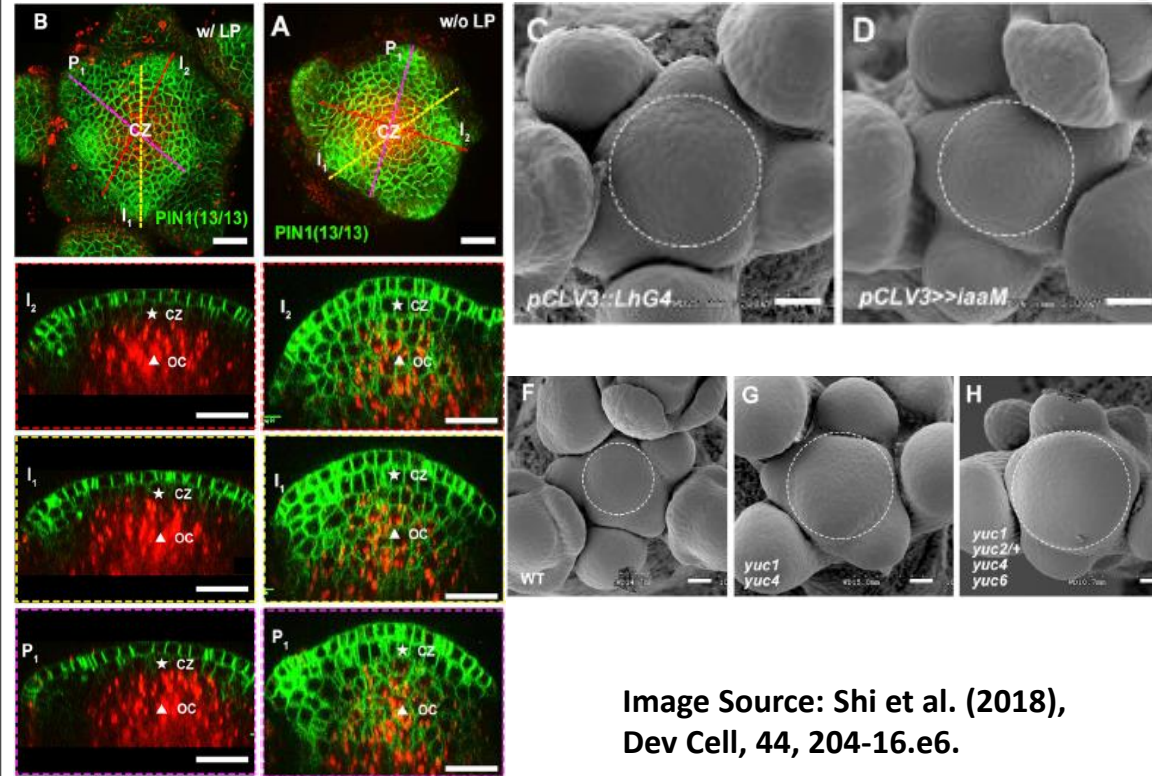
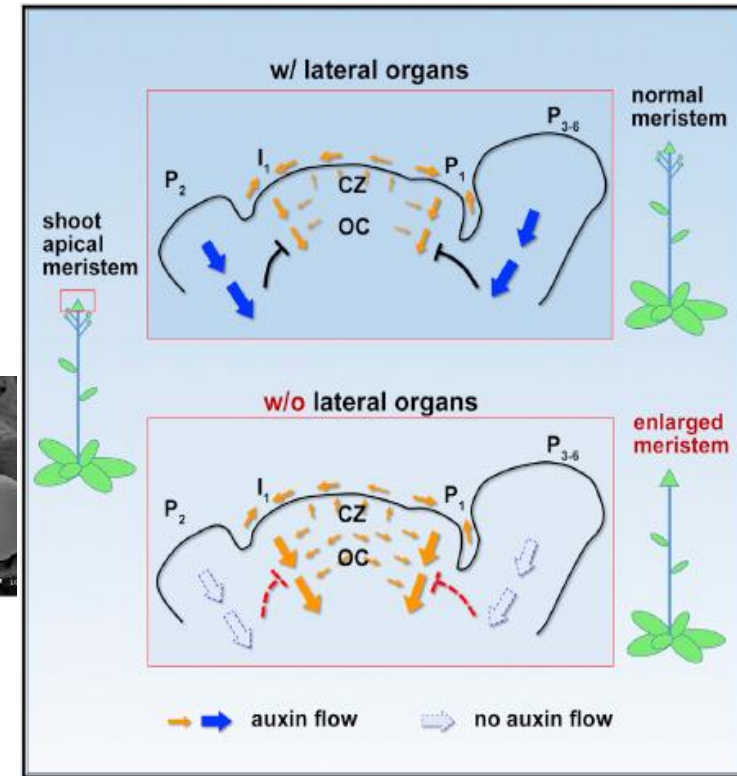


Image Source: Shi et al. (2018),
Dev Cell, 44, 204-16.e6.



Establishing Organ Polarity

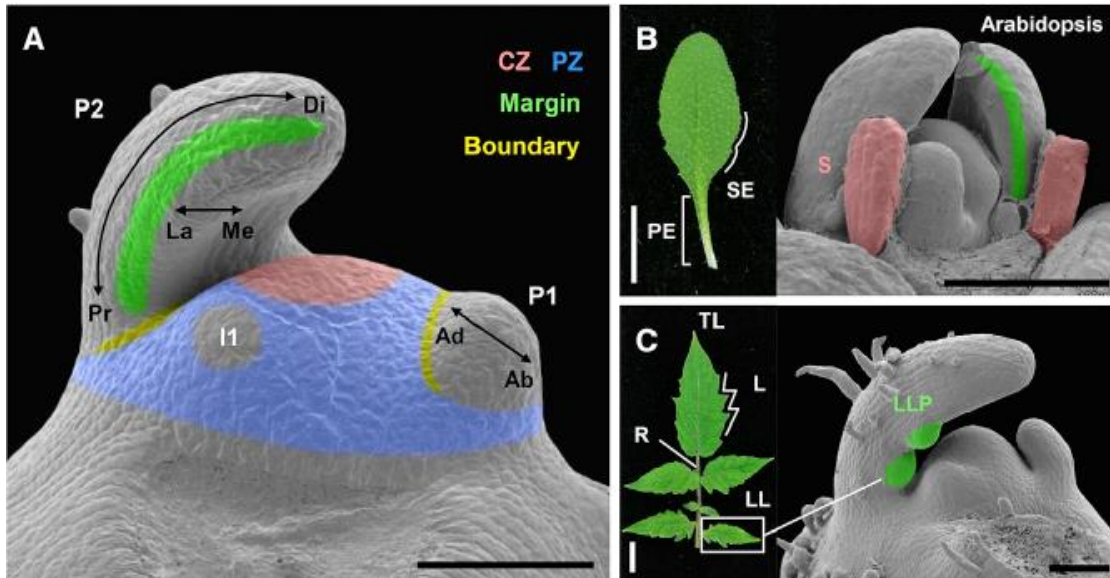
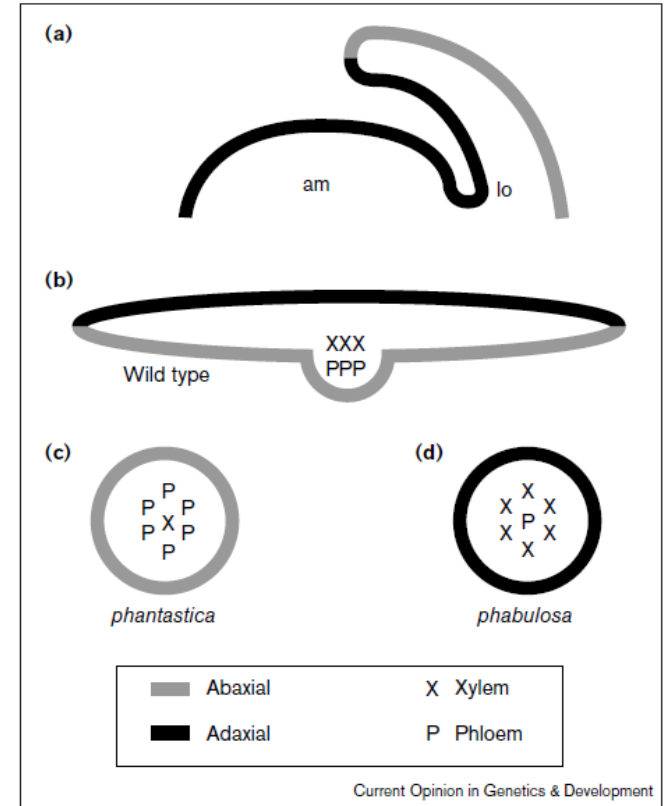


Image Source: Du et al. (2018), Mol Plant, 11, 1117-34.
Bowman, J. L. (2000) Curr Opin Genet Dev., 10, 399-404.



Positional Signals regulates Polarity

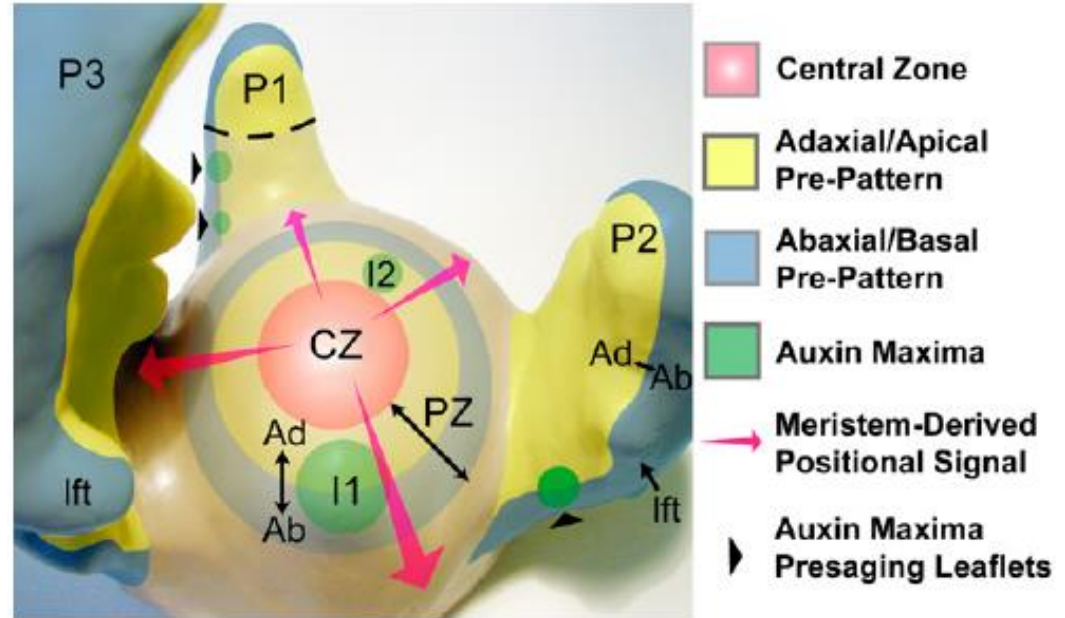
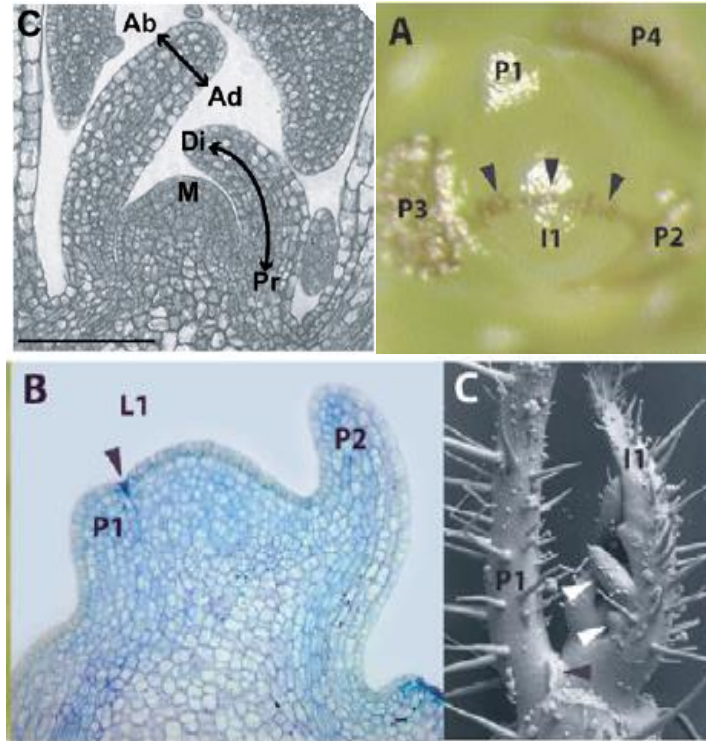


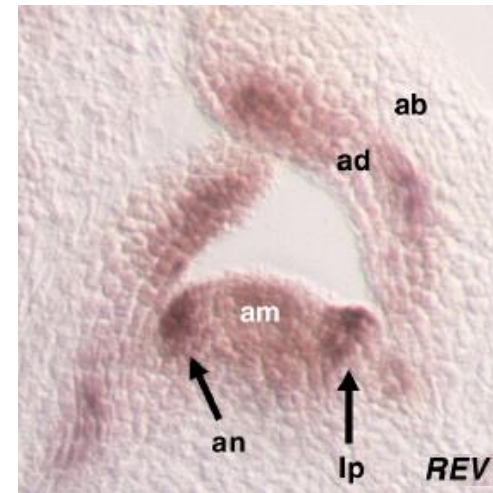
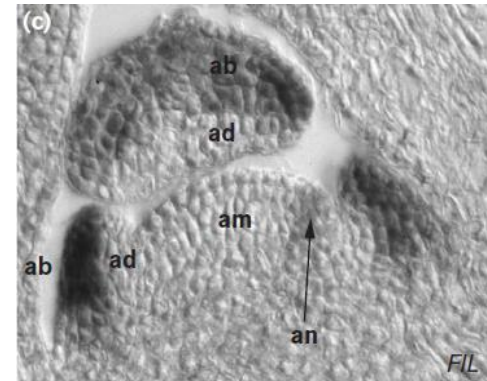
Image Source: Chitwood et al. (2007), *Development*, 134, 813-23.
Husbands et al. (2009), *Genes Dev.*, 23, 1986-97.

Establishing Organ Polarity

<i>Arabidopsis</i> gene	Family of protein	Expression in lateral organs	Loss-of-function phenotype ^a	Gain-of-function phenotype
<i>PHABULOSA</i>	Class III HD-ZIP	Adaxial	Unknown	Adaxialized
<i>PHAVOLUTA</i>	Class III HD-ZIP	Adaxial	Unknown	Adaxialized
<i>REVOLUTA</i>	Class III HD-ZIP	Adaxial	Abaxialized?	Unknown
<i>FILAMENTOUS FLOWER</i>	YABBY	Abaxial	Adaxialized?	Abaxialized
<i>YABBY2</i>	YABBY	Abaxial	Unknown	Unknown
<i>YABBY3</i>	YABBY	Abaxial	Adaxialized?	Abaxialized
<i>CRABS CLAW</i>	YABBY	Abaxial	Adaxialized	Abaxialized
<i>INNER NO OUTER</i>	YABBY	Abaxial	Adaxialized	Unknown
<i>KANADI1</i>	GARP	Abaxial	Adaxialized	Abaxialized

Image Source: Bowman et al. (2002), Trends Genet., 18, 134-41.

Bowman, J. L. (2000) Curr Opin Genet Dev., 10, 399-404.



Signals Derived from *YABBY* Gene Activities in Organ Primordia Regulate Growth and Partitioning of *Arabidopsis* Shoot Apical Meristems ^W

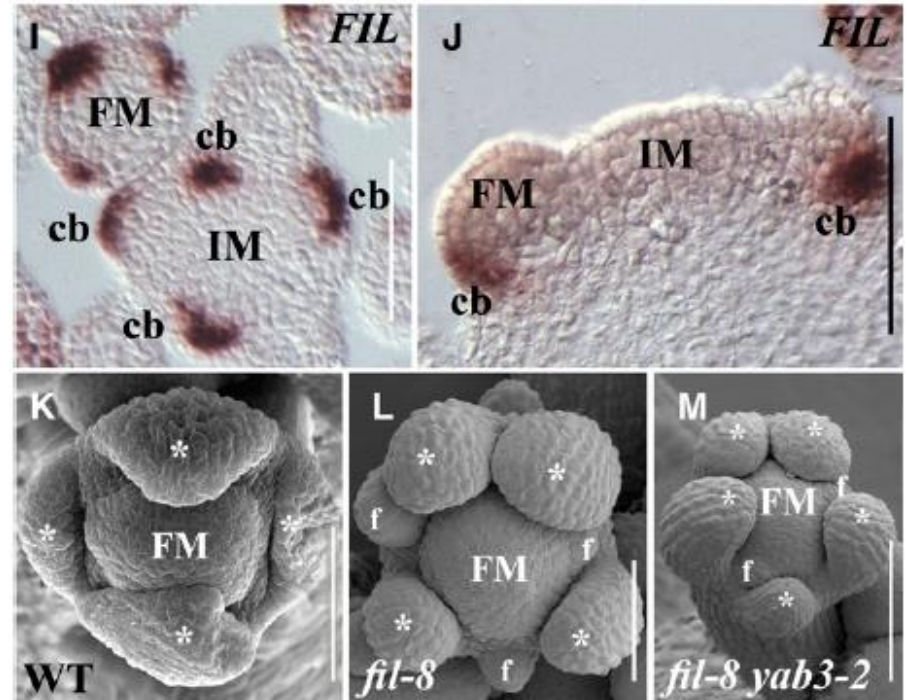
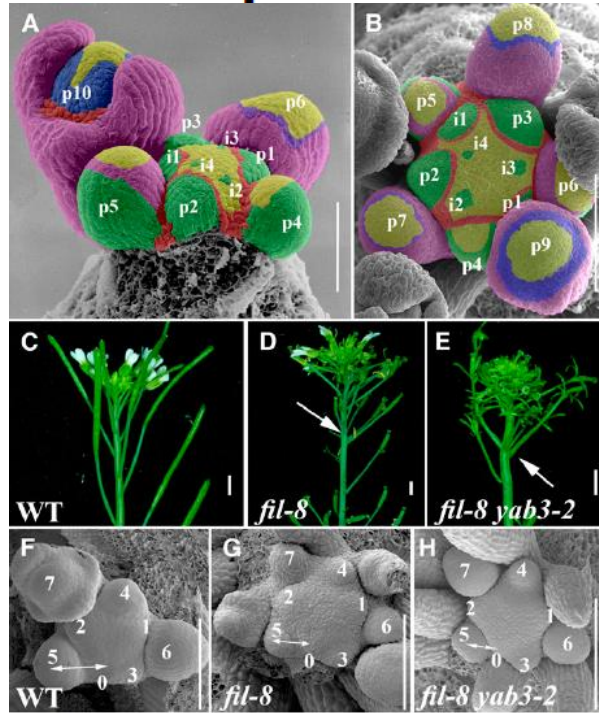


Image Source: Goldshmidt et al. (2008), Plant Cell, 20:,1217–30.

Signals Derived from *YABBY* Gene Activities in Organ Primordia Regulate Growth and Partitioning of *Arabidopsis* Shoot Apical Meristems ^W

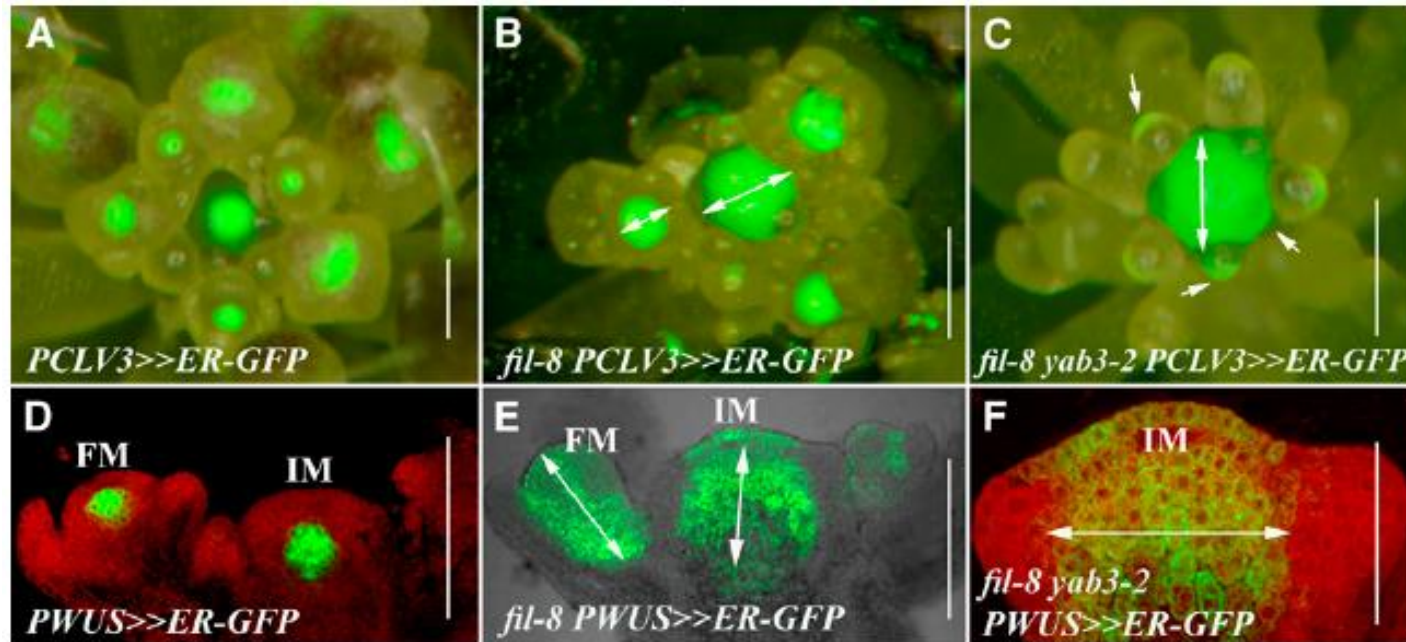


Image Source: Goldshmidt et al. (2008), *Plant Cell*, 20;1217–30.

Organogenesis at SAM

Meristem	Pre-founder cell	Founder cell	Outgrowth Polarity
KNAT	...		
		REV	
		ZWI	
		PIN1/AUX1	
	..		AS1
	..		LFY
	..		ANT
	..		CUC/PID/LAS
			KANADI/YABBY
			PHB/PHV/REV



Meristem proper



Formation pre-founder cells



Recruitment founder cells and boundary formation



Outgrowth and polarity

Image Source: Carraro et al. (2006) Plant Molecular Biology 60, 811–26.

Organogenesis at SAM

Meristem Centre

Meristem periphery

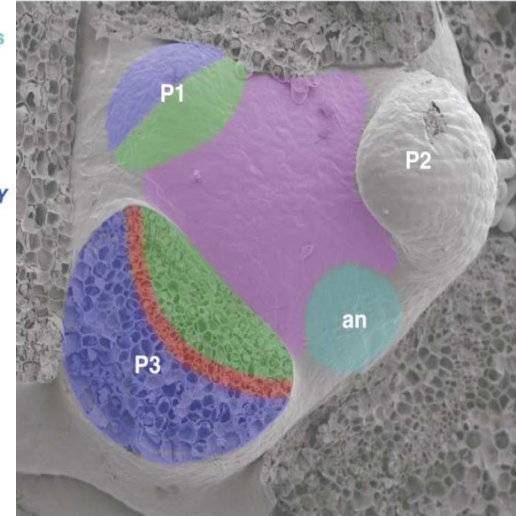
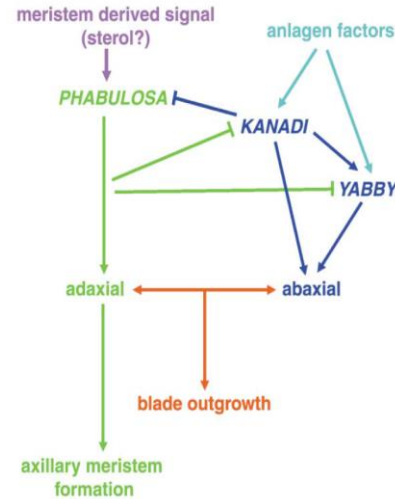
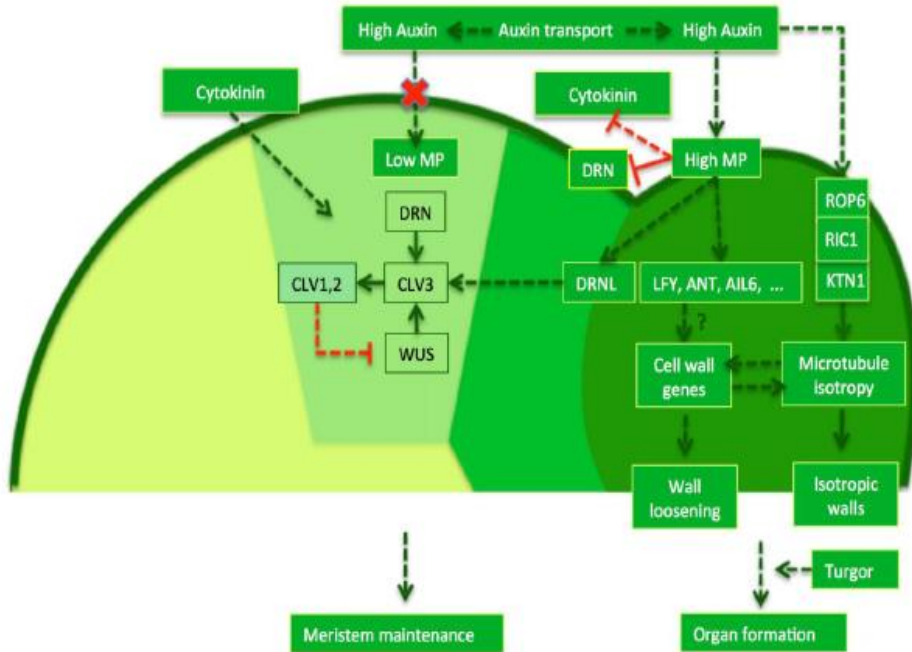


Image Source: Traas, J. (2019) Plants, 8, 6.
Eshed et al. (2001) Current Biology, 11, 1251–60.