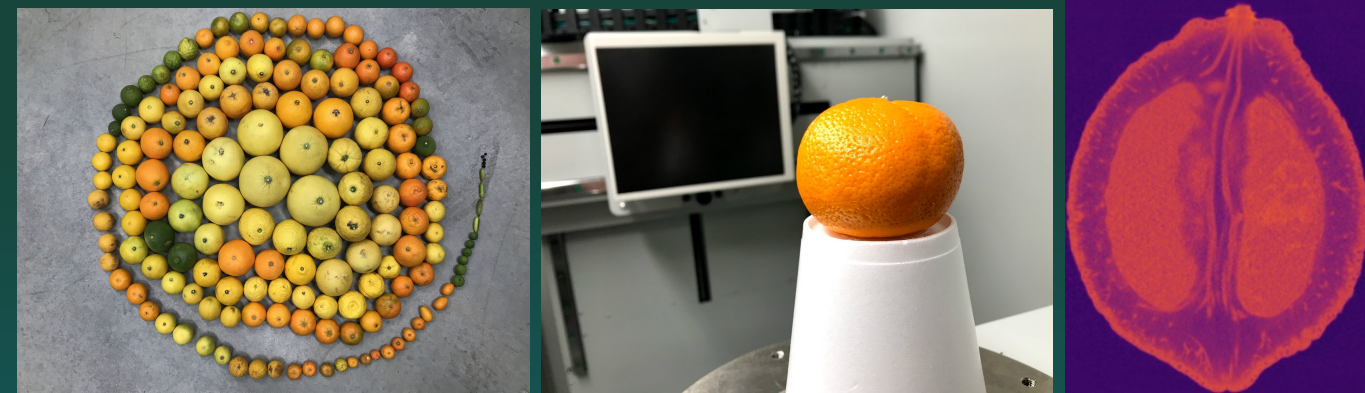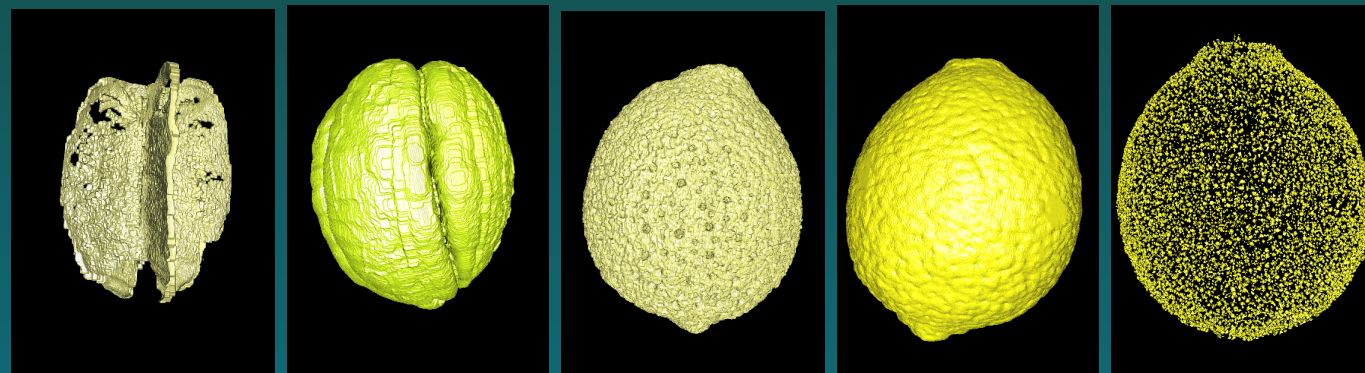# Modeling the **shape** of **citrus** and their oil **gland** distribution

UCR Citrus Collection   X-Ray CT Imaging   Raw 3D scans
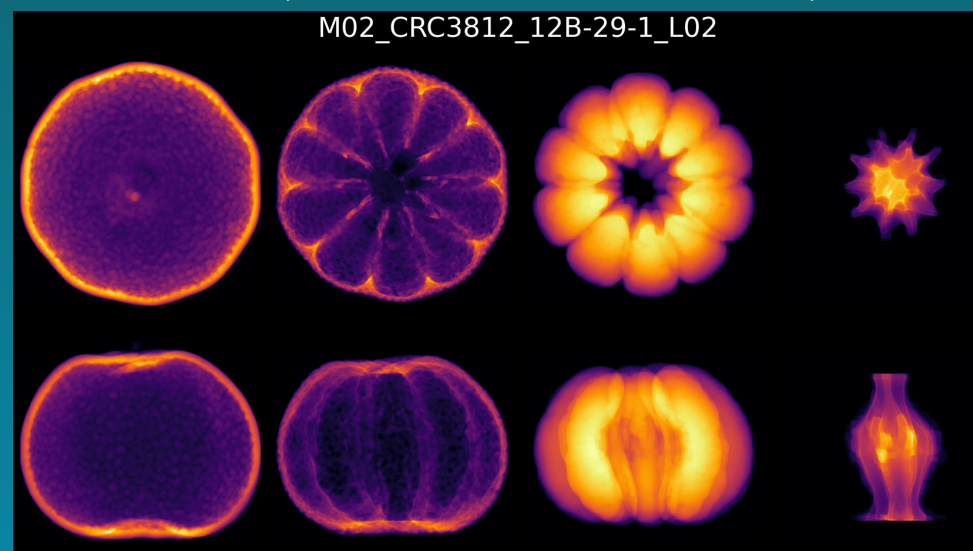
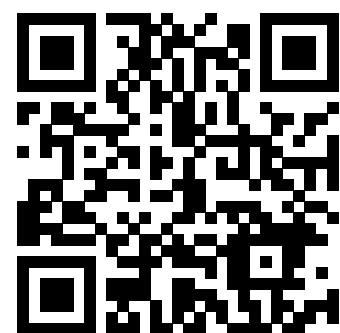Spine   Endocarp   Rind   Exocarp   Oil glands

M02_CRC3812_12B-29-1_L02

↓ **Animated** version! ↓

bit.ly/osu_pss22

The shape of aroma

Erik Amézquita [1], ⬤

✉ amezqui3@msu.edu

Michelle Quigley[2] **Tim Ophelders**[3] **Danelle Seymour**[4] **Elizabeth Munch**[1]
Dan Chitwood[2]

[1] *Computational Math, Science & Engineering, Michigan State University*
[2] *Horticulture, Michigan State University*
[3] *Mathematics and Computer Science, TU Eindhoven*
[4] *Botany and Plant Sciences, University of California, Riverside*

51 different citrus varieties

- 166 samples X-ray CT scaned (90 micron resolution)
- Extracted 5 tissues for all samples

Significant allometry across tissues' volumes
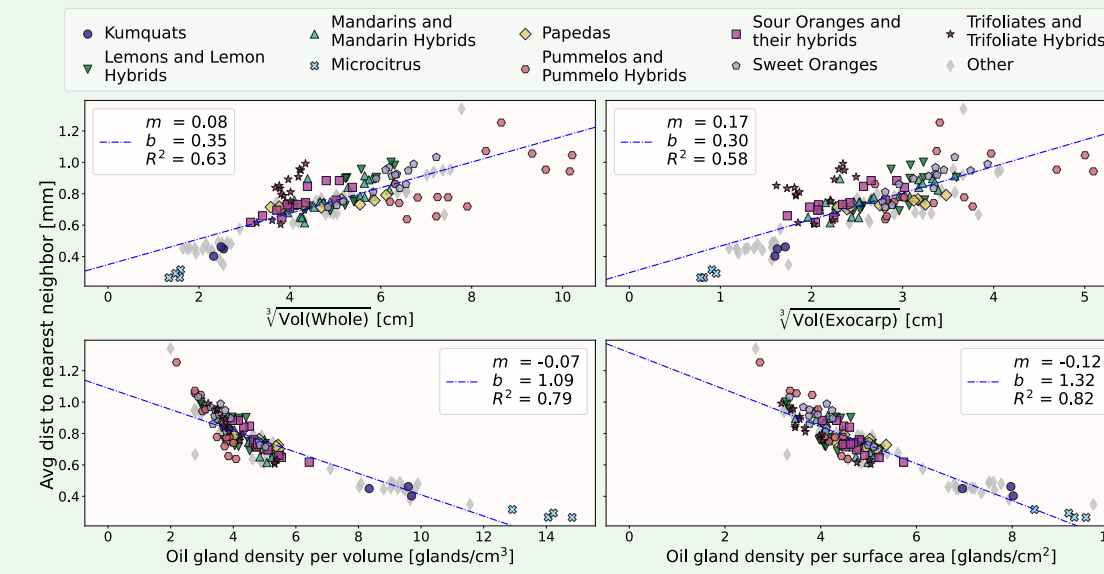

Allometric relationships between phenotypes
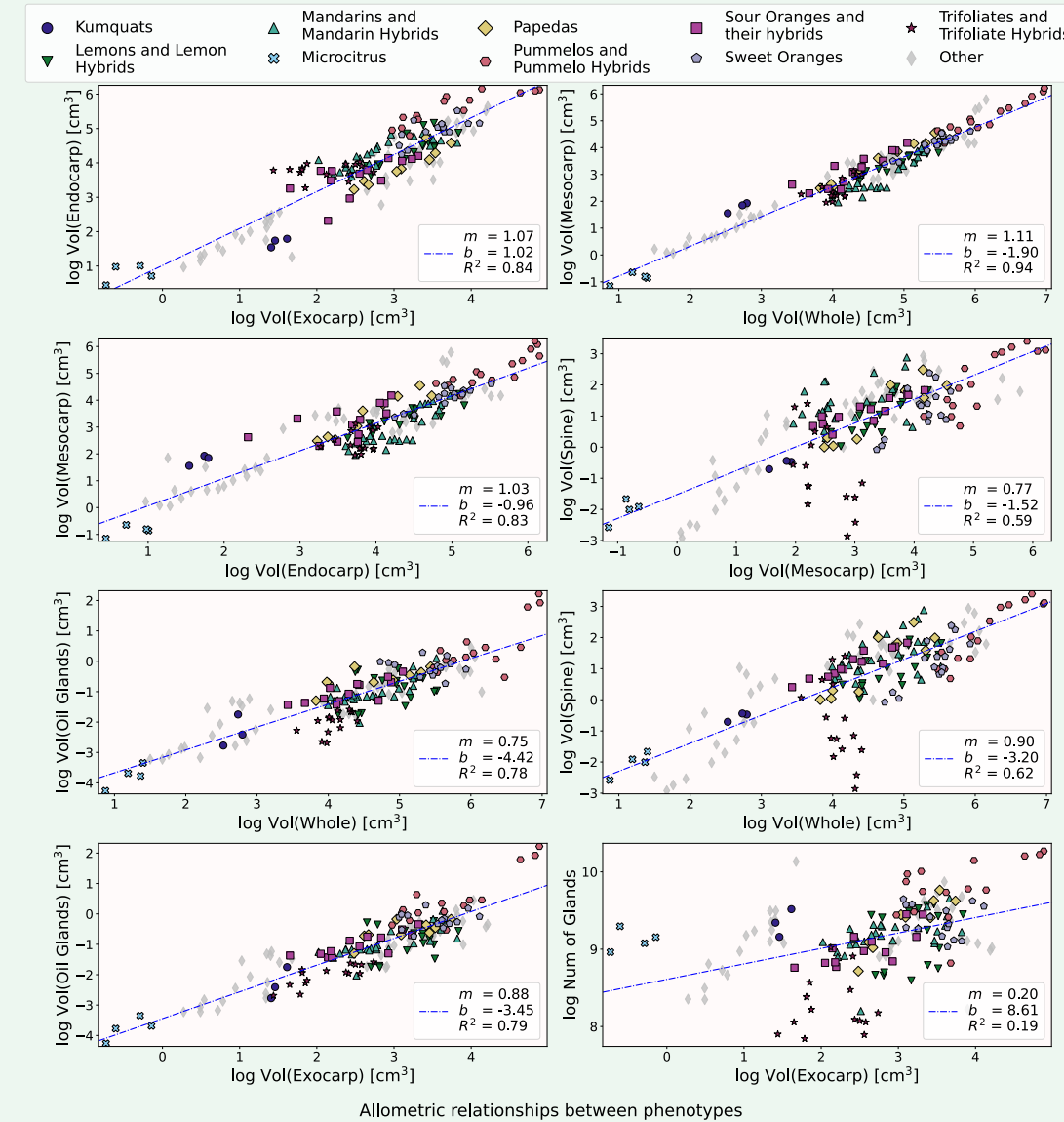
- Size relationships correspond to hybridization patterns
- E.g. Sour oranges are between mandarins and pummelos

Ellipsoid approximation of the whole fruit
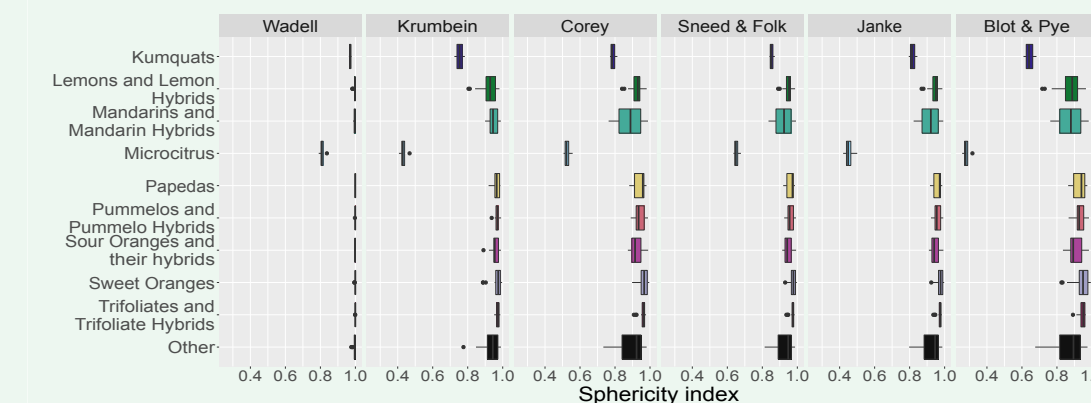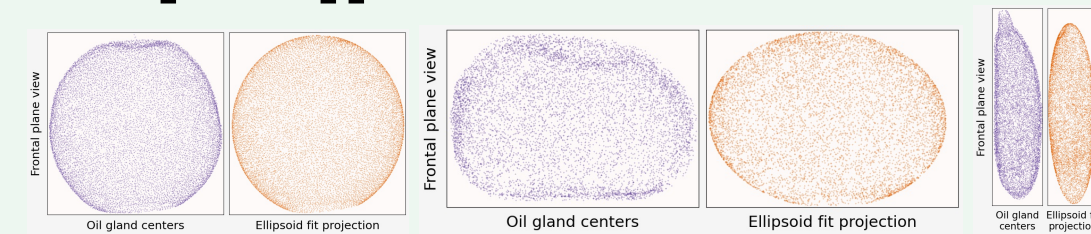
- Fruit **sphericity** with various indices: 0 (line/plane)→1 (sphere)

Size and average distance between closest glands has high R2 correlation coefficients

- Smaller fruits report higher density of oil glands
- Similar results when looking at the average distance between each oil gland and its 2nd, 3rd, ..., 25th nearest neighbors

The average distance to the oil gland nearest neighbors follows a square root relationship
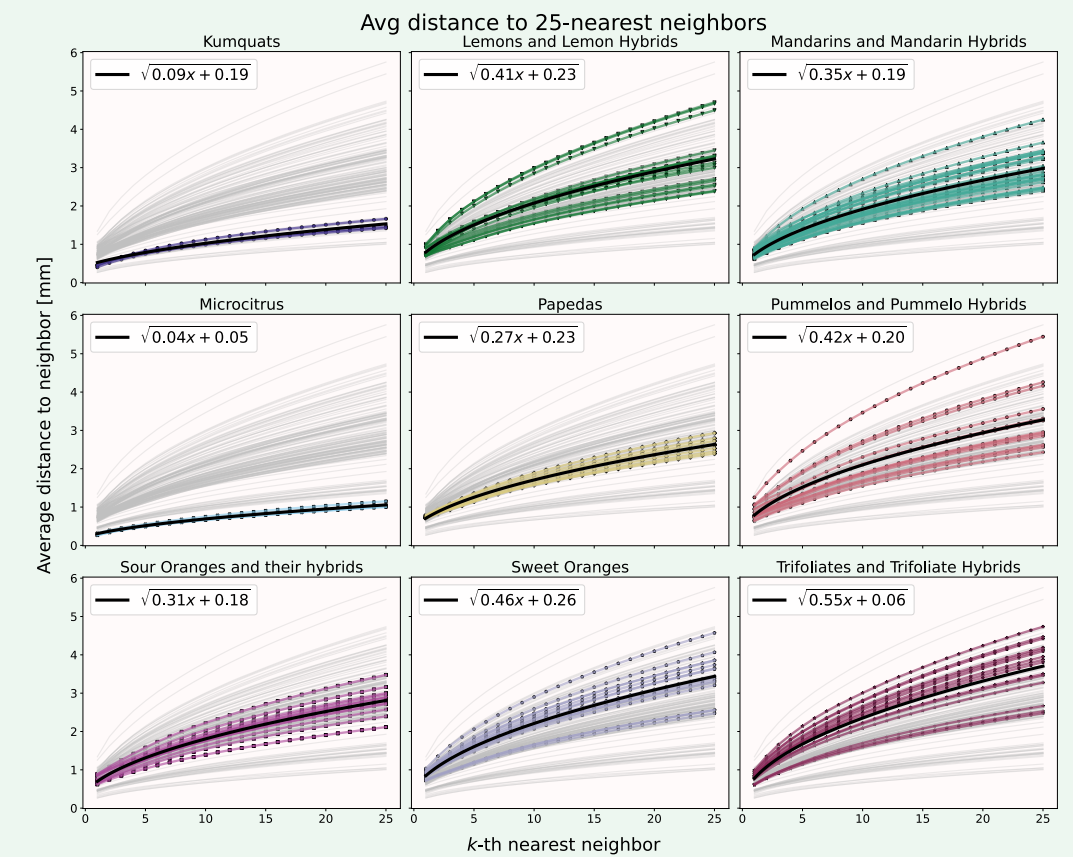
- The average distance from each oil gland to its k-th nearest neighbor follows a square root formula

$$\text{Avg.dist}(k) = \sqrt{Mk + B}$$

- M is the distance increase rate; B an adjusting intercept
- This formula suggests that oil glands might be distributing themselves following **normal diffusion** mechanics
- Distance increase **rate** is related to oil gland **density**
- The **outliers** for citrus groups usually correspond to **hybrids**
- E.g. lemon outliers are Interdonatos, lemon x pummelo hybrids

Conclusions and takeaways

- **X-ray CT** technology offers a new powerful lens to study citrus shape at a much more granular level, even oil glands!
- Oil gland distribution can shed new light in **citrus development**
- Shape patterns can give us insight into **citrus hybridization**