Outline

1. Leaf Structure: Morphology & Anatomy
2. Leaf Development
   A. Anatomy
   B. Sector analysis
   C.
Leaf Structure - Morphology

- Dermal Tissue System
  - Upper & Lower epidermis
  - Stomatal complexes
  - Cuticle
  - Trichomes

- Fundamental Tissue System
  - Upper & Lower epidermis
  - Stomatal complexes
  - Cuticle
  - Trichomes

- Vascular Tissue System
  - Veins: Xylem & Phloem
  - Bundle Sheath cells

Leaf Structure - Anatomy

Variation in Leaf Structure

- Iris unifacial leaf
- Lilac bifacial leaf

Sclerenchyma

Bulliform Cells

Bundle Sheath Cells

Sugar cane leaf
Characteristics of simple leaves

1. Determinate growth
2. Three planes of orientation in a leaf

**One** → Upper – Lower
Upper = adaxial side = dorsal = towards the stem axis
Lower = abaxial side = ventral = away from the stem axis
Adaxial palisade mesophyll & Abaxial spongy mesophyll
Adaxial xylem and abaxial phloem in vascular bundles

**Two** → Apical-Basal axis = tip to base.
**Three** → Lateral axis = width

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How many cells does it take to make a leaf from a shoot apical meristem?

Poethig & Sussex 1985
Tobacco leaf development
Sector analysis of SAM

1. Irradiate buds
   → knock out pigment production gene in cells at SAM
2. Observe mitotic descendants of a single “marked” cell as unpigmented clonal sectors.

Three sectors across apical-basal axis ⇒ three cells in SAM
Five sectors across lateral axis ⇒ five cells in SAM

Results for I2
1. Sectors found in only fraction of leaf
   → many founder cells in leaf even before leaf primordium forms
2. Based on sector length, width & depth ⇒ 100-200 founder cells.

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Leaf Primordia and Leaf Determination

Leaf primordia form in peripheral zone
Before P5: Primordium → peg-like axis
After P5: Leaf fate established → Lamina form
(Sussex & Steeves work)
Lamina (leaf blade) formation

- Developing lamina → transition from radial to dorsi-ventral development
- Marginal meristem
- The tobacco shoot tip

Sector Analysis in Tobacco Leaves

- Irradiated at P2
- P2 = emerged primordium

Conclusions
1. Growth by Intercalary cell divisions throughout leaf.
2. Large sectors at base & small sectors at tip → frequency of cell division declines from tip to base.

Is Leaf Lamina Growth Marginal or Intercalary?

- Larger Sectors in Basal leaf area
- Small Sectors in Apical Leaf Area

Periclinal Chimeras in Geranium

- White (L2) over green (L3)
- Green (L2) over white (L3)

L1 → epidermis → no color
L2 → Spongy & Palisade Mesophyll in leaf center
Spongy Mesophyll at leaf periphery
L3 → Inner leaf Spongy Mesophyll & Vasculature

Conclude → Leaf cells are clonally related
- L1 → Epidermis
- L2 → outer palisade & spongy mesophyll
- L3 → inner spongy mesophyll & vasculature

Are Leaf Sectors (Blade, Midrib & Petiole) derived from different cells in the leaf primordium?

Sector Analysis

- Irradiate prior to primordium Initiation

Observe different sector boundaries
1) Middle of midrib to leaf margin
2) Internode through midrib to leaf margin
3) Internode through midrib terminating before leaf margin
4) Midrib and petiole
5) ... or... Many clones encompassed all three sectors

→ Major leaf parts are derived from same initials in shoot meristem
Summary: Anatomical Aspects of Leaf Development

- 1. What is the structure of a young leaf?
  Small curved peak or buttress at SAM.

- 2. Where does it begin?
  About 2 plastochrons before emergence.

- 3. How does it begin?
  L1 & L2 ... L3 cells divide more

- 4. Contributions of SAM to leaf:
  L1 → epidermis
  L2 → mesophyll both palisade and spongy
  L3 → midrib vasculature & some spongy mesophyll in middle of leaf

- 5. Later lamina development is intercalary not marginal

- 6. Leaf parts derived from same SAM population before primordium formation

Pattern Formation in Leaves - Lobes

Knotted1 (kn1) gene family characteristics
1. Phenotype → adventitious, ectopic meristems
2. Strongly expressed in meristem
3. May maintain indeterminacy & repress differentiation
4. Molecular → Encodes a homeodomain transcription factor

Gene orthologs
KNAT1 in Arabidopsis = knotted1 in maize

Pattern Formation in Leaves - Lobes

KNAT1 (Knotted1 ortholog) gene overexpression in Arabidopsis:
1. → transforms simple leaves to lobed leaves
2. Normal KNAT 1 expression → only in shoot meristems, but not first leaf primordium cells
3. KNAT1 gene probably ... negatively regulates gibberellic (GA) acid synthesis.
   - GA → inhibition of cell differentiation & cell expansion

Interpretation of lobed, transgenic leaves with knotted1 mutation
→ Lobes form due to an inhibition of lamina expansion.

Compound Leaf Development

Leaflet meristems along flank of primordium
Leaf primordium
Axillary Bud
Leaflet meristems along flank of primordium
Single genes influence leaf architecture

**Compound Leaf Characteristics**

1. Divided blades forming leaflets
2. Leaves have axillary buds, leaflets do not

**Supercompound leaf of transgenic tomato expressing KN1 gene**

**Whole plant of B**

**Bushy appearance**

**Loss of apical meristem**

**Lanceolate (La)**

**Heterozygous dominant mutation**

**Compounding results from**

- Simple leaves → end marginal meristematic activity
- Compound leaves
  - Reiteration of leaflet meristem formation
  - Compounding is a competition between lamina expansion and leaflet meristem development

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**Summary**

1. Lobes form due to an inhibition of lamina expansion.
2. Compounding is due to an inhibition of lamina expansion … and a reiteration of leaflet meristem formation.