



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Shoot Development: Flowering

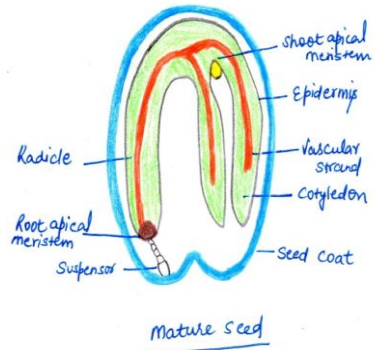
Dr. Shri Ram Yadav

Department of Biotechnology

Indian Institute of Technology, Roorkee



Floral Transition



Post-embryogenesis

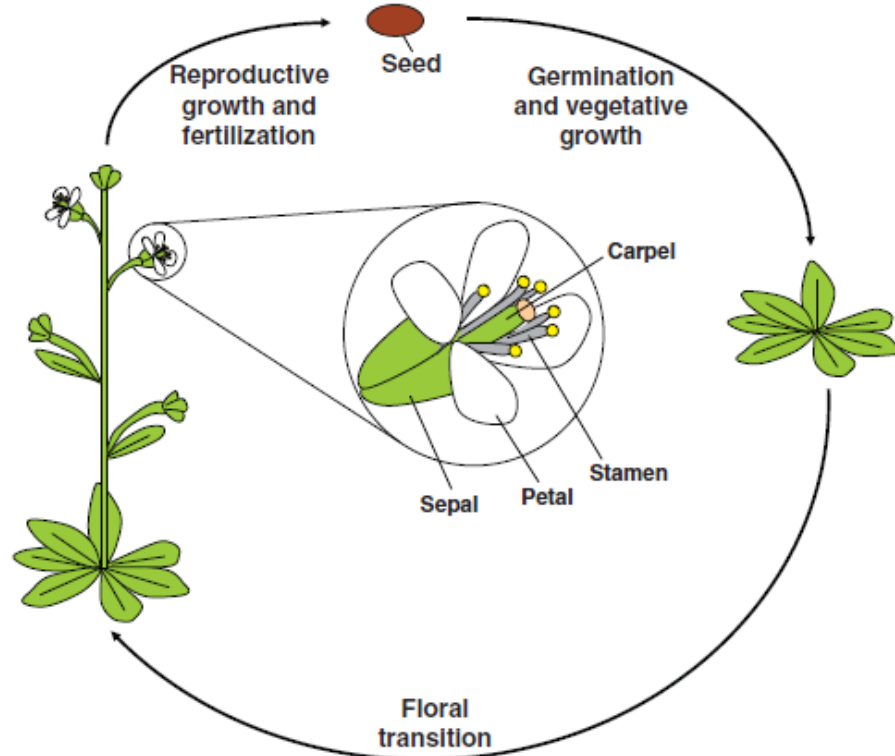


Image Source: Liu et al. (2009), Development ,136, 3379-91.

Floral Transition: Terminal Flower (TFL1)

EMS-mutagenized seed of ecotype Columbia



C

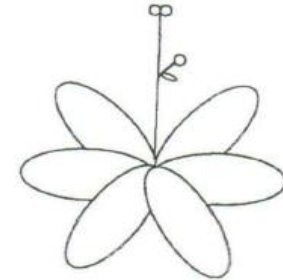
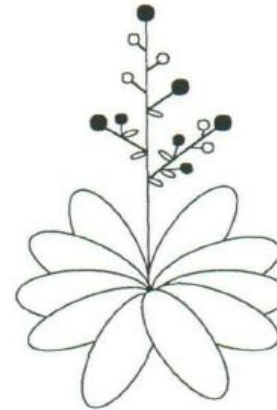


Image Source: Shannon & Meeks-Wagner (1991), Plant Cell, 3, 877-92.

Arabidopsis three metameric types

Floral Transition: LEAFY (LFY)

**LEAFY Is Required for Development of Type 3
Metamers**

1. Type 1, Rosette



2. Type 2,
coflorescence-bearing
with bract



3. Type 3,
flower-bearing
without bract

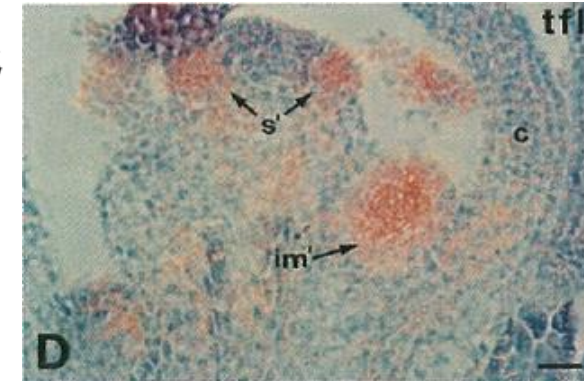
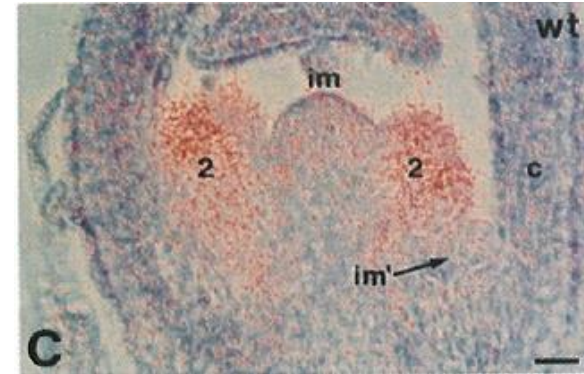
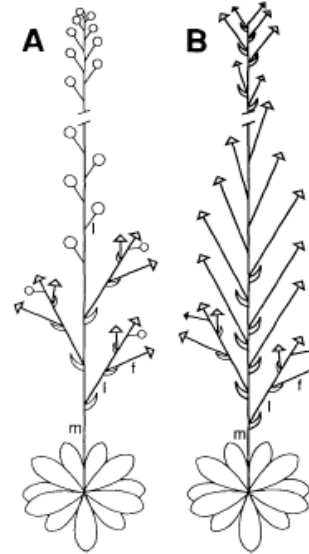


Image Source: Schultz & Haughn (1991), Plant Cell, 3, 771-81.

Floral Transition: Genetic Interaction

Arabidopsis three metameric types

1. Type 1, Rosette



2. Type 2, coflorescence-bearing with bract



3. Type 3, flower-bearing without bract

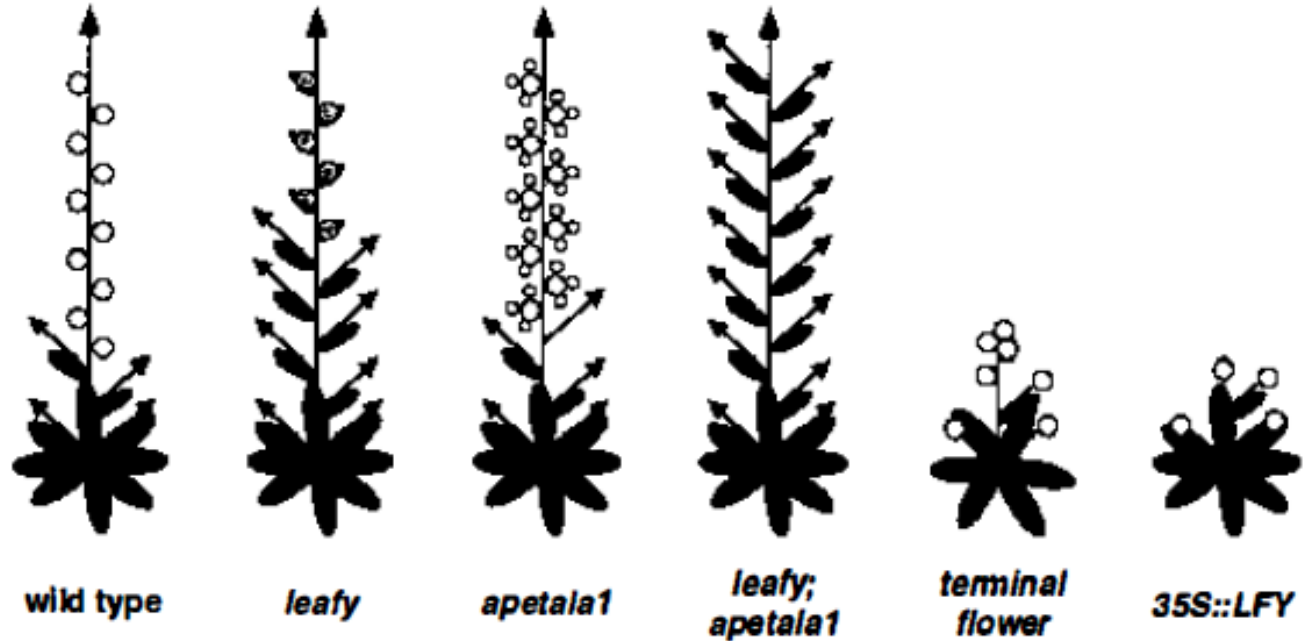


Image Source: Weigel, D. (1995), Annu. Rev. Genetics, 29, 19-39.

Floral Transition: TFL-LFY-AP1 Interaction

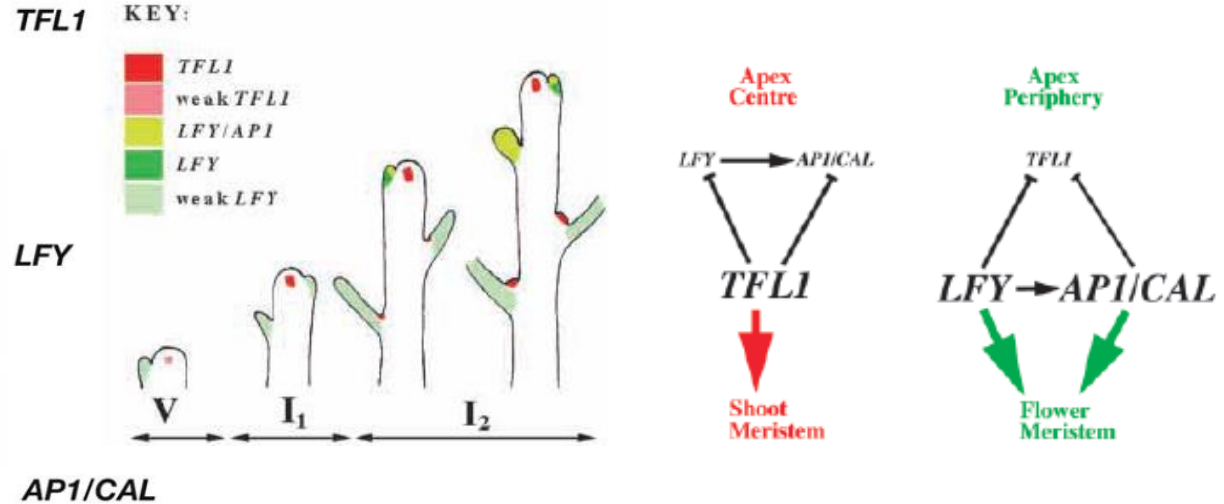
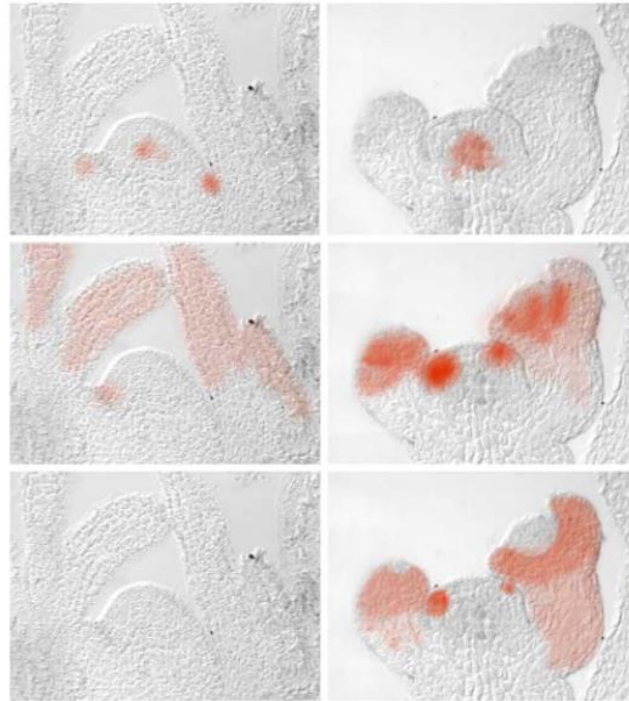


Image Source: Bla' zquez et al., (2006) Plant Mol. Biol. 60, 855-70
Ratcliffe et al. (1999), Development 126, 1109-20.

Floral Transition
SAM → IM/FM

Floral Transition: Genetic Interaction

Arabidopsis three metameric types

1. Type 1, Rosette



2. Type 2, cophlorescence-bearing with bract



3. Type 3, flower-bearing without bract

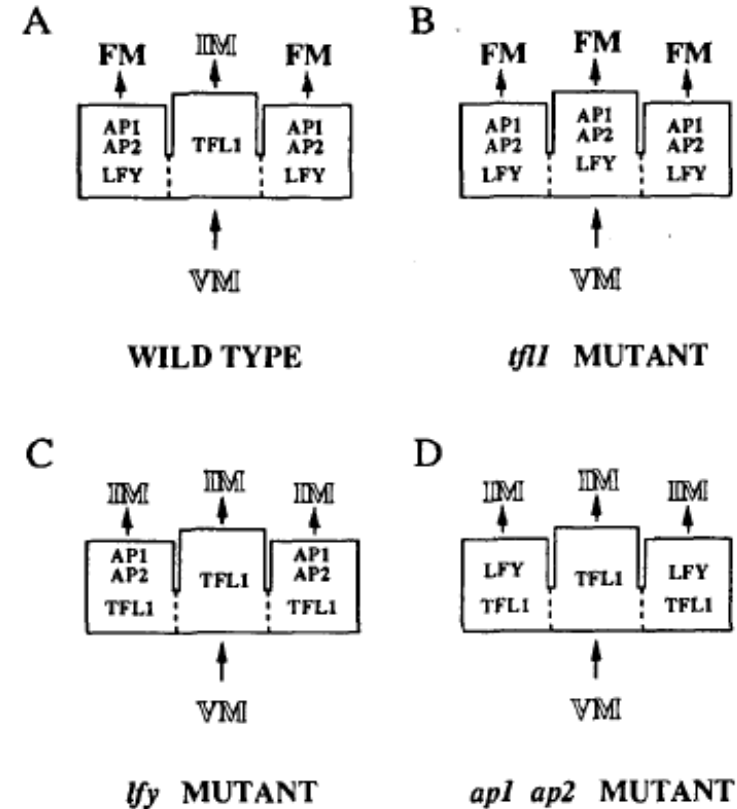
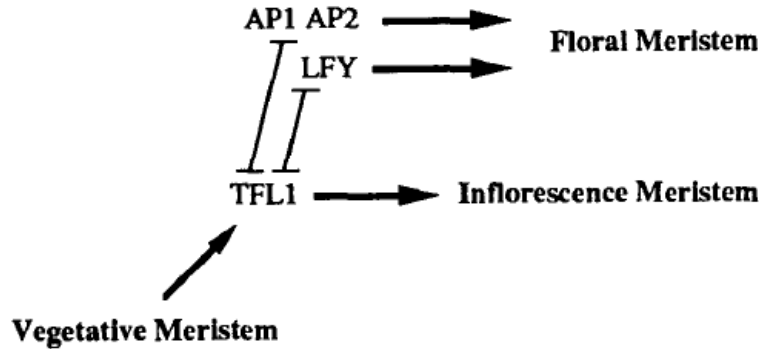


Image Source: Shannon & Meeks-Wagner (1993), Plant Cell, 5, 639-55.

Regulation of Flowering Time

- Late flowering**
- CONSTANS (CO)*
 - DE-ETIOLATED 2 (DET2)*
 - ETHYLENE INSENSITIVE 2 (EIN2)*
 - ETHYLENE RESISTANT 1 (ETR1)*
 - FRIGIDA (FRI) (=FLA)*
 - GIGANTEA (GI)*
 - LATE FLOWERING (FCA, FD, FE, FHA, FLC, FPA, FT, FVE, FWA, FY)*
 - LUMINIDEPENDENS (LD)*
 - VERNALIZATION INSENSITIVE (VRN)*
- Early flowering**
- EARLY FLOWERING 1-3 (ELF1, ELF2, ELF3)*
 - EMBRYONIC FLOWER 1, 2 (EMF1, EMF2)*
 - LONG HYPOCOTYL 1,2 (HY1, HY2)*
 - PHYTOCHROME B (PHYB)*
 - SPINDLY (SPY)*
 - TERMINAL FLOWER (TFL)*
- Late flowering in short days only**
- GIBBERELLIN INSENSITIVE (GAI)*
 - GIBBERELLIN REQUIRING 1 (GAI)*
- Early flowering in short days only**
- ABSCISIC ACID DEFICIENT (ABA)*
 - ABSCISIC ACID INSENSITIVE 1 (ABI1)*
- Not delayed by short days**
- CONSTITUTIVE PHOTOMORPHOGENIC 1 (COP1) (=FUSCA1)*
 - DE-ETIOLATED 1 (DET1) (=FUSCA2)*
- Night-break/day-length-extension insensitive**
- PHYTOCHROME A (PHYA)*

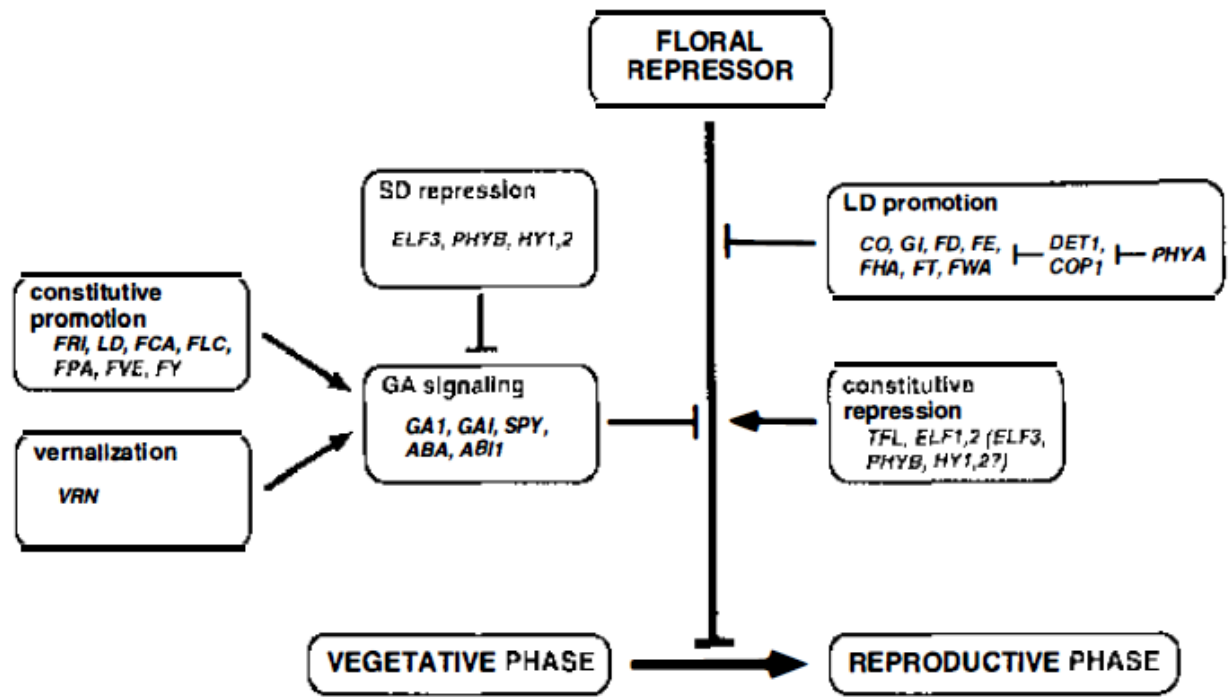
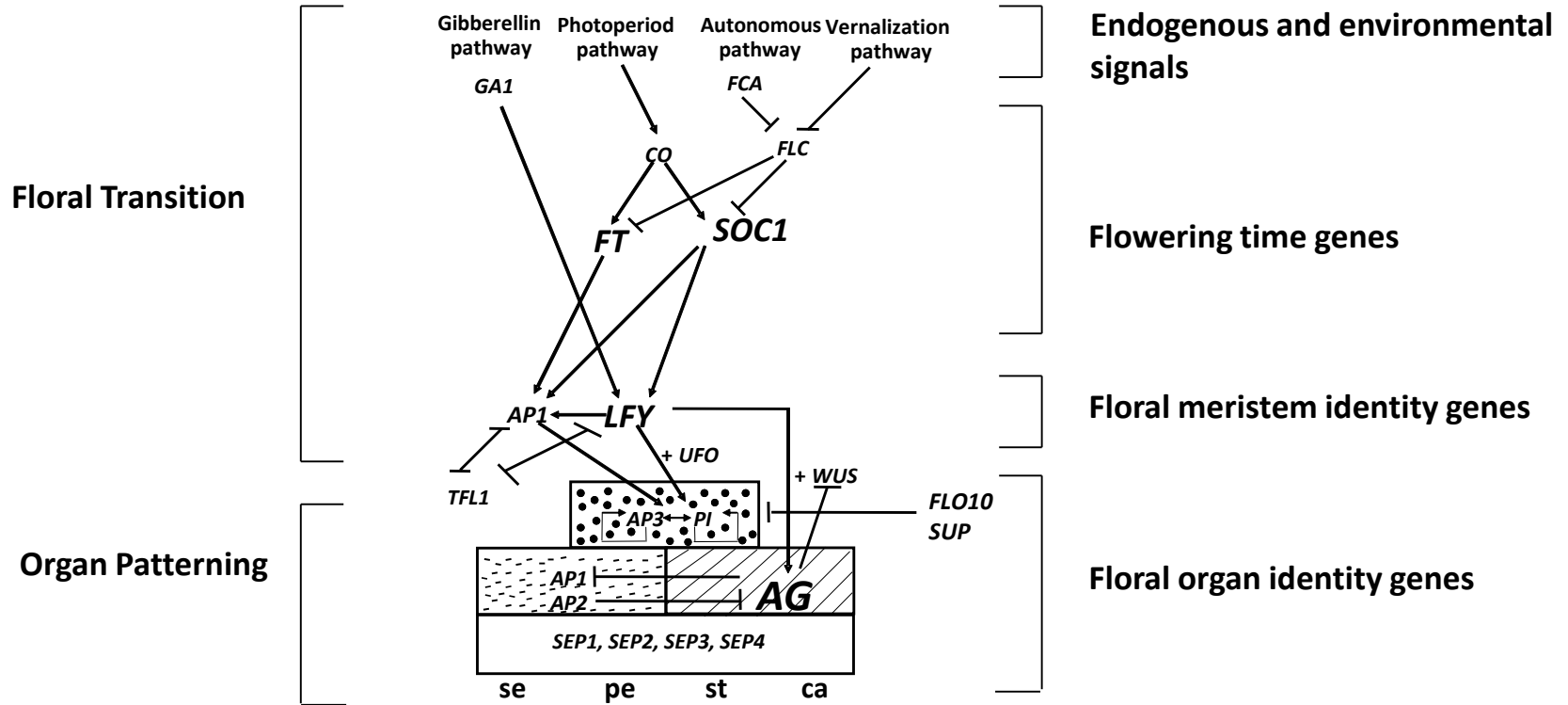


Image Source: Weigel, D. (1995), Annu. Rev. Genetics, 29, 19-39.

Genetic Pathways Regulating Flowering Time



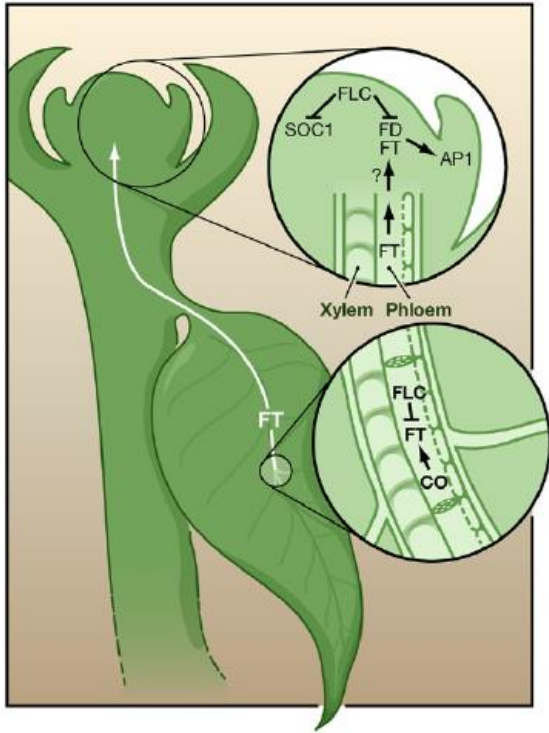
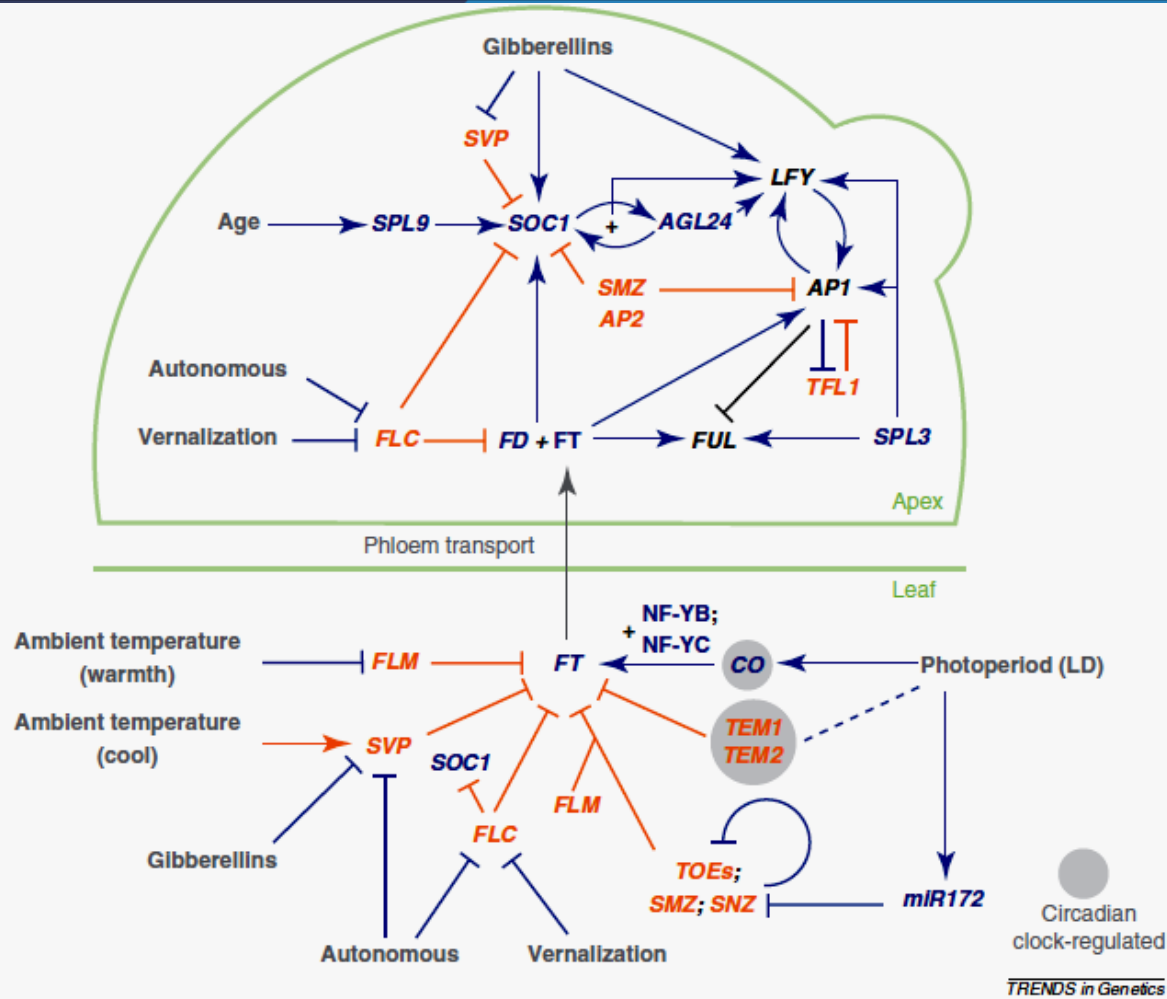


Image Source: Bäurle & Dean (2006)
Cell, 125, 655-64.
Wellmer & Riechmann (2010), Trends
Genet., 26, 519-27.



Floral Organ Identity Genes: ABCDE genes

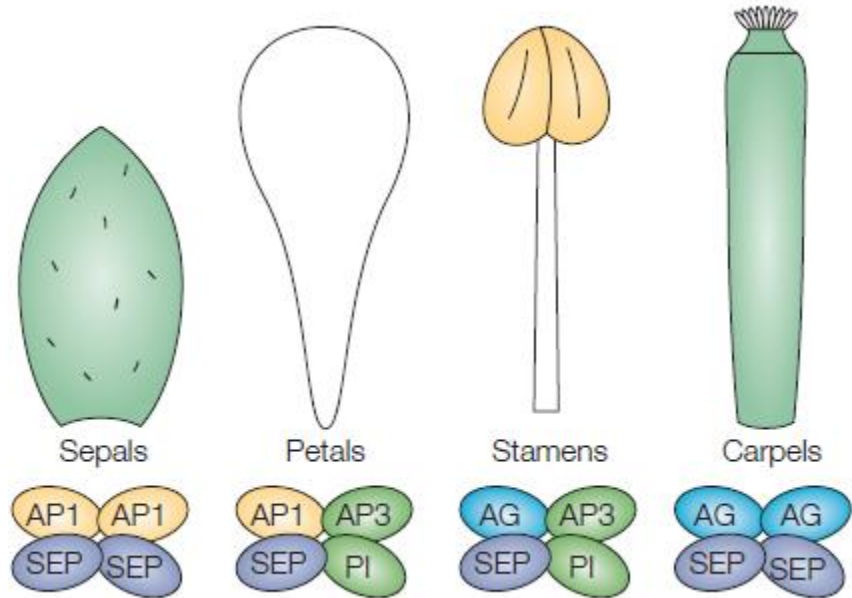
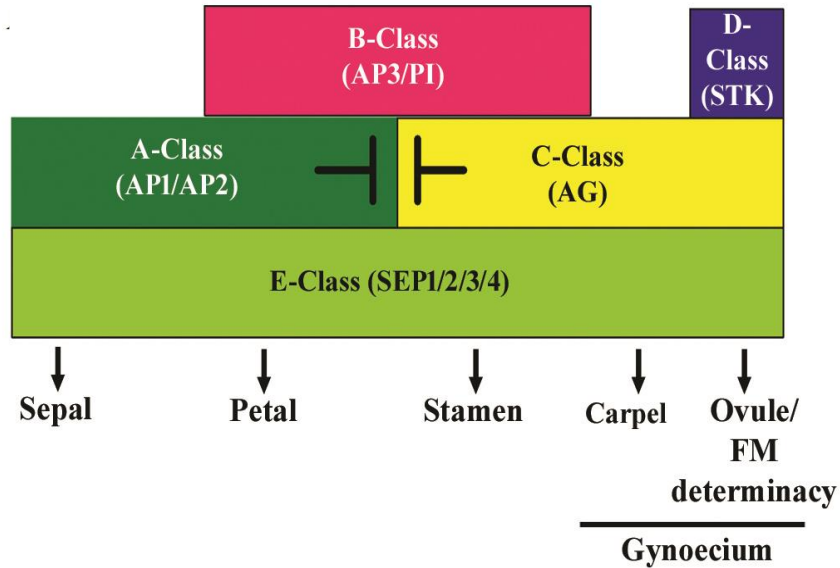


Image Source: Krizek & Fletcher (2005), Nat Rev Genet. 6, 688-98.

Activation of Floral Meristem Identity Genes

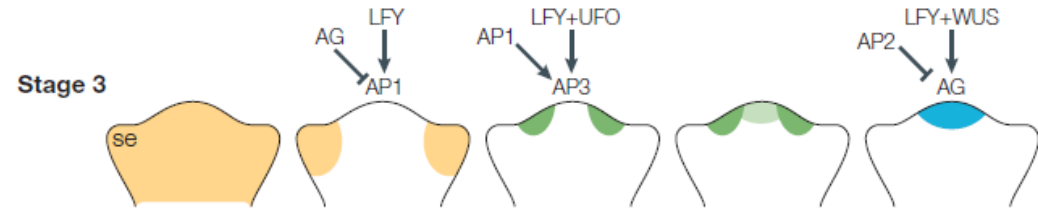
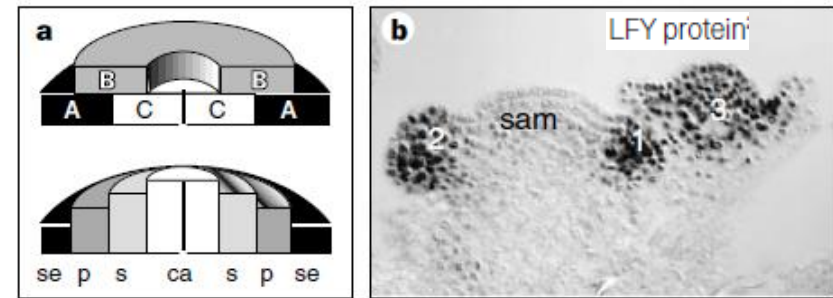
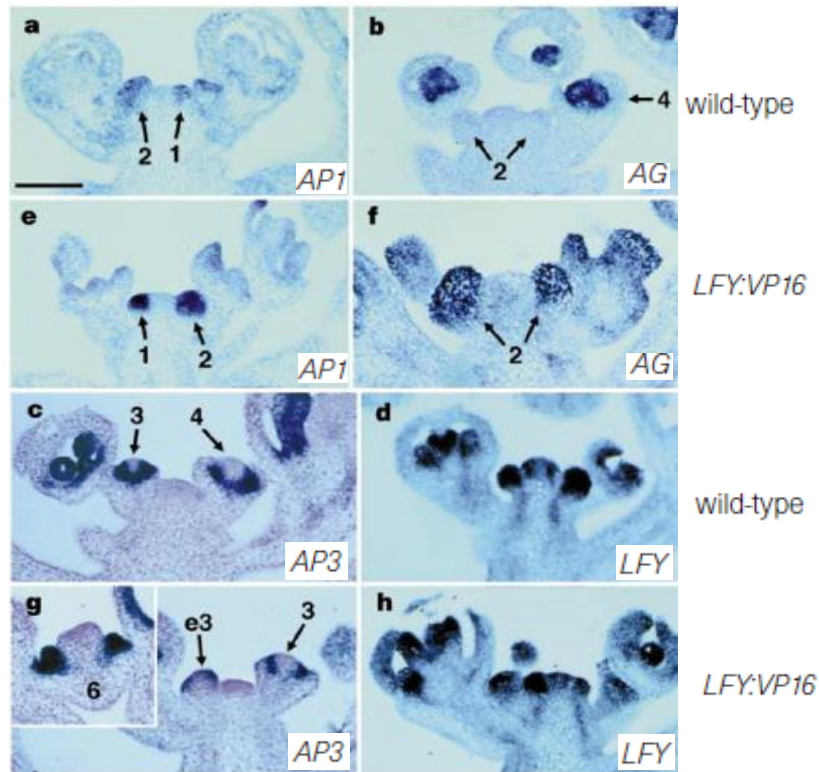


Image Source: Parcy et al. (1998), Nature, 395, 561-66.
Krizek & Fletcher (2005), Nat Rev Genet. 6, 688-98.

Floral Organ Identity Genes: ABCDE genes

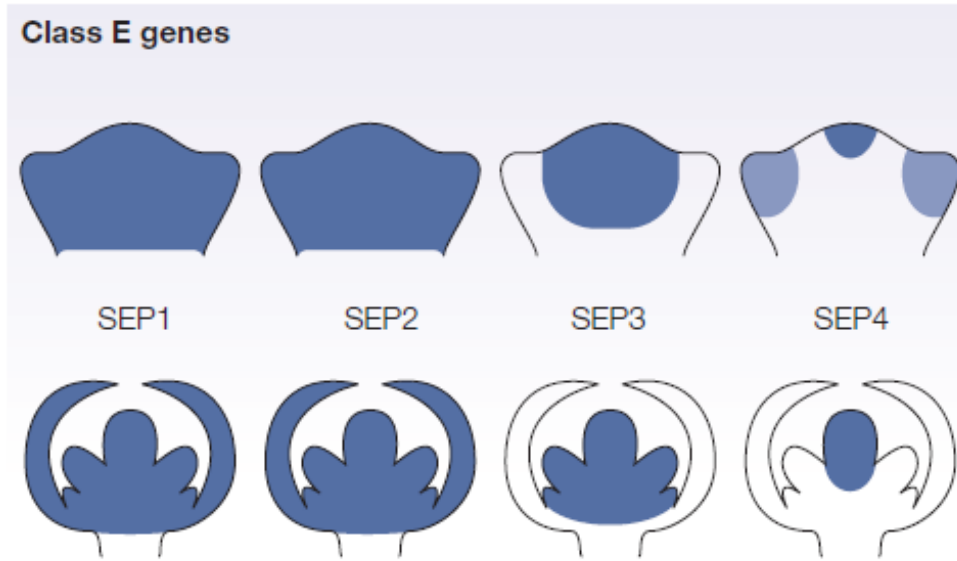
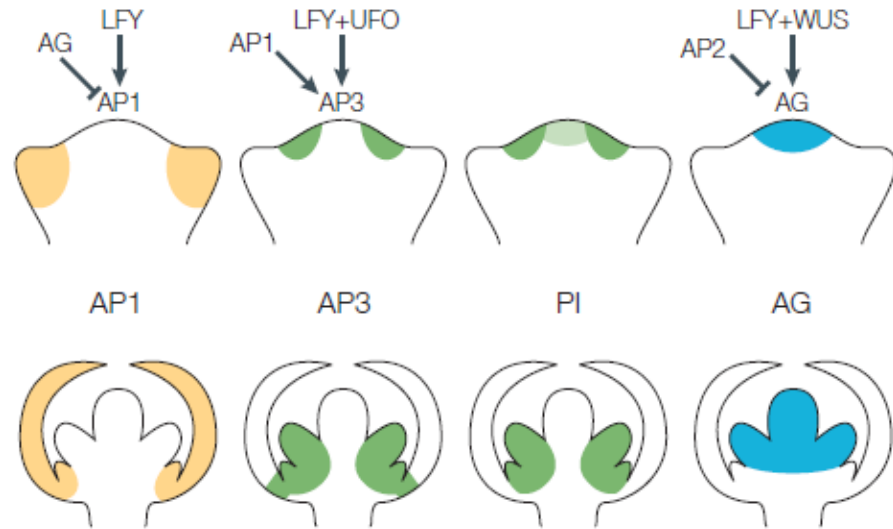


Image Source: Krizek & Fletcher (2005), Nat Rev Genet. 6, 688-98.

Floral Organ Identity Genes: ABCDE genes

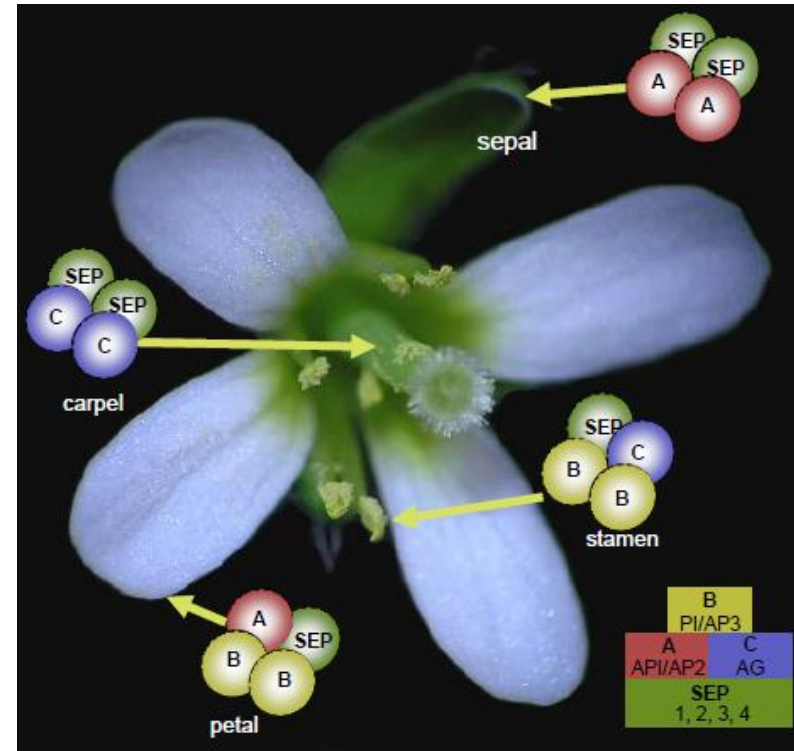
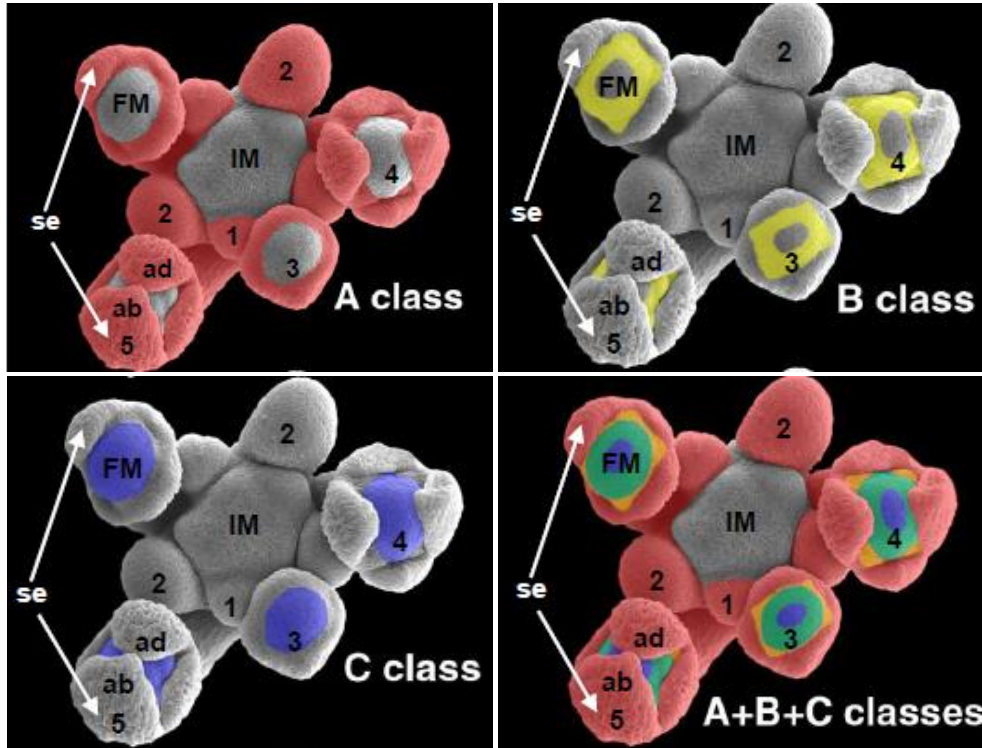


Image Source: Alvarez-Buylla et al. (2010), Arabidopsis Book, 8, e0127.

Floral Organ Identity Genes: ABCDE genes

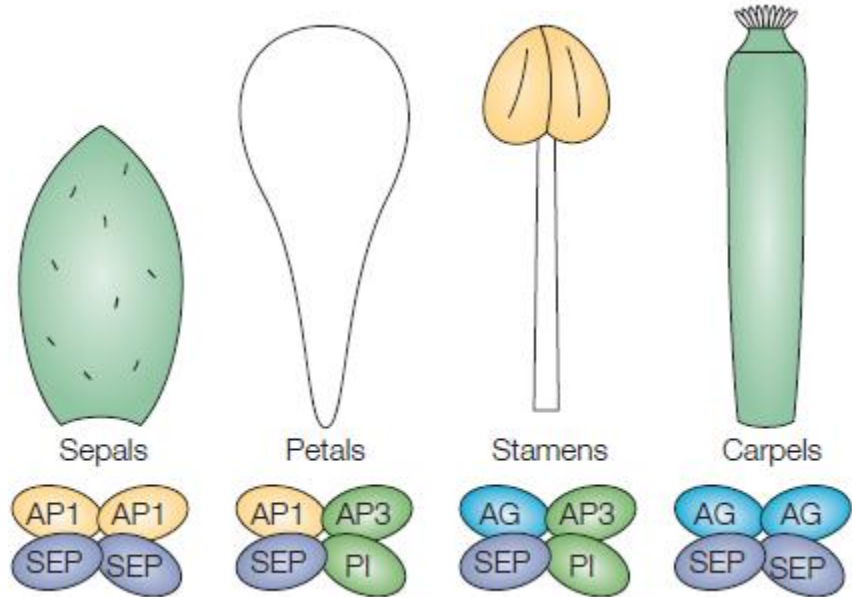
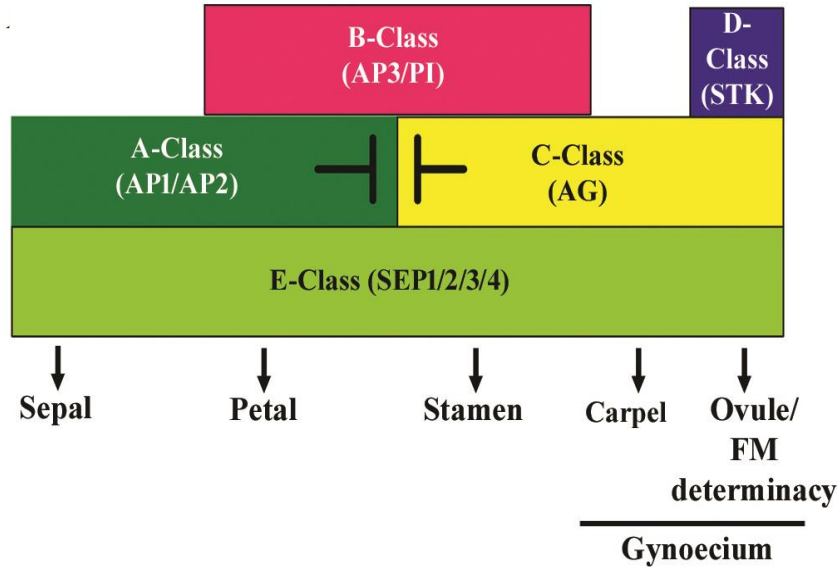


Image Source: Krizek & Fletcher (2005), Nat Rev Genet. 6, 688-98.

Floral Organ Identity Genes: ABCDE genes

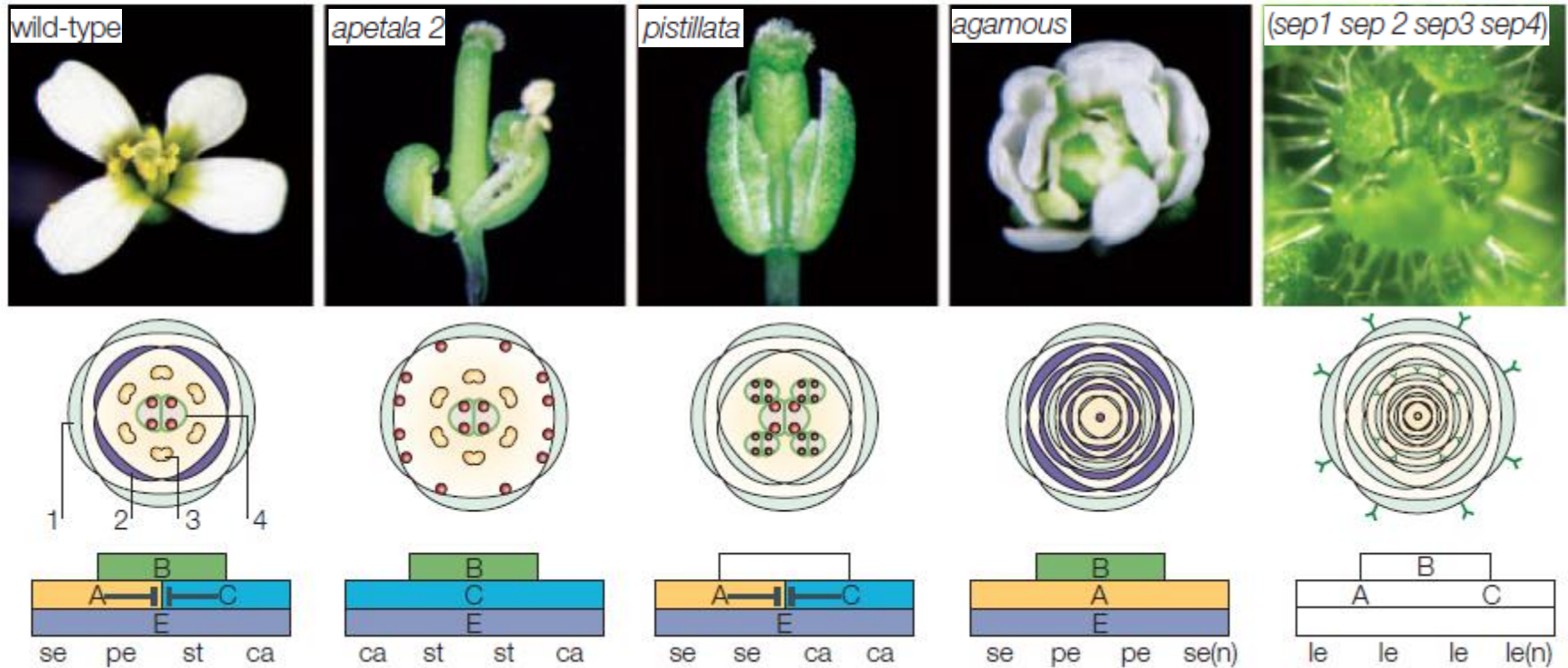
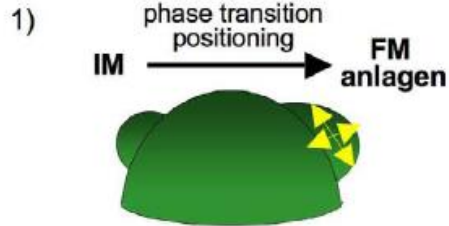


Image Source: Krizek & Fletcher (2005), Nat Rev Genet. 6, 688-98.

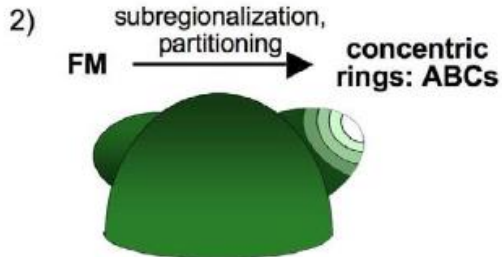
Floral Organ Patterning

DEVELOPMENTAL PROCESS

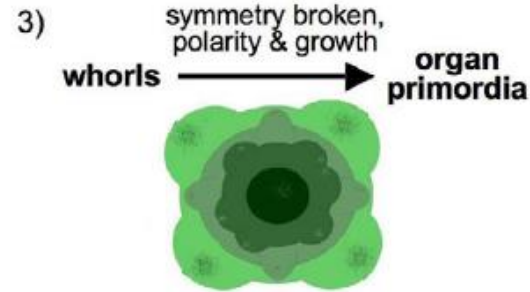
FUNCTIONAL REGULATORY MODULES (key genes)



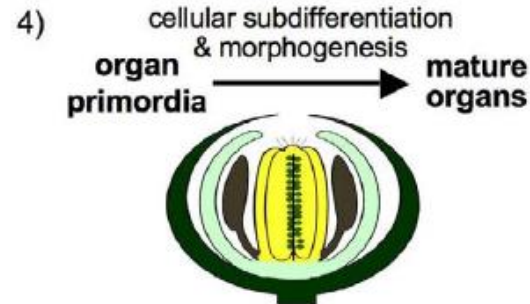
AS1, FMI genes, PIN1, YAB, PHABs, KANs;
Figures 9, 15, 20 and 21.



WUS, UFO, ANT, SUP, ABC genes, SEP genes;
Figures 13, 14, 15, 20 and 21.



PAN, SUP, AXR1, ARGOS, ANT, ETT, WUS/CLV, YABs, KANs, PHABs, UFO, CUCs, LBD genes, JAG, NUB, AS1/2;
Figure 15.



Genes in Figures 15, 16, 17, 18, 19 and Table S1.

Image Source: Alvarez-Buylla et al. (2010), Arabidopsis Book, 8, e0127.

Floral Determinacy

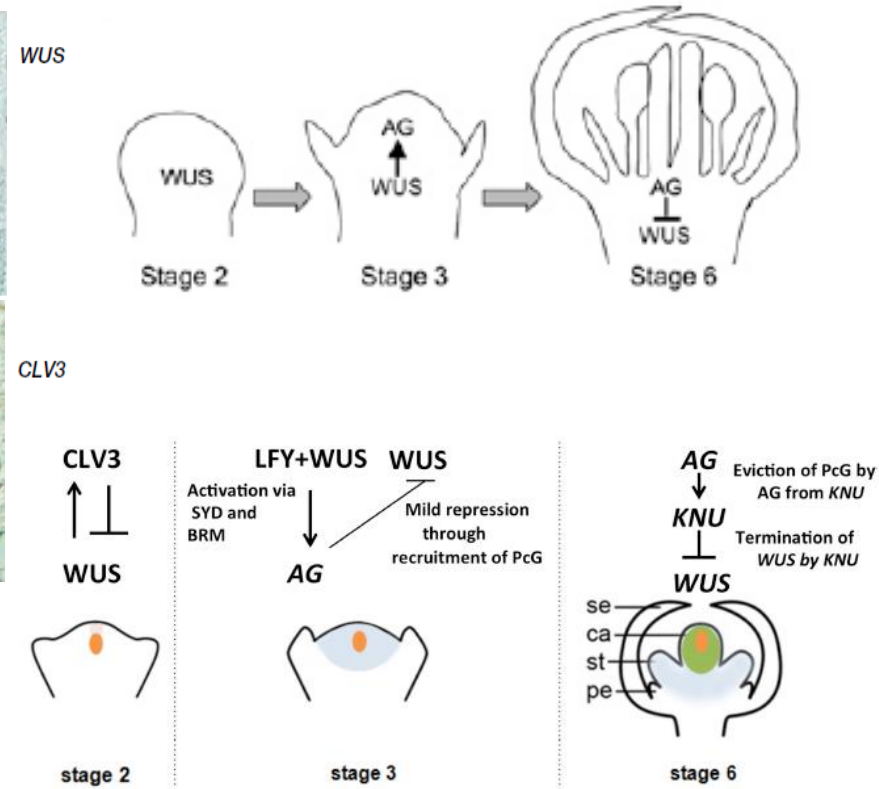
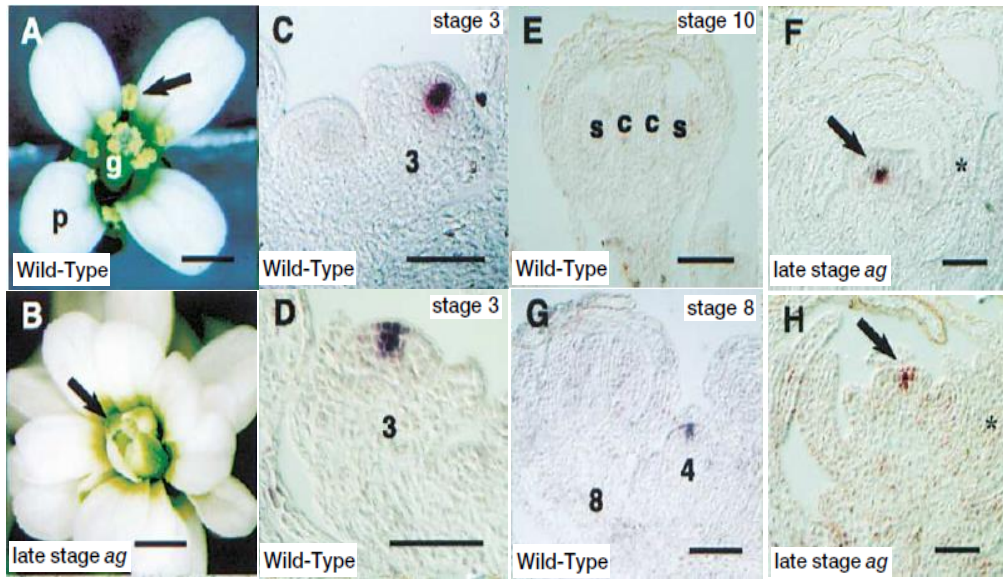


Image Source: Lenhard et al. (2001), Cell, 105, 805–14.
 Ming & Ma (2009), GENES & DEVELOPMENT 23, 1705–08.
 Sun & Ito (2015), Front Plant Sci., 6:17.

Floral Determinacy

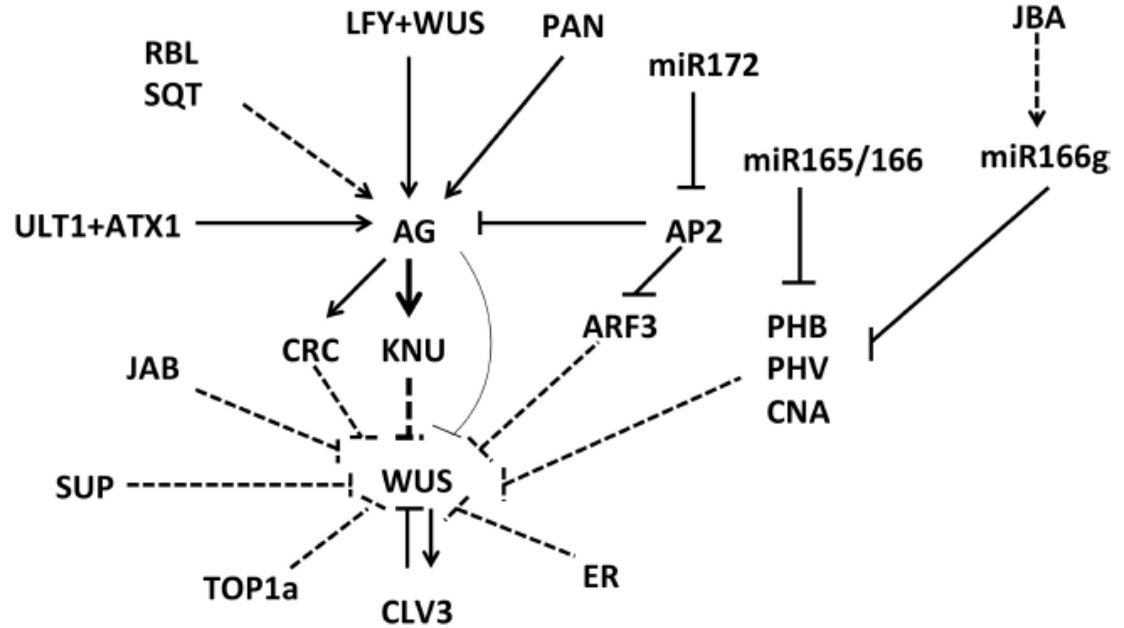
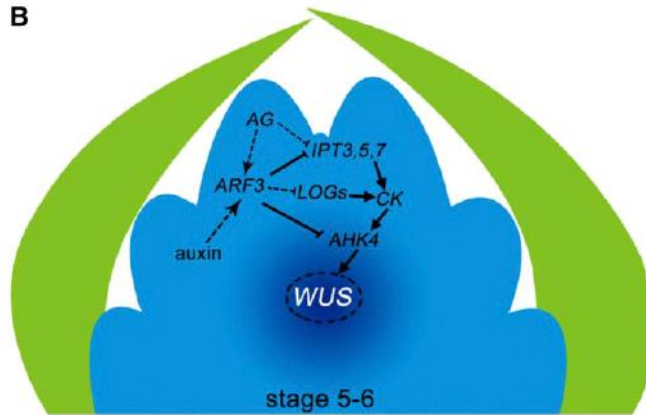
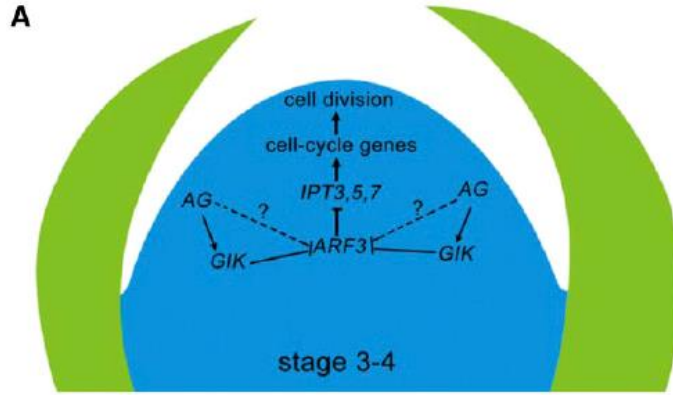


Image Source: Zhang et al. (2018), Plant Cell, 30, 324–46.
Sun & Ito (2015), Front Plant Sci., 6:17.