

Update on Pistachio Fruit Development, Insect Resistance, and Optimal Shell Splitting

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Pistachio Fruit Development, Insect Resistance, and Optimal Shell Splitting

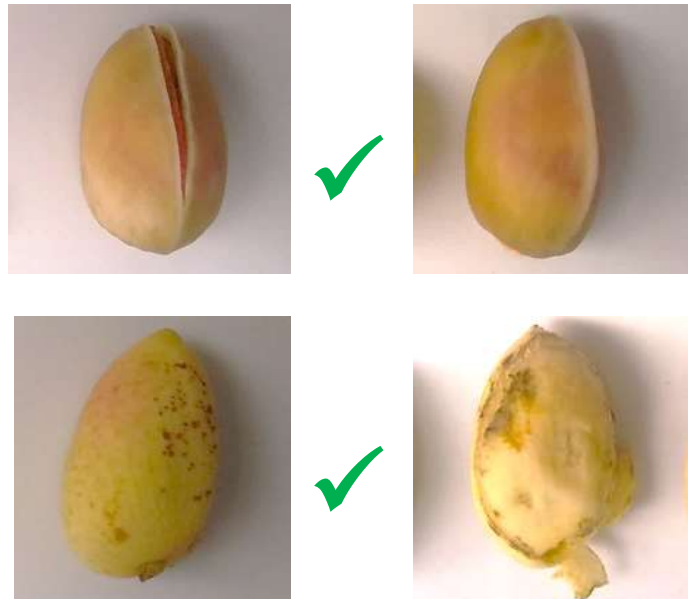


How does the pistachio shell split at maturity?

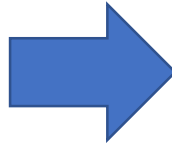


How does the hull fall apart at maturity?

Properties of the ideal nut at harvest

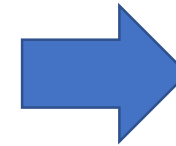


X



X

		SHELL	
		split	unsplit
HULL	intact	☺	☹
	broken	☹	☹

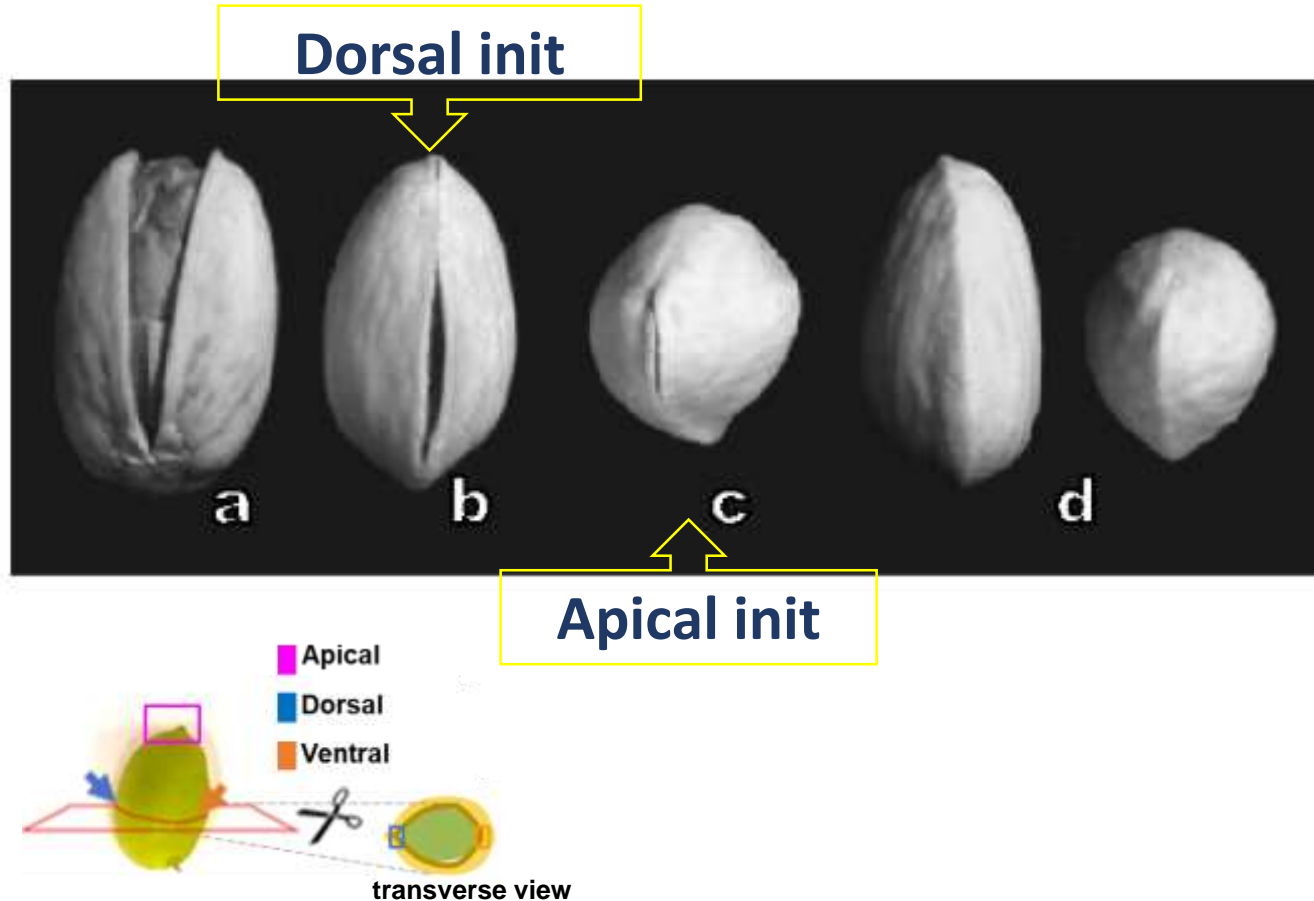


1. What drives the shell to split?
2. What causes the hull to breakdown (and or split)?

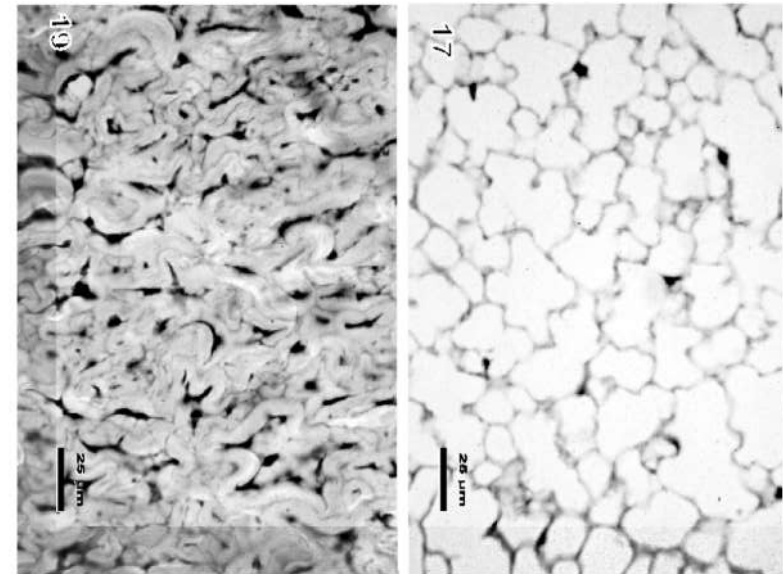
How does the pistachio shell split at maturity?



Pistachio shell split: the puzzle



Shell is made of wavy cells



Polito & Pinney 1999

Polito & Pinney 1999

- Splitting starts at apical and dorsal site
- Kernel expansion causes shell split?

How does a shell that is only made of a single cell type “know” to split at the suture?

Pistachios shell split: the puzzle

Pistachio Walnut and Arabidopsis all split at a suture site but...

Pistachio

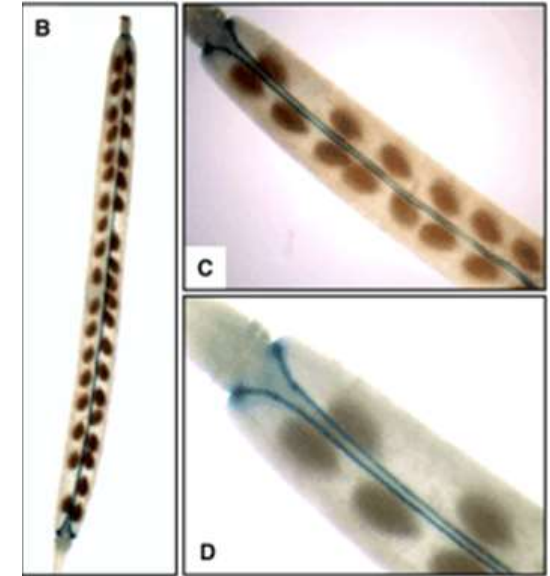


Walnut



Photo by Ivar Leidus

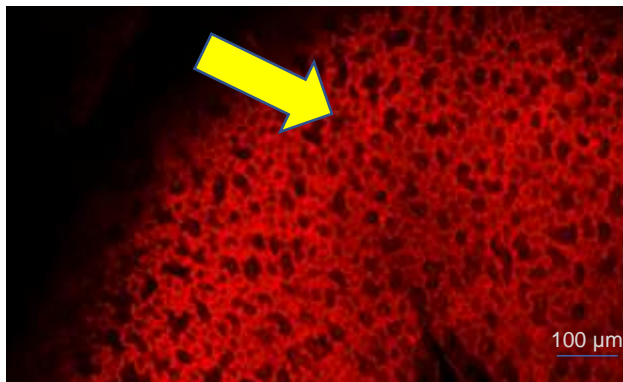
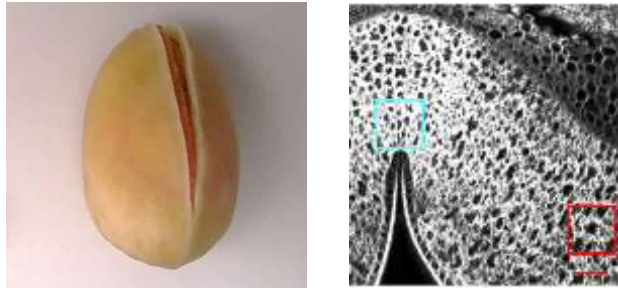
Arabidopsis



Aharoni et al 2004

Pistachio does not have a dehiscence zone

Pistachio



Walnut

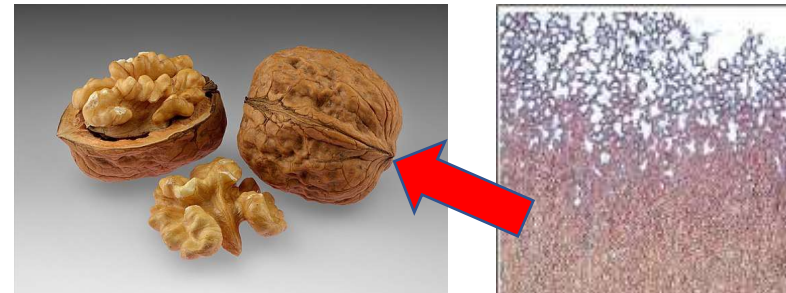
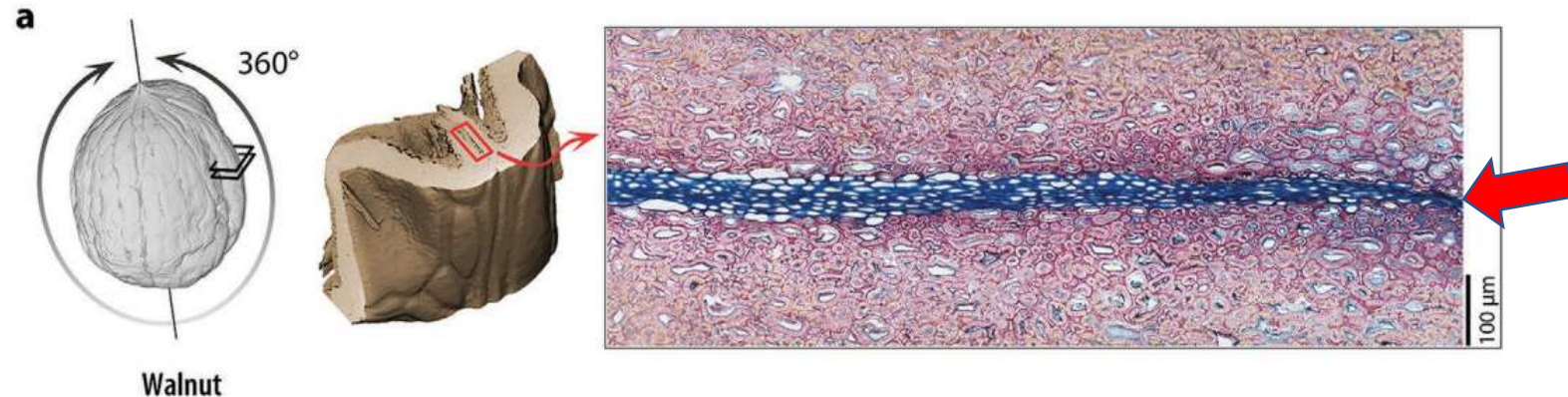


Photo by Ivar Leidus



Huss et al 2020

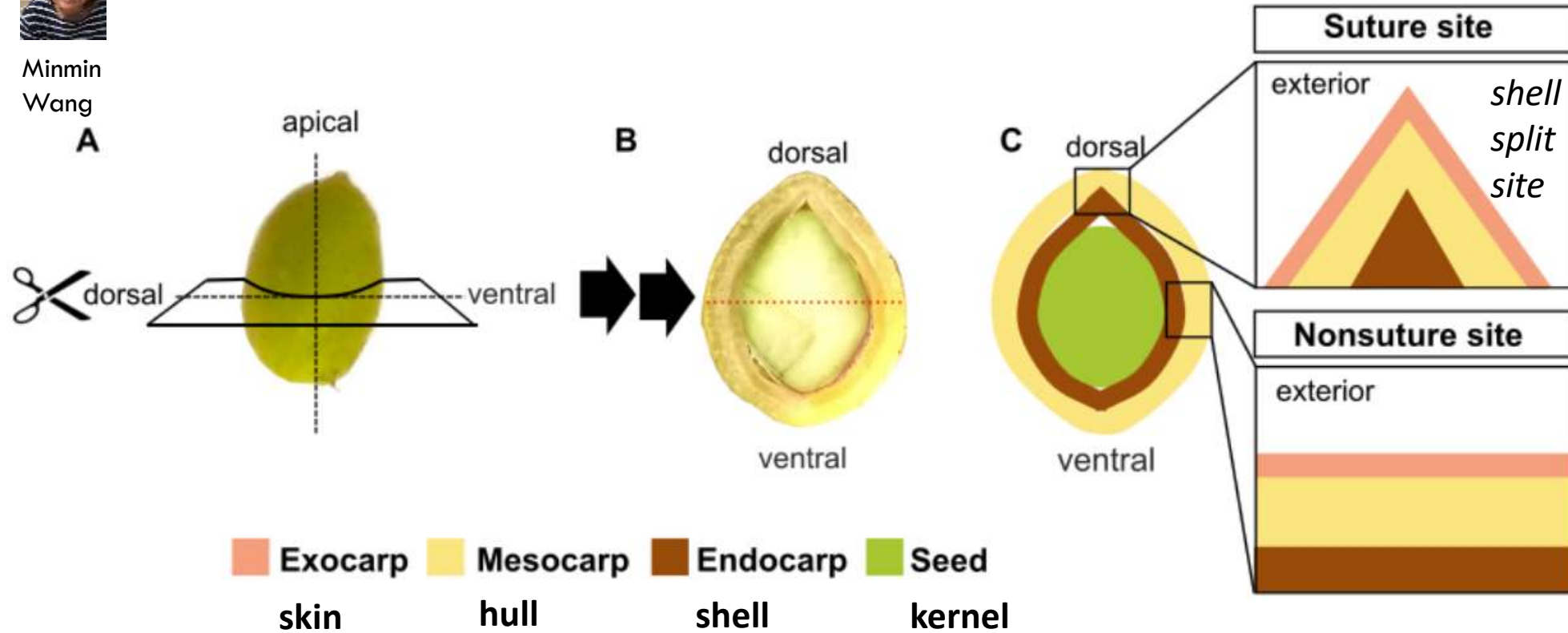
Orientation of pistachio fruit cross sections



Shuxiao
Zhang



Minmin
Wang



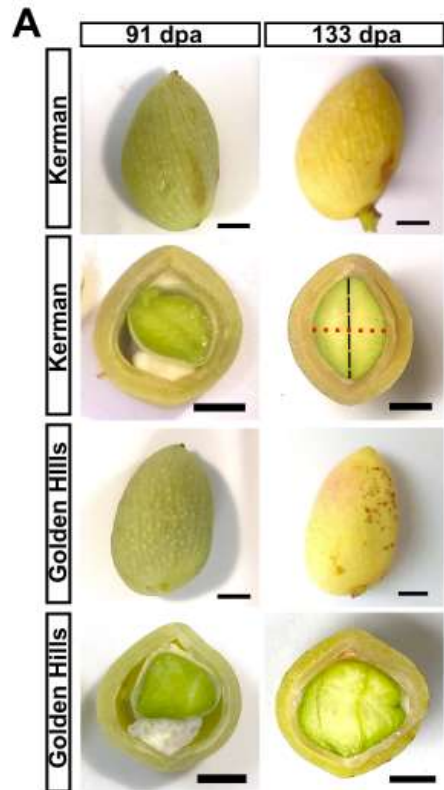
Samples taken from the middle of the fruit. Images from microscope taken with exterior facing up.

Suture = where shell splits. Dorsal = side with longer, curvier suture with sharper angle. Ventral = shorter, flatter suture.

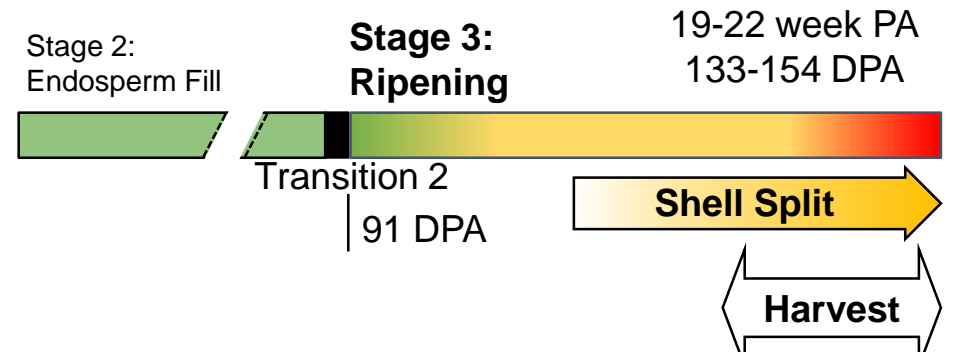
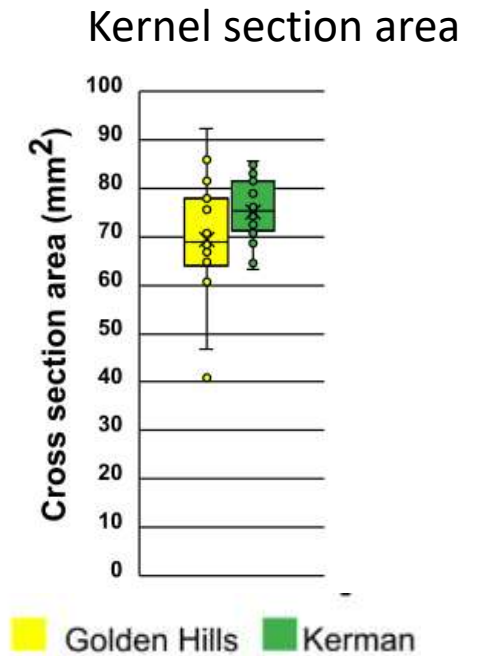
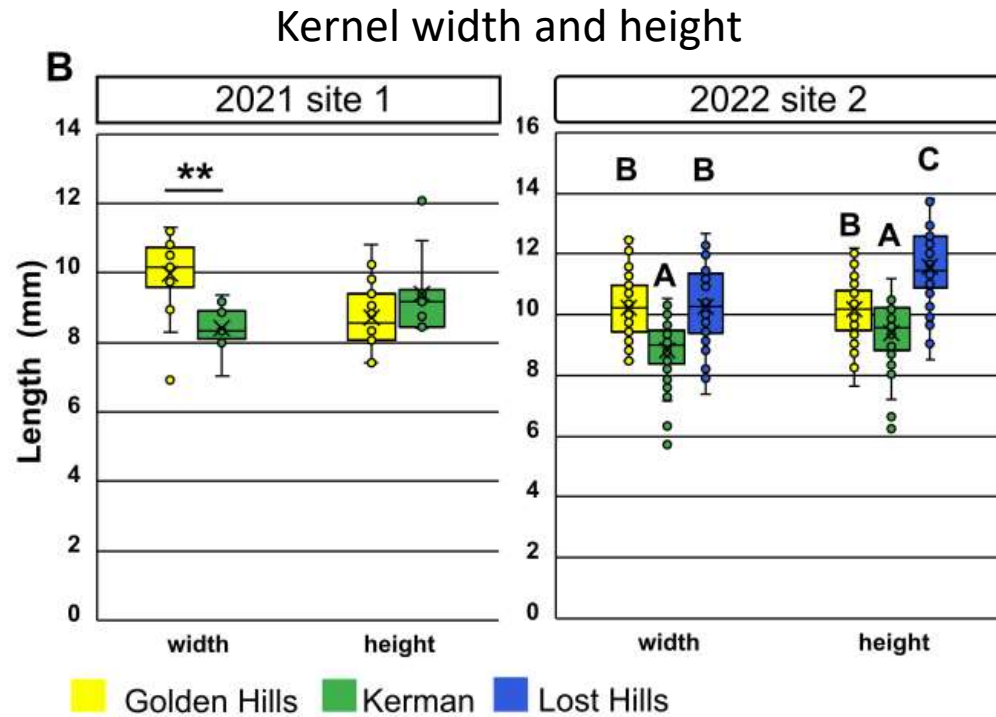
Kernel width but not height correlates best with split rate



Alisa



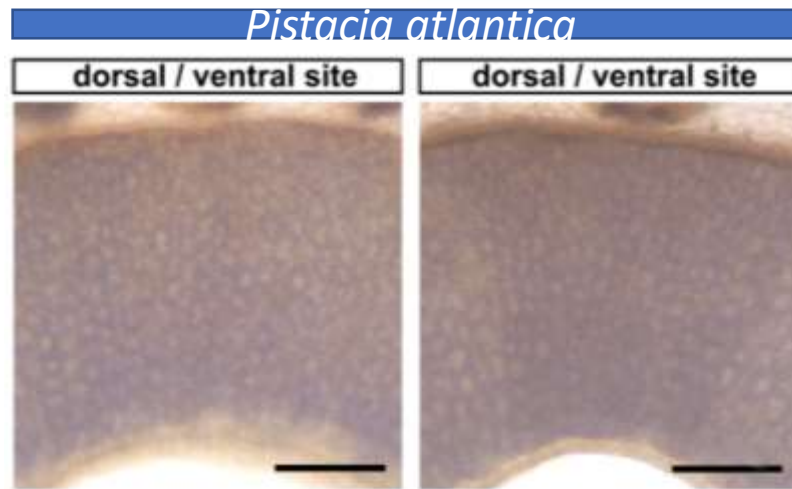
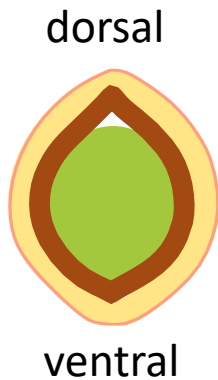
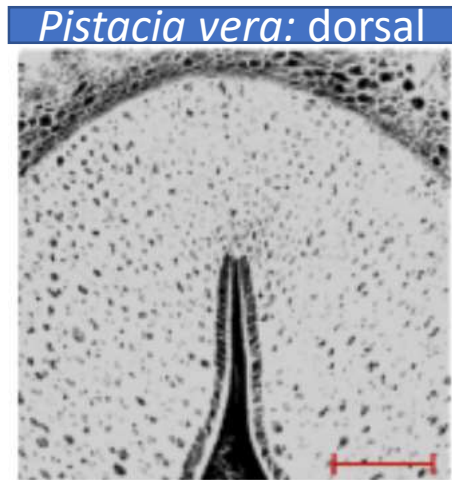
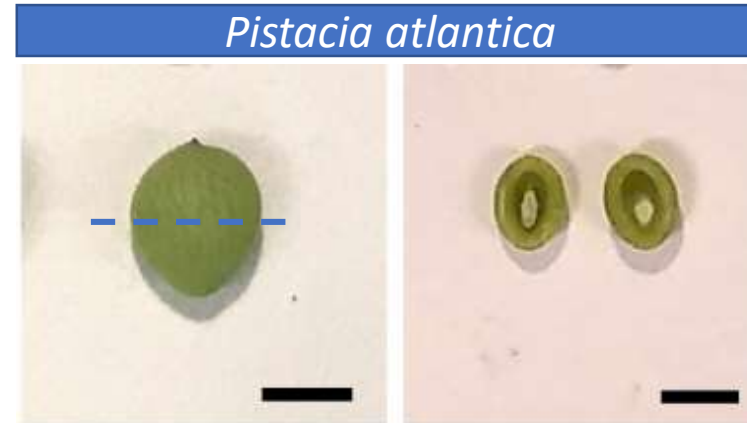
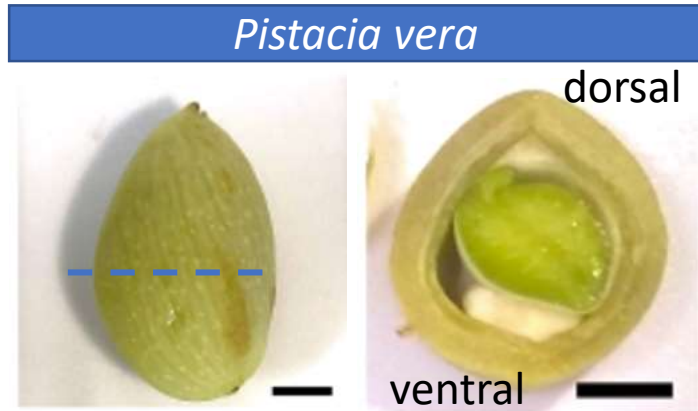
----- = width, - - - - = height



Why does shell split there?



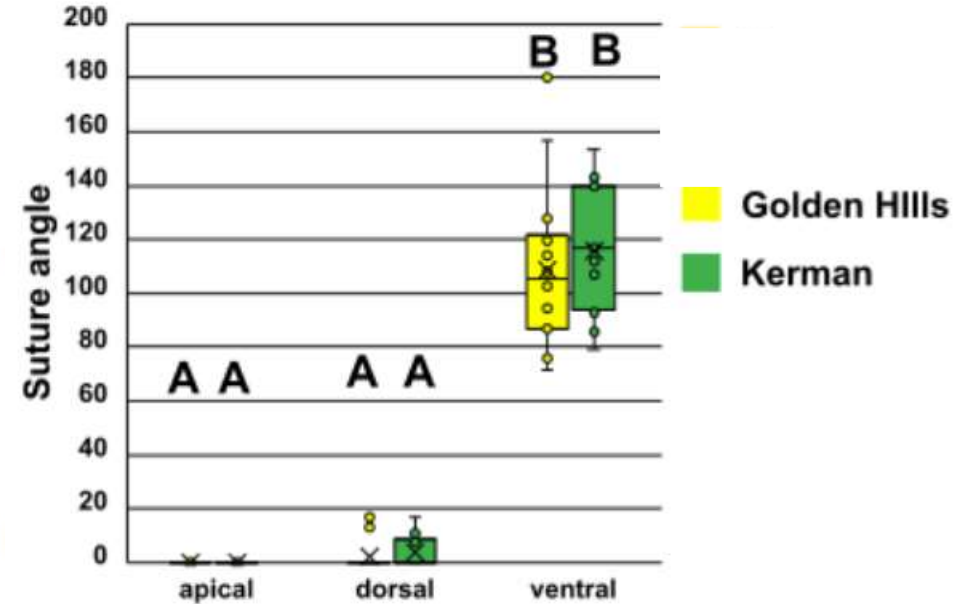
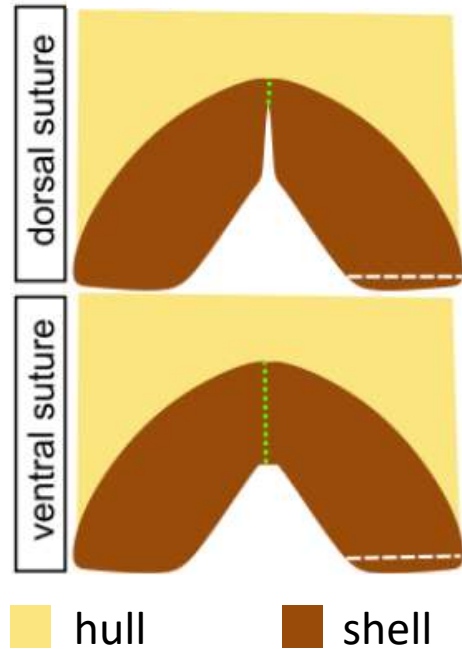
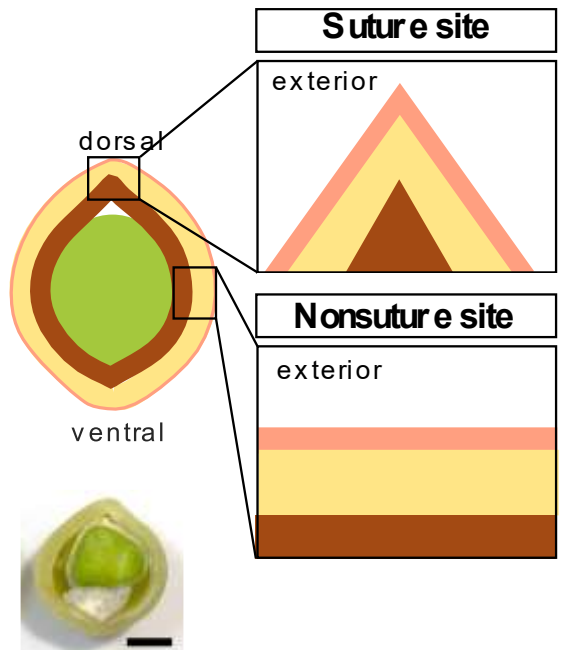
Shuxiao Zhang



- Dorsal and ventral suture morphology is different in *P. vera*
- This difference is not seen in *P. atlantica*, which has a shell that doesn't split at maturity
- *P. Atlantica* does not have a acute folding on either side

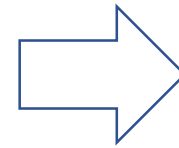
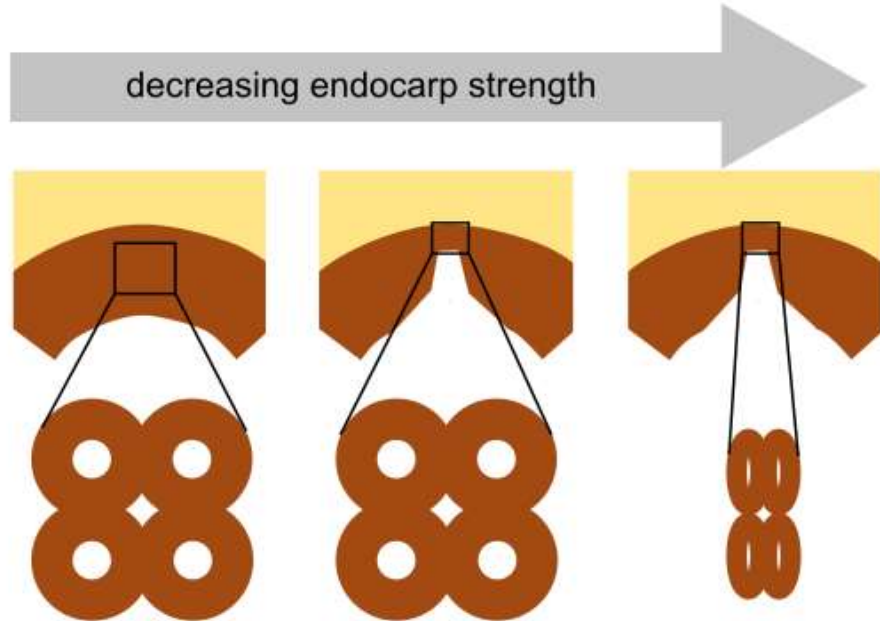
Why does it split there: suture shape matters

Dorsal suture has sharper angle



Dorsal and ventral suture morphology is different in *P. vera*

Our current model

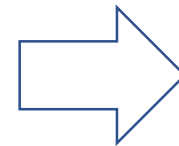


Shape of suture
and shape & size
of cell matters
when there's only
one cell type!

Low split rate



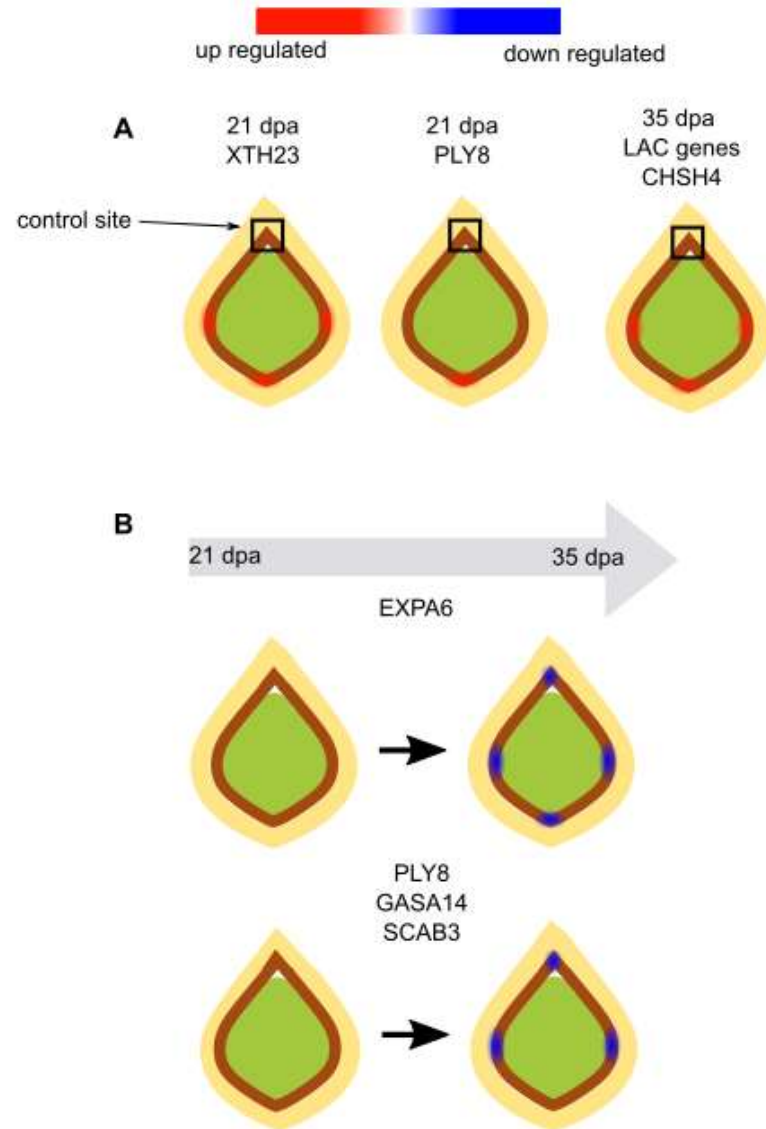
High split rate



Kernel shape
matters!
Wider Kernel is
associated with
high split rate

*Traits of
interest for
breeding*

Cell walls genes are differentially regulated



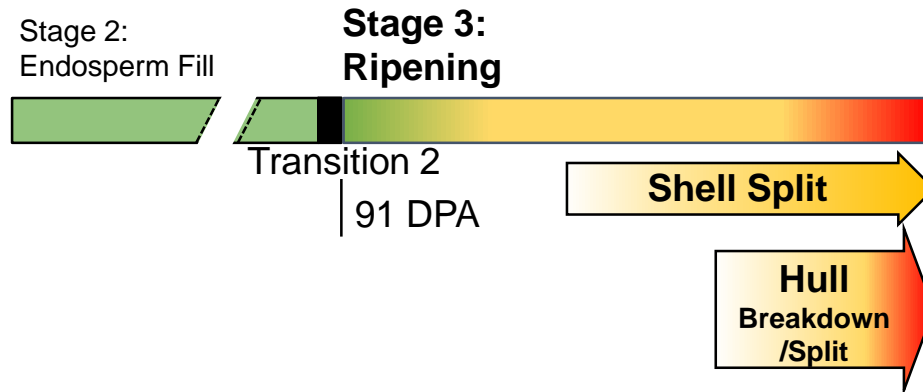
- Difference in spatial AND temporal regulation
 - Different between suture & nonsuture
 - Different between dorsal and ventral
 - Different between early and late stage I

**Why does the hull fall apart
at maturity?**

**How many ways does the
hull fall apart?**

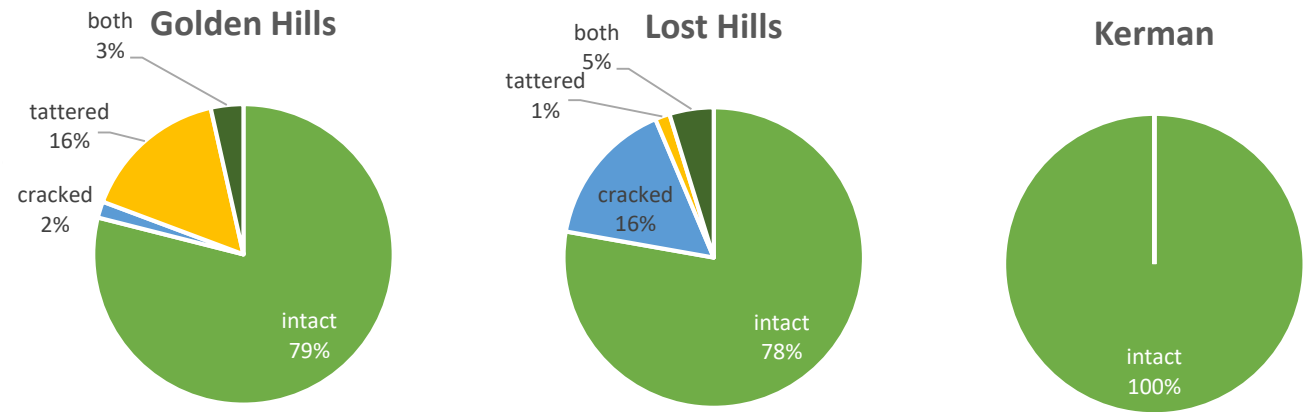


Difference in hull breakdown events

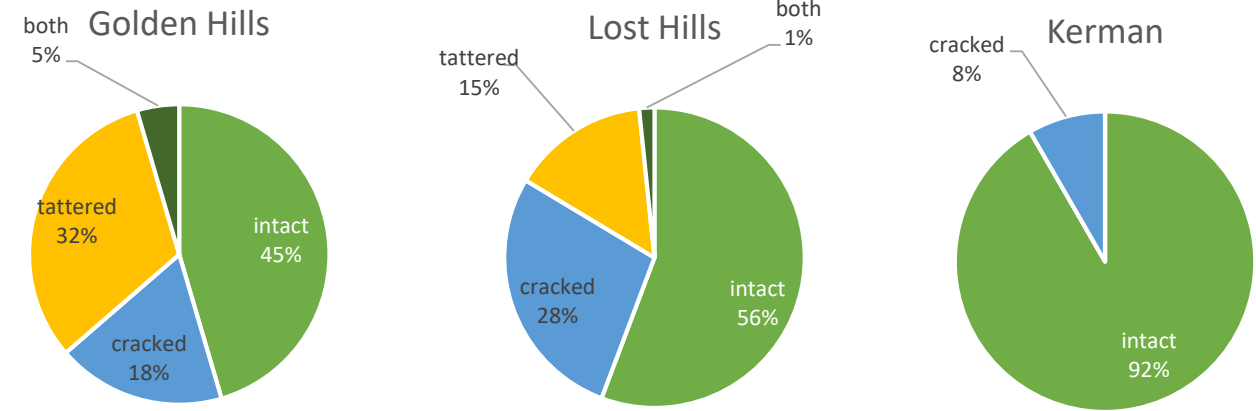


Difference in hull breakdown events between cultivars

133 dpa



142 dpa



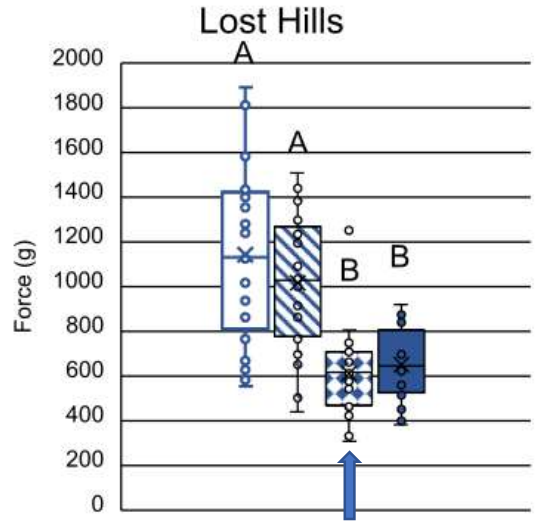
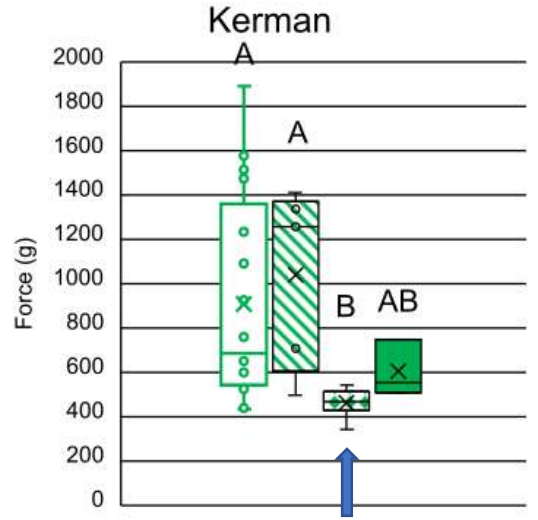
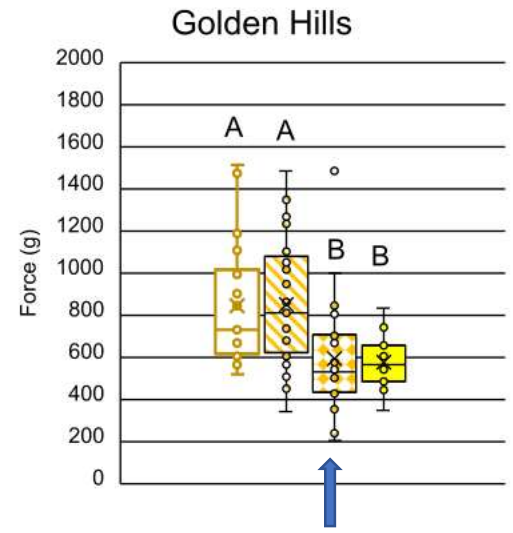
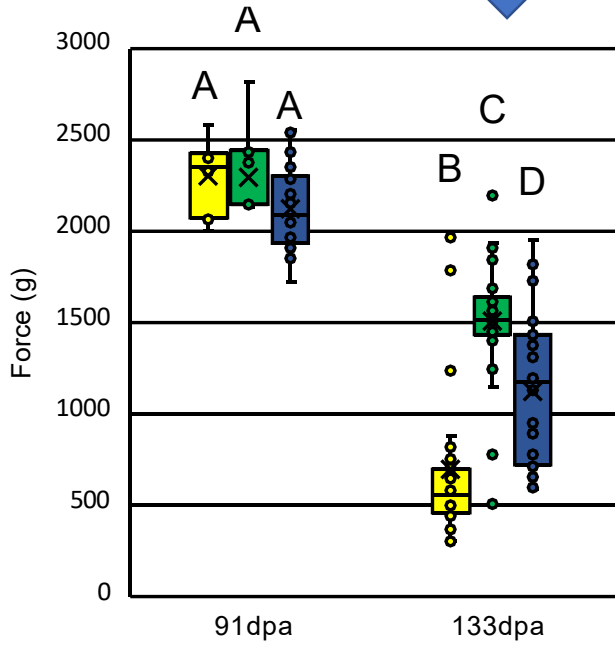
Fruits show different types of hull breakdown in the field

Cultivars show different rates of different breakdown types



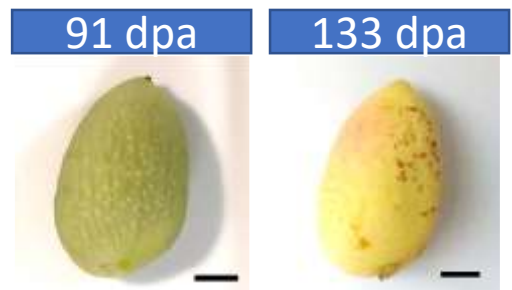
Minmin Wang

Hull softens with ripening

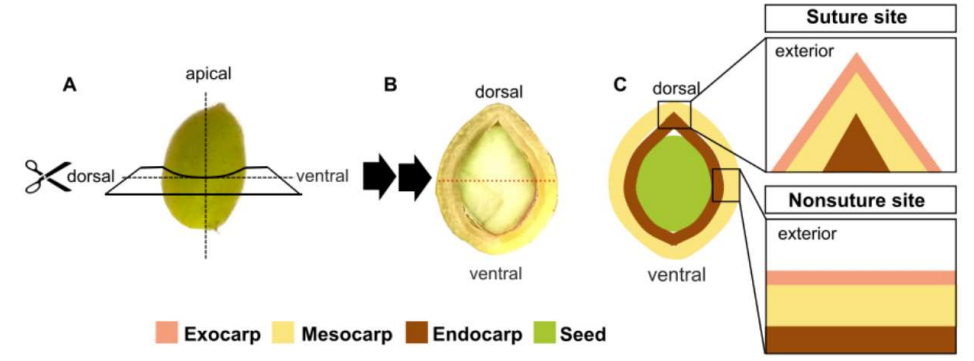
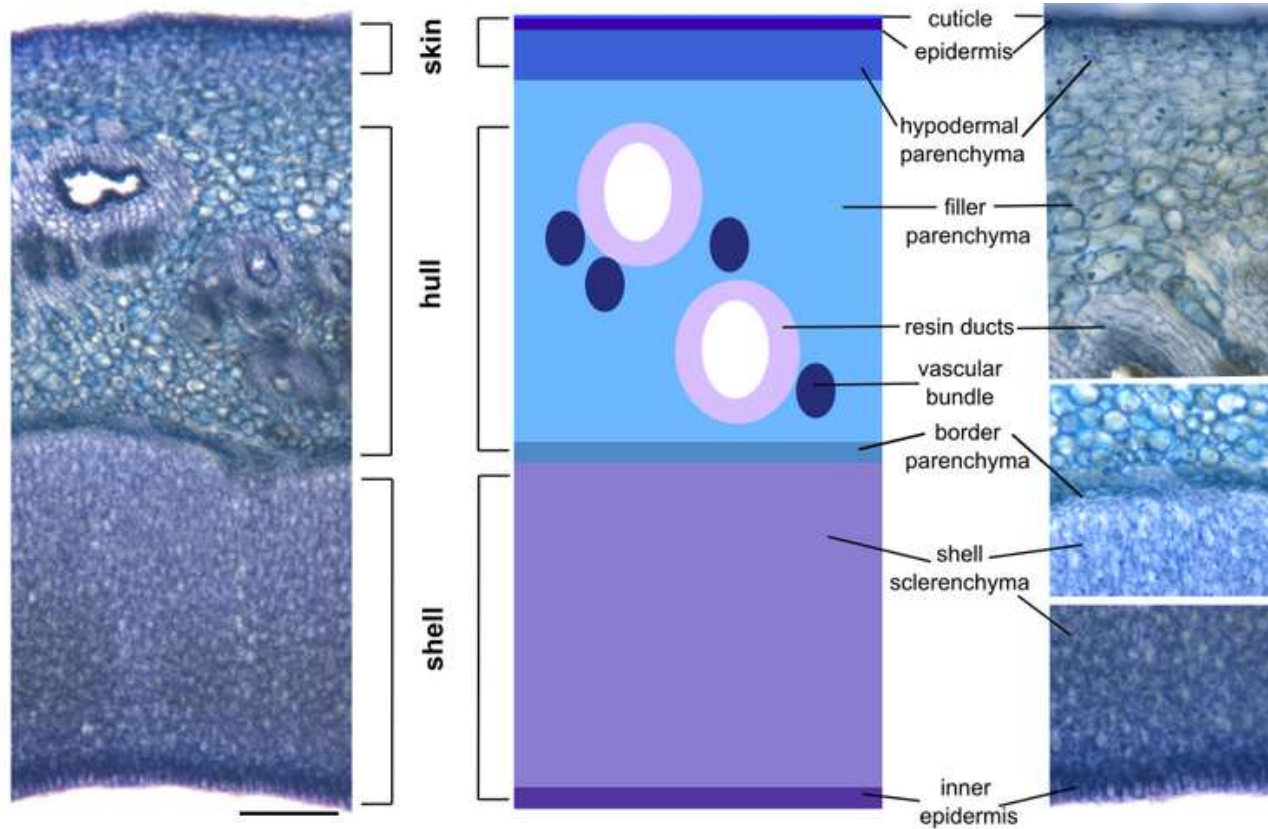


□ Intact ▨ Cracked ▩ Tattered ■ Both

■ Golden Hills ■ Kerman ■ Lost Hills



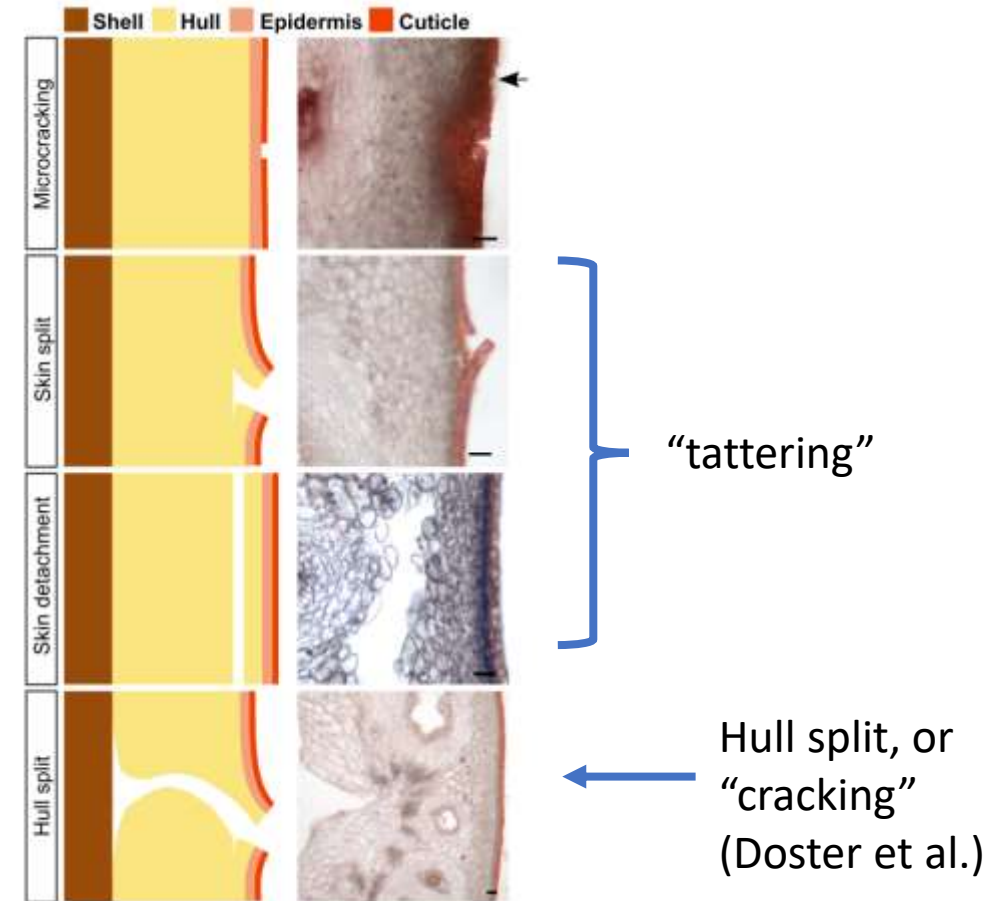
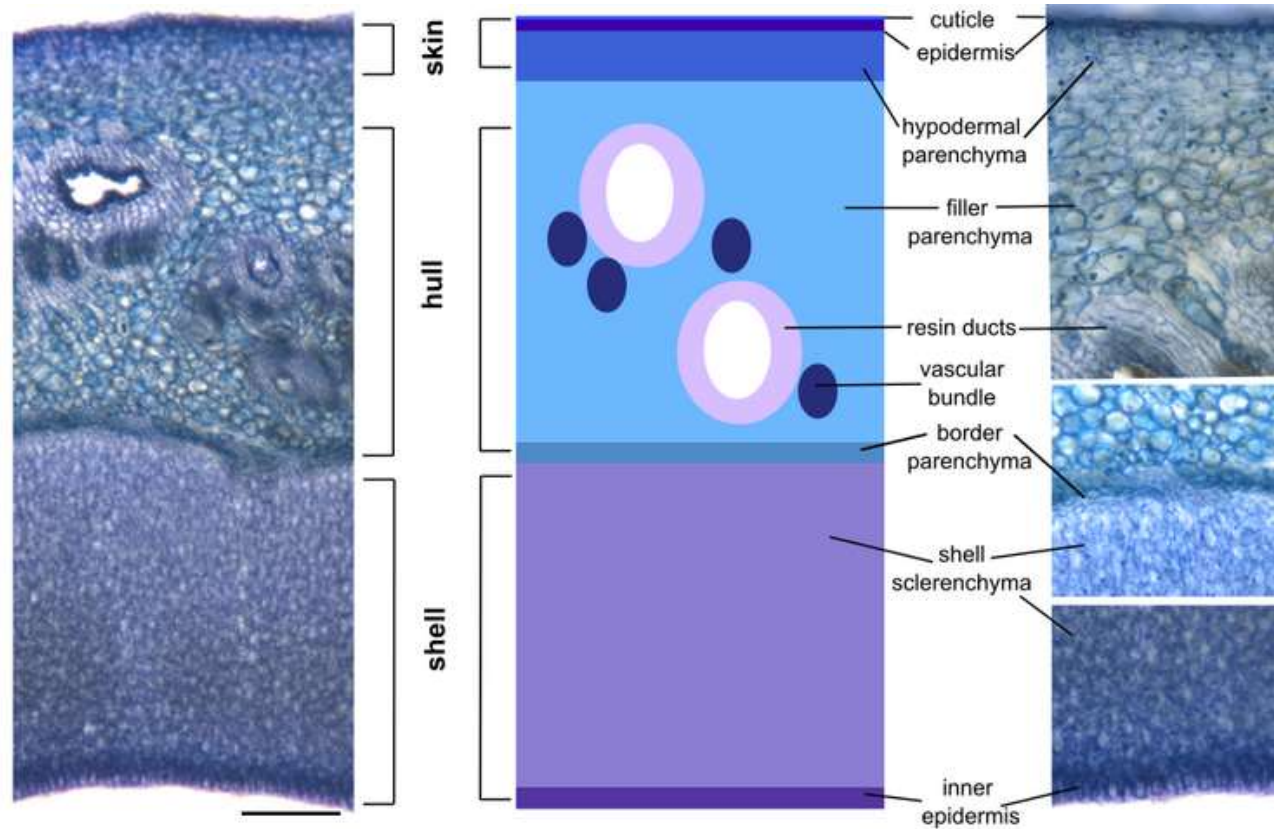
What's happening during breakdown?



skin hull shell kernel

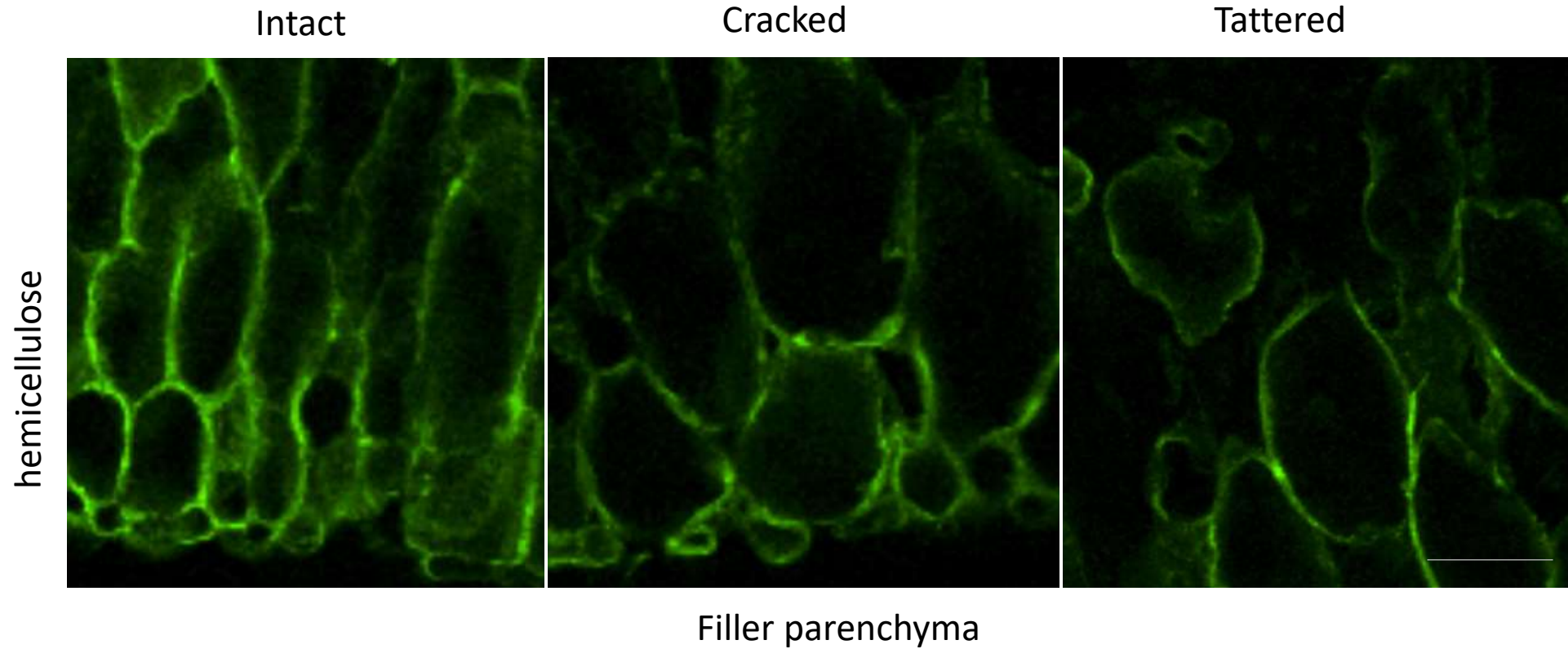
The major events that occur during the hull breakdown process and what cells they affect.

What's happening during breakdown?

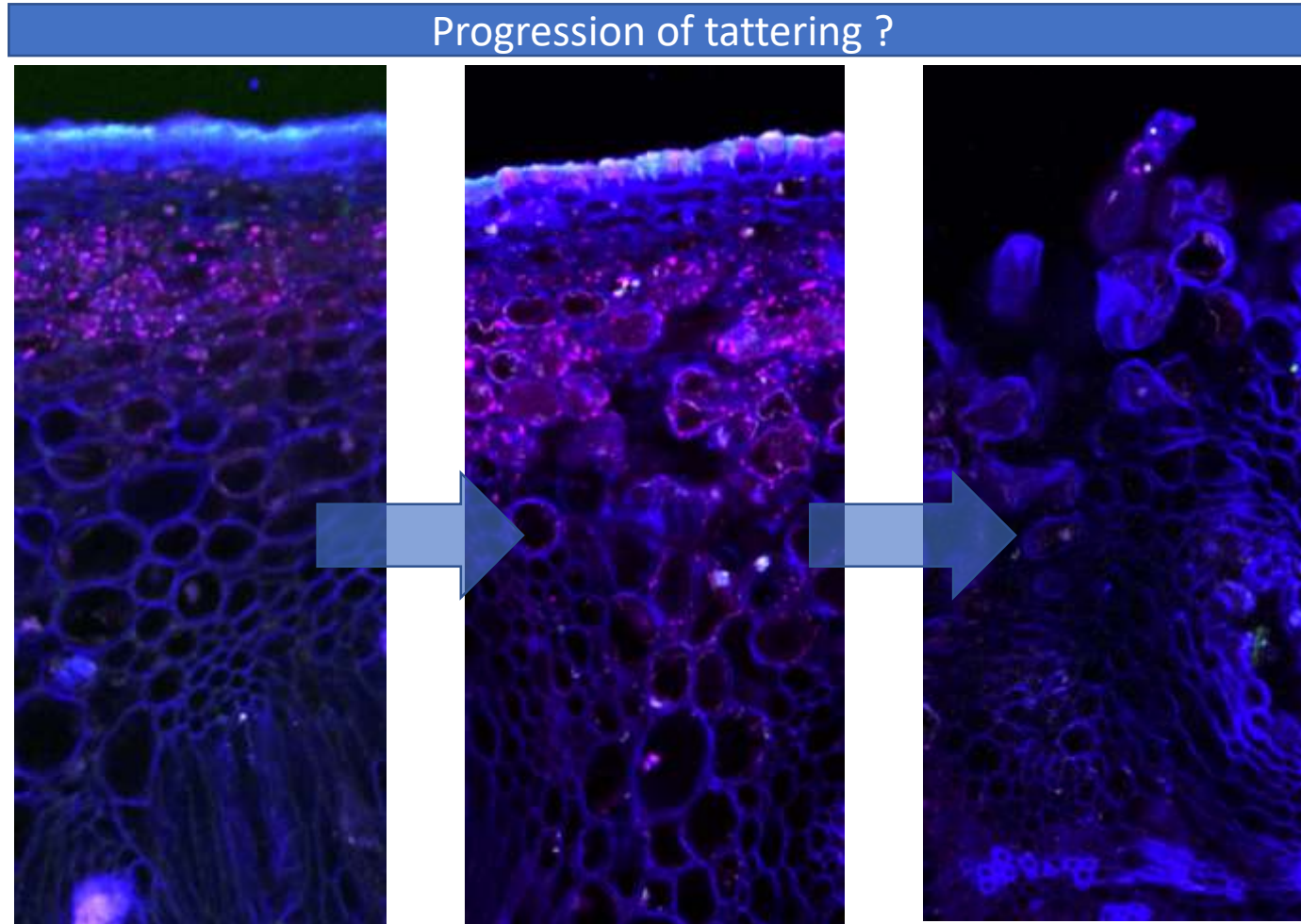


Tattering is different from hull split

Cell wall changes during hull breakdown



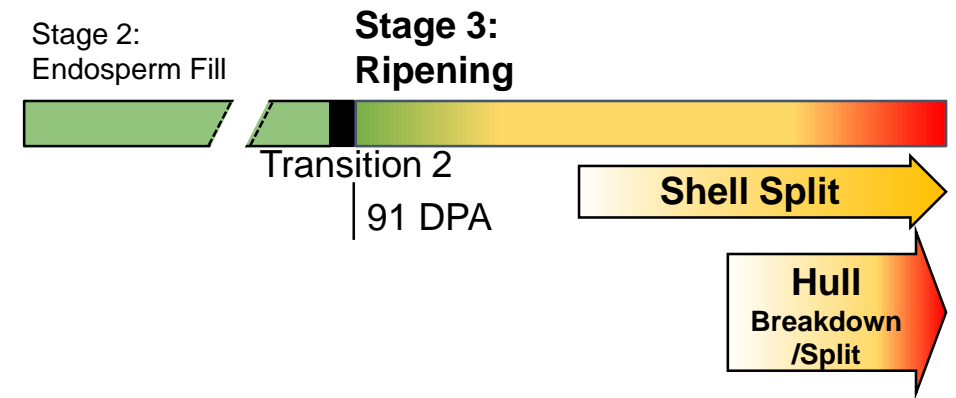
Towards a model of hull breakdown



Events during tattering

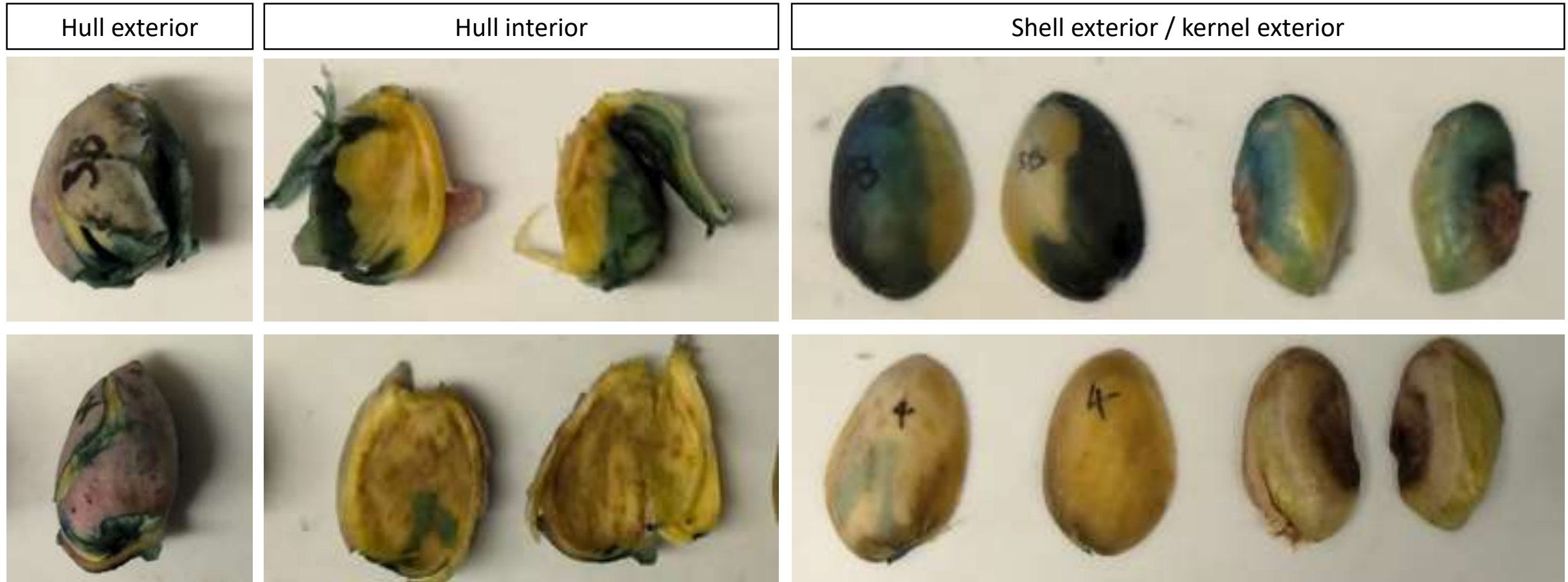
- 1) Loss of cell-cell adhesion & cell collapse at junction of hypodermal parenchyma and filler parenchyma
- 2) Collapse and breakdown of filler parenchyma (soft hull)

Relationship between hull breakdown during ripening & pest / pathogen



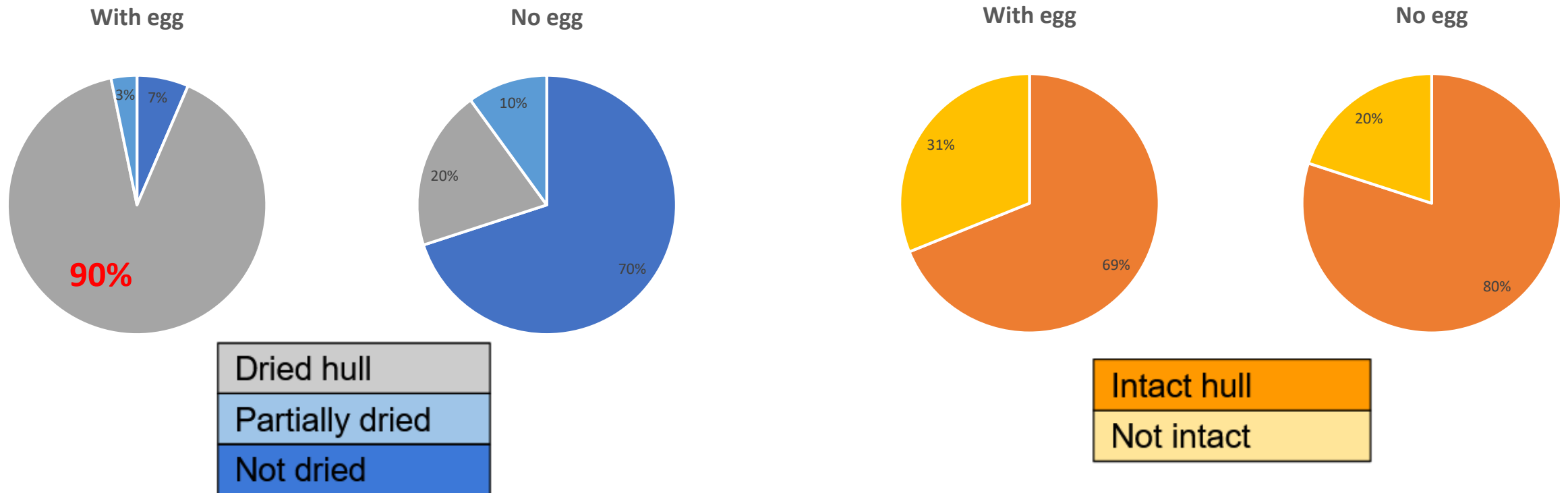
- The hull is the outermost protective layer of the fruit
- Integrity of the hull must be compromised for pest / pathogen infection
- Hull breakdown occurs as part of fruit ripening

Visual prediction of site of pathogen entry



Hull exterior do not always match with respect to interior

Navel Orangeworm at the end of the season



- Strong association with dehydrated fruit

Kernel Quality

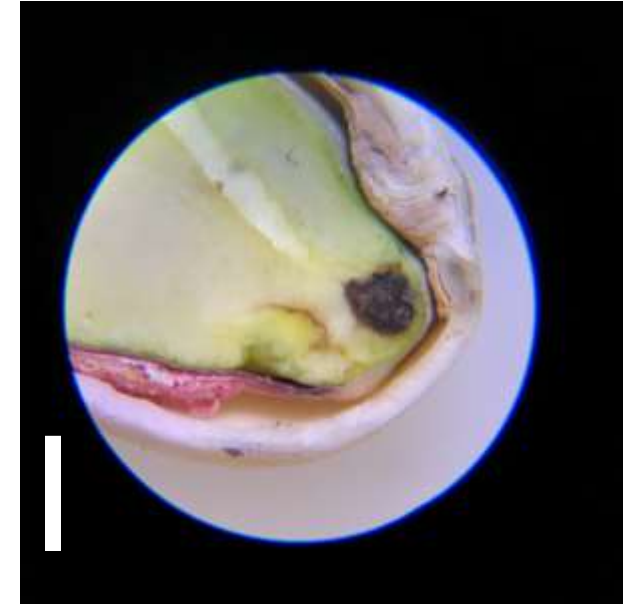
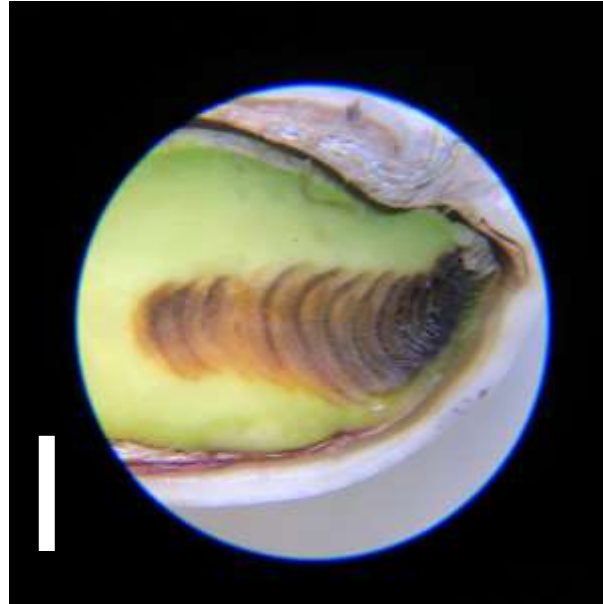


Internal Kernel Discoloration

Golden Hills

Golden Hills
Lost Hills

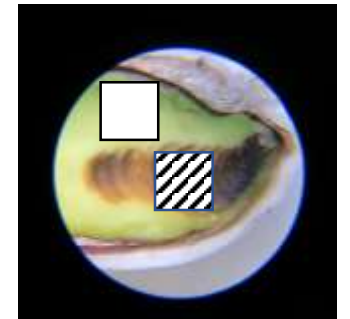
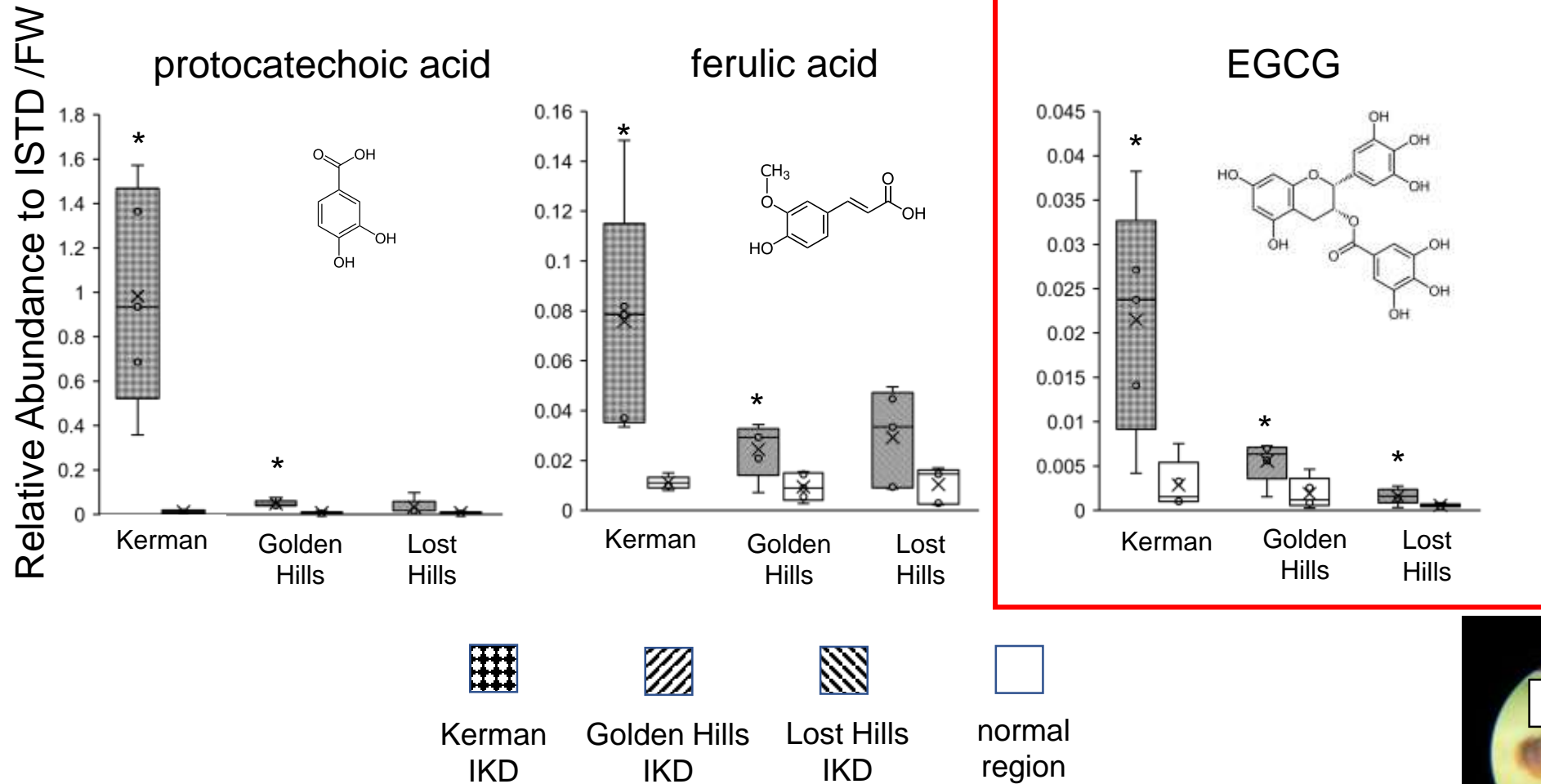
Kerman



High accumulation of polyphenol and precursors is at the IKD site



Minmin Wang



The color of IKD stripes is very likely contributed by polyphenols accumulated at the IKD site.

Who did the work



Georgia Drakakaki lab
Current Lab Members:

Shuxiao “Susan” Zhang
Minmin Wang
Rosalie Sinclair

Past Lab Members:

Mingqin Chang
Destiny Davis
Natasha Worden
Michel Ruiz Rosquete
Eunsook Park
Guangxi Ren

Undergraduate students:

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Shaina Eagle
Kaleigh Marie Bedell
Karen Nguyen
Akaash Prasaf
Darren Yong

Collaborators:

Thomas Wilkop
Giulia Marino
Pat J. Brown
Phoebe Gordon
Louise Ferguson
Houston Wilson
Barbara Blanco-Ulate
John Preece
Craig E. Kallsen
Judy Jernstedt
Maricopa Farms

High school students:

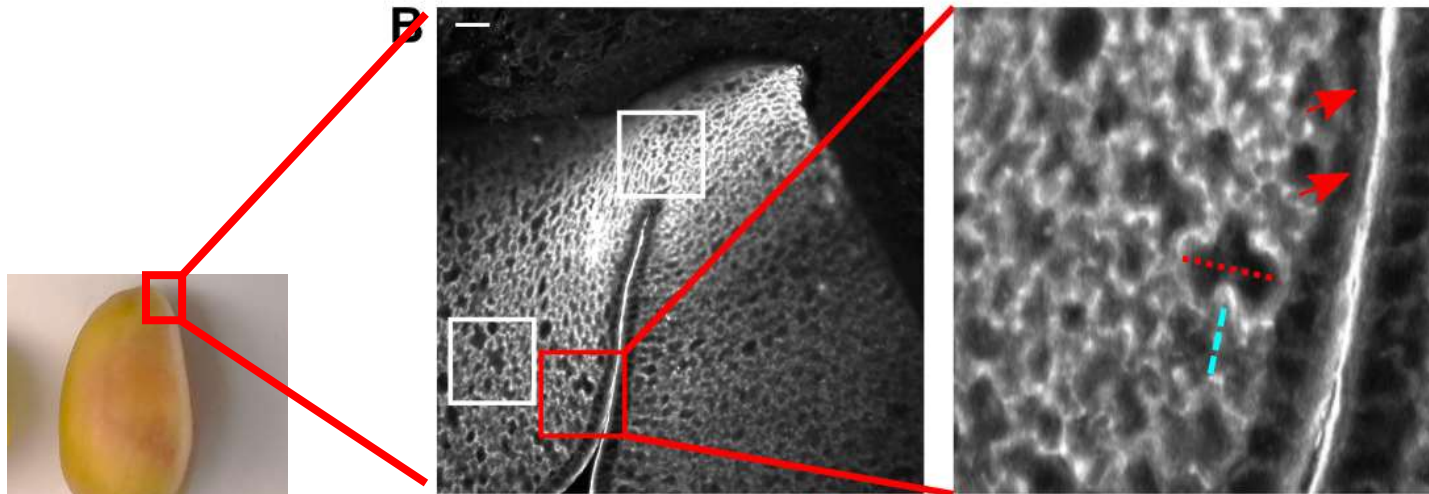
Dua Hassan
Jacqueline Schmidt
Siena Yang

Funding and support:

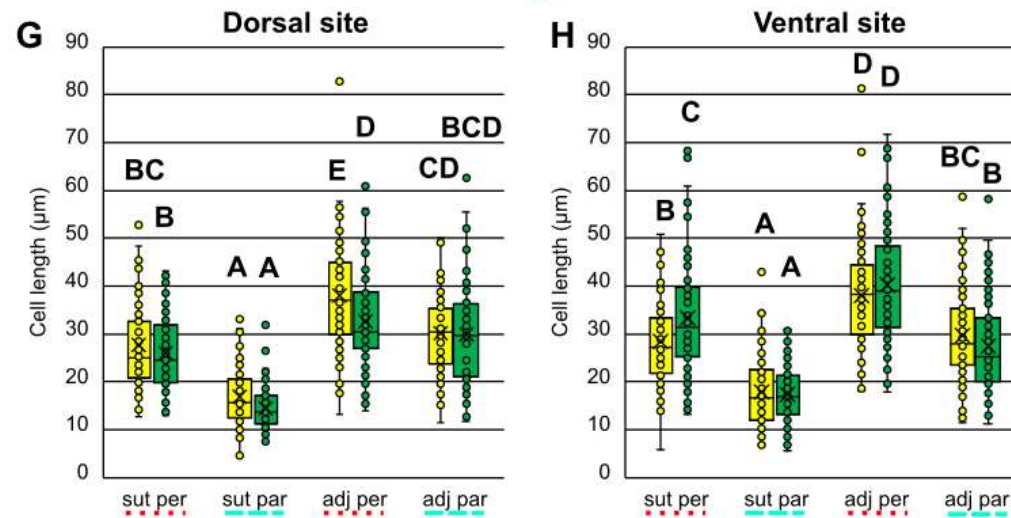
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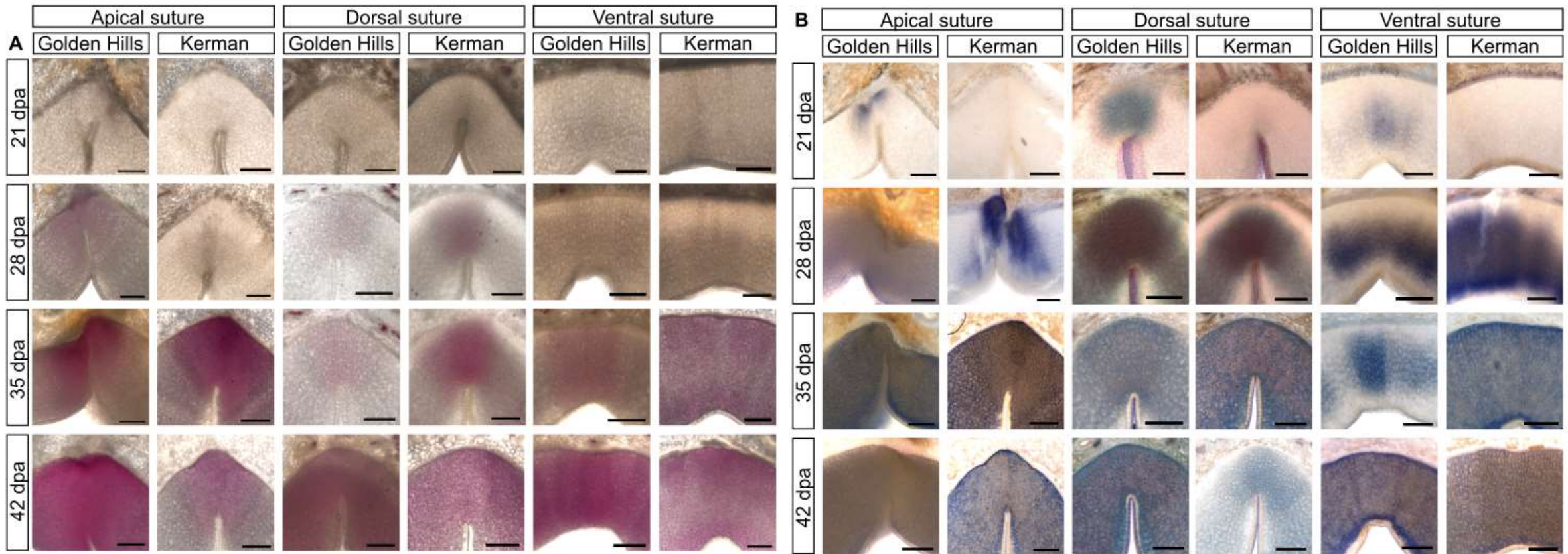
1B: Why does it split there?



- Shell cells are smaller and flattened at suture



Why smaller & flatter cells at the suture?



Lignification & cell death in cells start at the suture = less time for cells to expand