Plant morphogenesis II
Meristems produce plant organs, while maintaining themselves.
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Phyllotaxis (organ arrangement)
Leaf morphology (whole organ)
Leaf pattern (cellular features)
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Phyllotaxis (organ arrangement)

Leaf morphology (whole organ)

Leaf pattern (cellular features)

--- Cell division #s and directions

--- Differential expansion

--- Subject to environmental input

Leaves from a single tree outside Munger residence
Phyllotaxis (organ arrangement)
Leaf morphology (whole organ)
Leaf pattern (cellular features)
Leaves in two classes of flowering plants (monocots and dicots) grow in very different ways.
Building and patterning the epidermis of the Arabidopsis leaf
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Building and patterning the epidermis of the Arabidopsis leaf
Stomatal lineage products
Pavement cells + stomata

CO₂ in
H₂O and O₂ out
Stomatal lineage: a model for cell fate, asymmetry and communication
The stomatal lineage team...

Anne Vaten
On Sun Lau
Martin Bringmann
Kelli Davies
Emily Abrash
Cora MacAlister

Dirk Spencer
Yan Gong
Andrew Muroyama
Asymmetric Self-renewing divisions

Oriented Asymmetric Divisions & Differential Fate

stoma (breathing pore)
Questions to ask in/about the stomatal lineage

How are cells “chosen” to initiate the lineage?

How does pattern emerge between siblings, neighborhoods, globally?

What types of information are cells integrating to make decisions?

Divisions are physically asymmetric and can be oriented:

What’s the relationship between that asymmetry and cell behavior and identity?
bHLH transcription factors are at the core of cell identities
How are asymmetric divisions initiated and maintained?
Many targets of SPCH are related to promoting division and fate.
How is the “repeated on/off” pattern of SPCH established?

Work from: Bergmann, Gray, Kakimoto, Hara-Nishimura, Sack, Torii labs
SPEECHLESS

YODA (MAPKs)

EPFL ligands

ERECTA/TMM receptors

Delayed feedback

Formal model: Horst et al., 2016

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+ feedback

Lau et al., 2014
How is SPCH on/off coordinated spatially?
“everything you know is wrong”
PIN3 is present, but not polarized.
These novel, **plant specific, polarized** proteins link SPCH and signaling.

Zhang et al., 2015
Juan Dong’s Lab, Waksman
YODA (MAPKs) 

SPEECHLESS 

BASL 

MAPK 

SPCH 

MAPK 

+ Post-division growth
The narrow view

How do plants set up and use information for fates and local pattern?

A broader view

What happens when products of these dispersed populations interact?
New imaging pipeline to capture polarity dynamics and final fate

Capture cell dynamics from birth to division (24 hr @20min)

Capture divisions and ultimate fate (+72 hr @24hr intervals)

POME
Quantitative polarity Measurement
Are local behaviors coordinated across the organ? If so, how?

What happens when products of these dispersed populations interact?
Are local behaviors coordinated across the organ? If so, how?

Is there planar polarity?
Do cellular polarities follow the leaf axis?

Equally oriented at all points?

Polarity angle $\alpha$

BRXL2-YFP
Do cellular polarities follow the leaf axis?

Equally oriented at all points?
What's the relationship between BRXL2 and local growth?

Monitor BRXL2 polarity over time

Does BRXL2 just go to the curviest or fastest growing region?
What’s the relationship between BRXL2 and local growth?
What’s the relationship between local and global growth?
What’s the relationship between local and global growth?
Might BRXL2 orient relative to mechanical information?

- Local ablation
- PDMS-stretching

Tension (Hamant)

Realigned toward wound center

High-tech stretch device
Which information takes precedence?

Local ablation  Vs.  Neighboring stomata

14/15 cells orient polarity crescent relative to stomatal information
Some questions to answer...

How does patterning work at multiple scales?

Is there feedback from growth (mechanical info) on divisions and pattern?

Patterning of stomatal is very flexible (and a bit sloppy). What types of regulatory networks permit/favor this?

What is going to be predictive of cell behavior?

If plants have a natural planar polarity system and no cell movement, might cells in certain lineages need to escape to solve local problems?