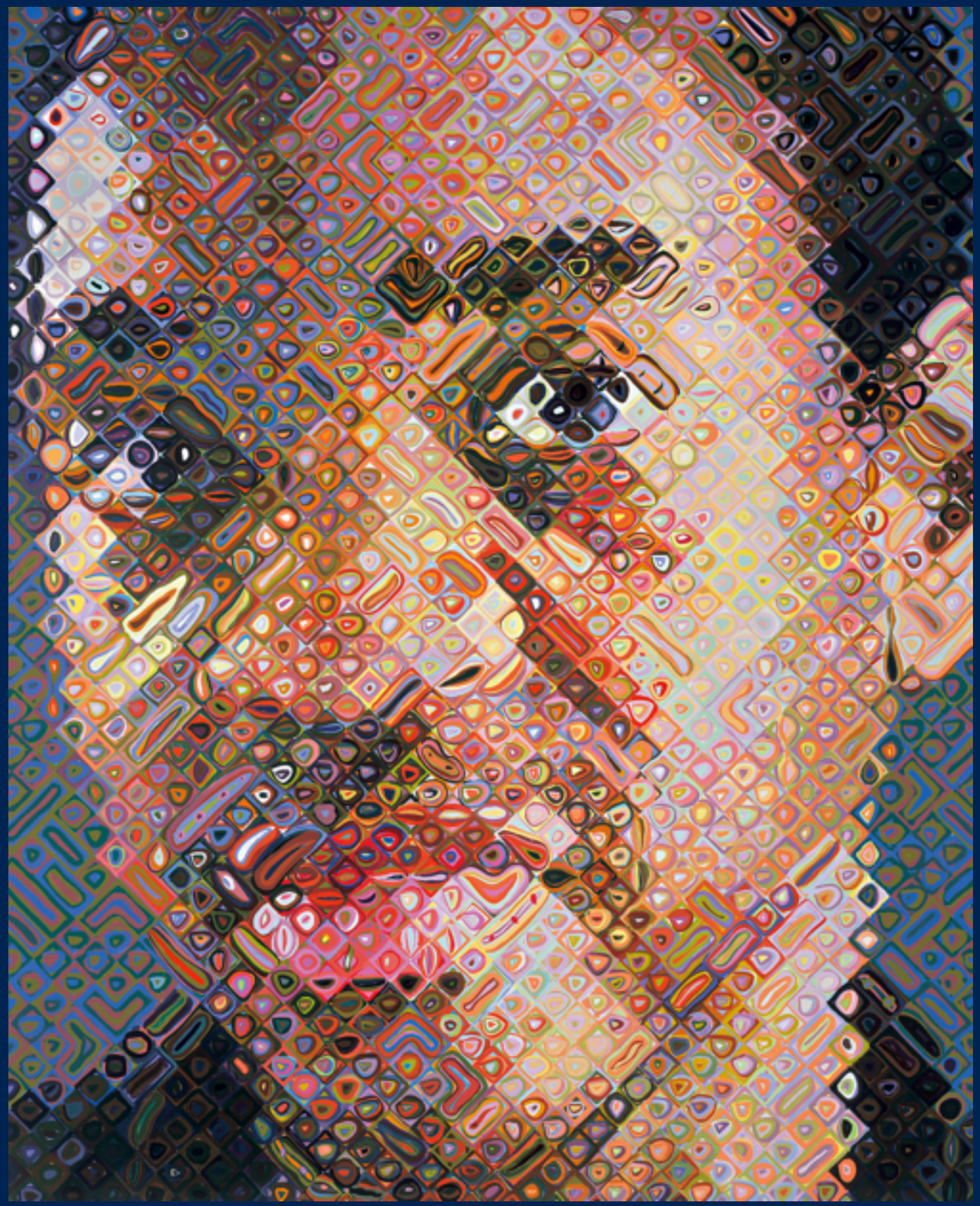
Development of the Compound Eye in Drosophila

Richard Carthew
Northwestern University, Evanston

Scaling of Pattern Formation

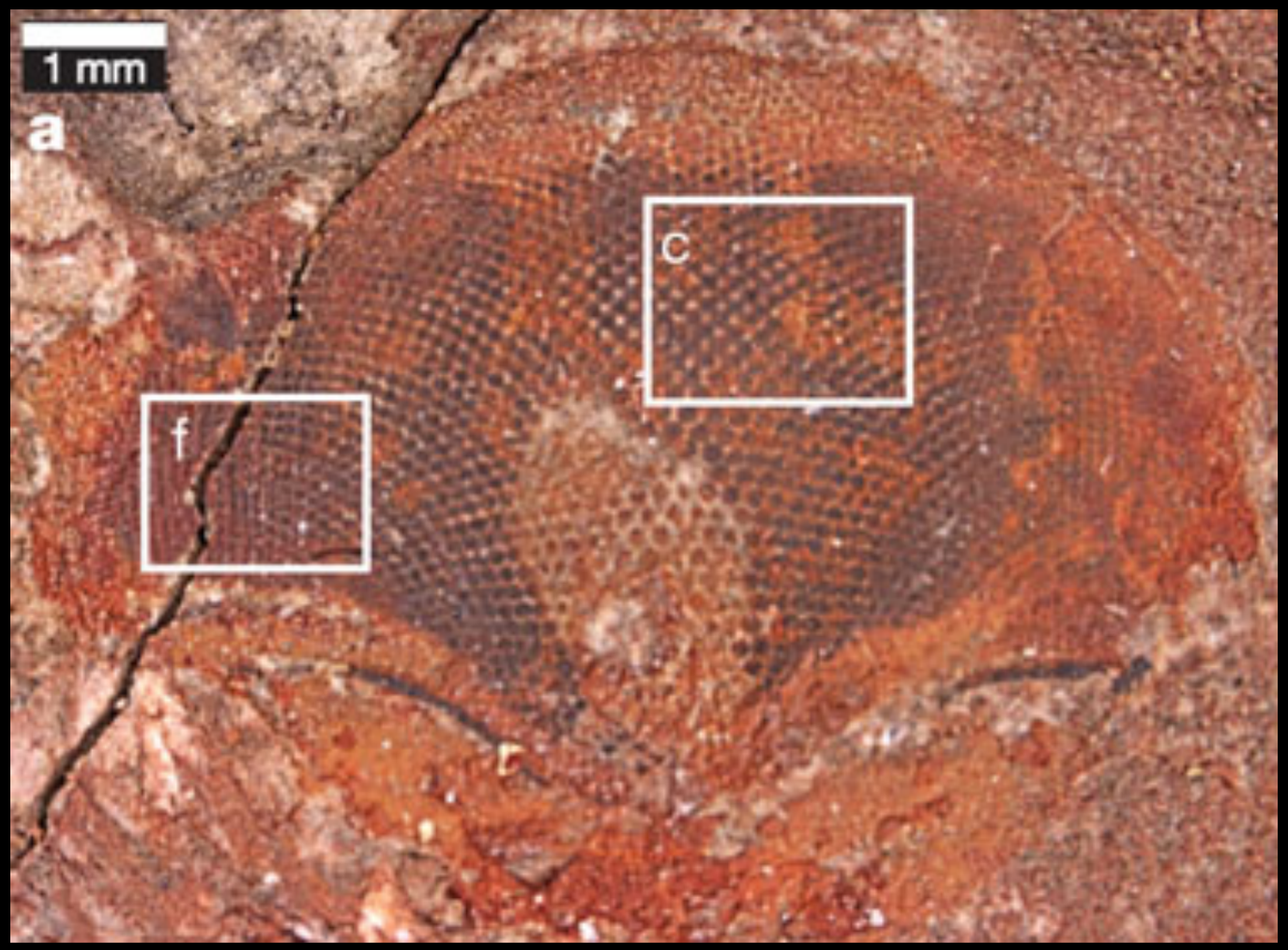


1 m

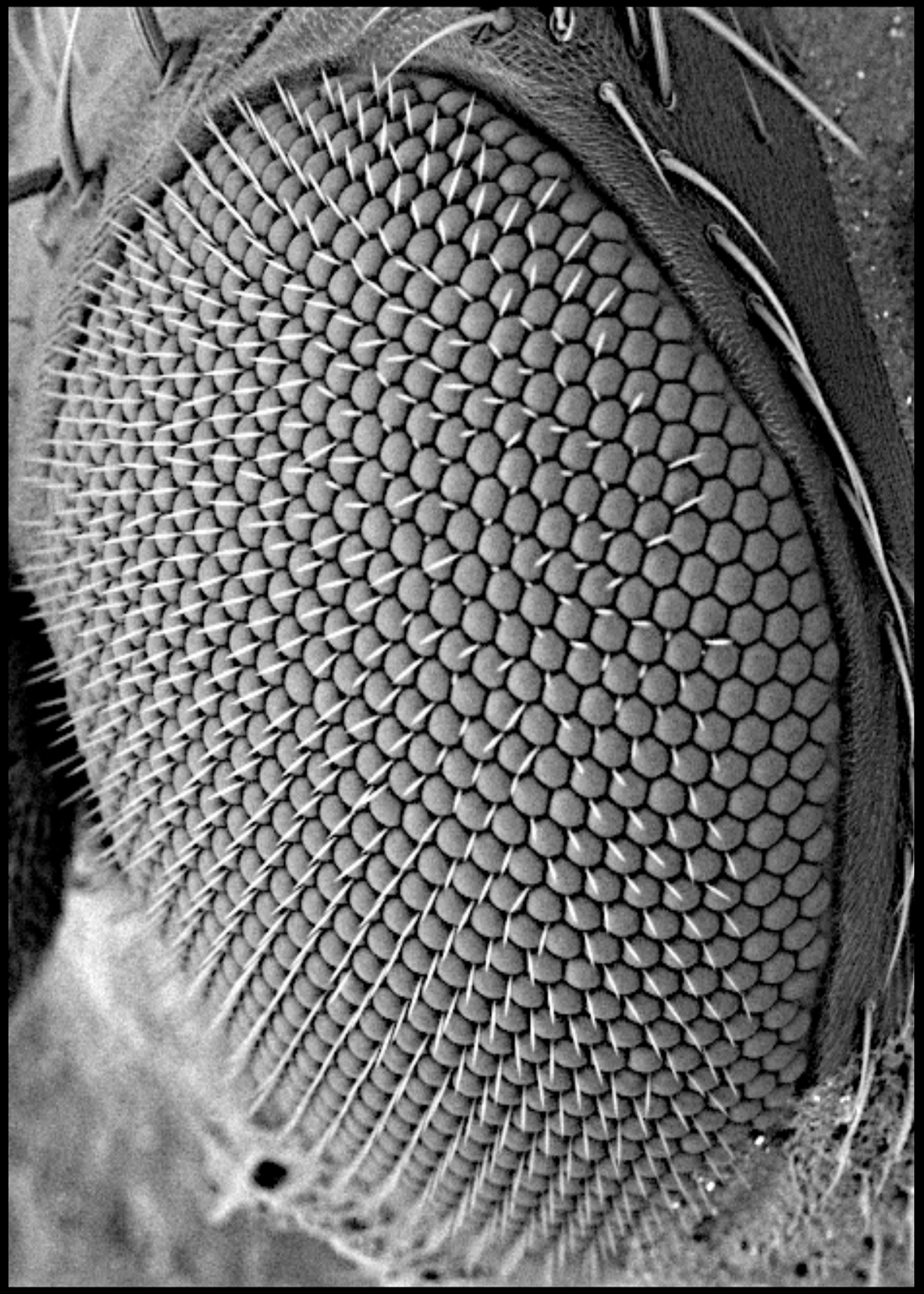
Scaling of Pattern Formation

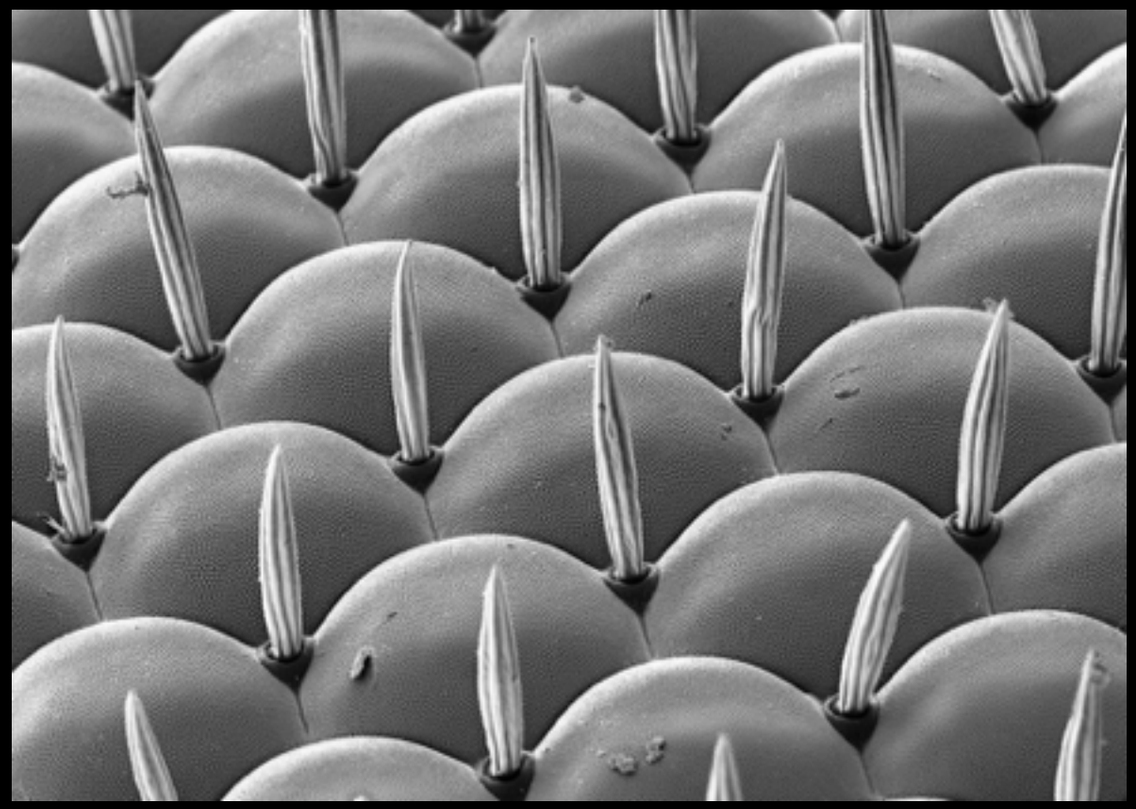
2.3 cm

Ancient Origins of the Compound Eye

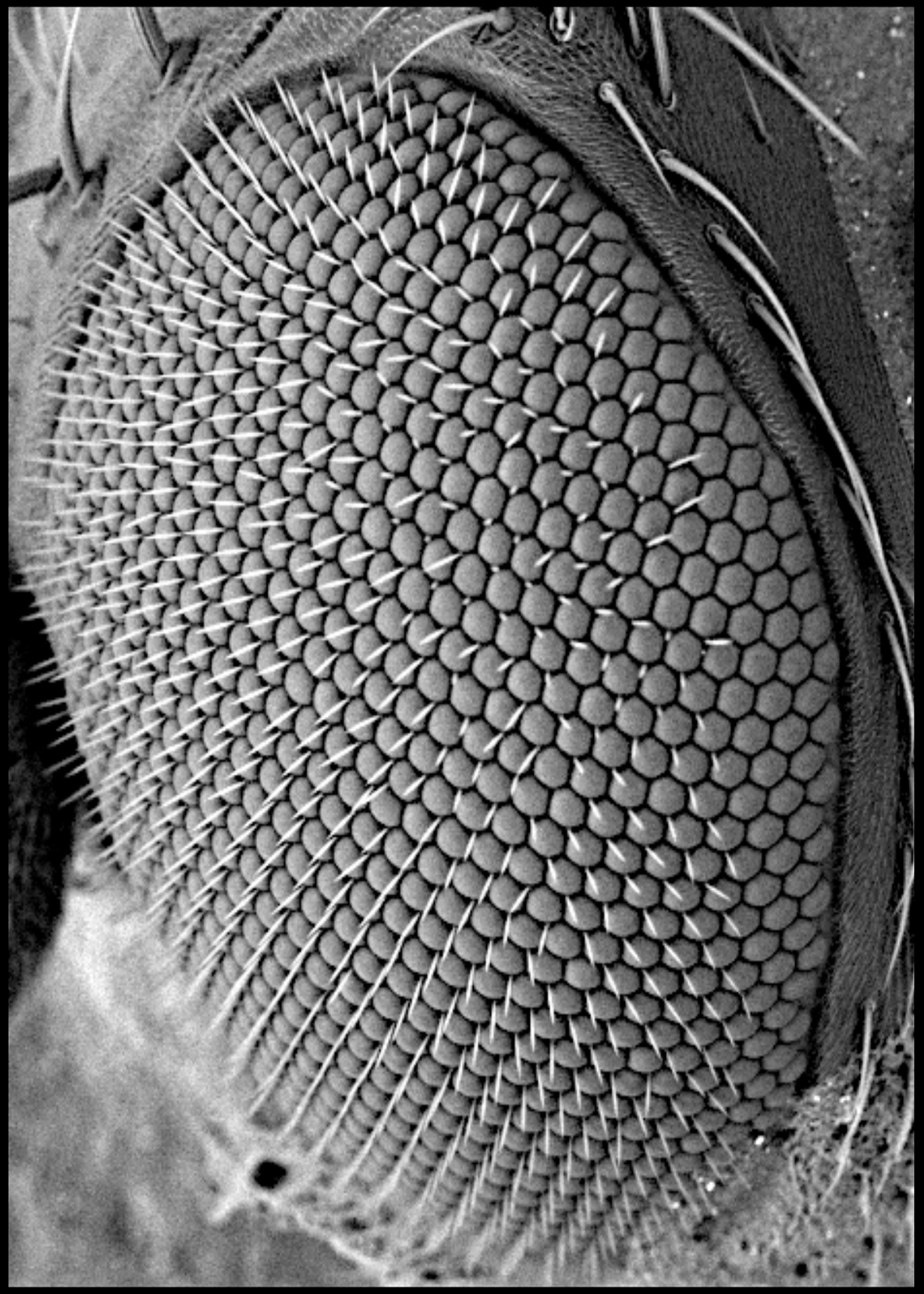


Lee et al, (2011) Nature

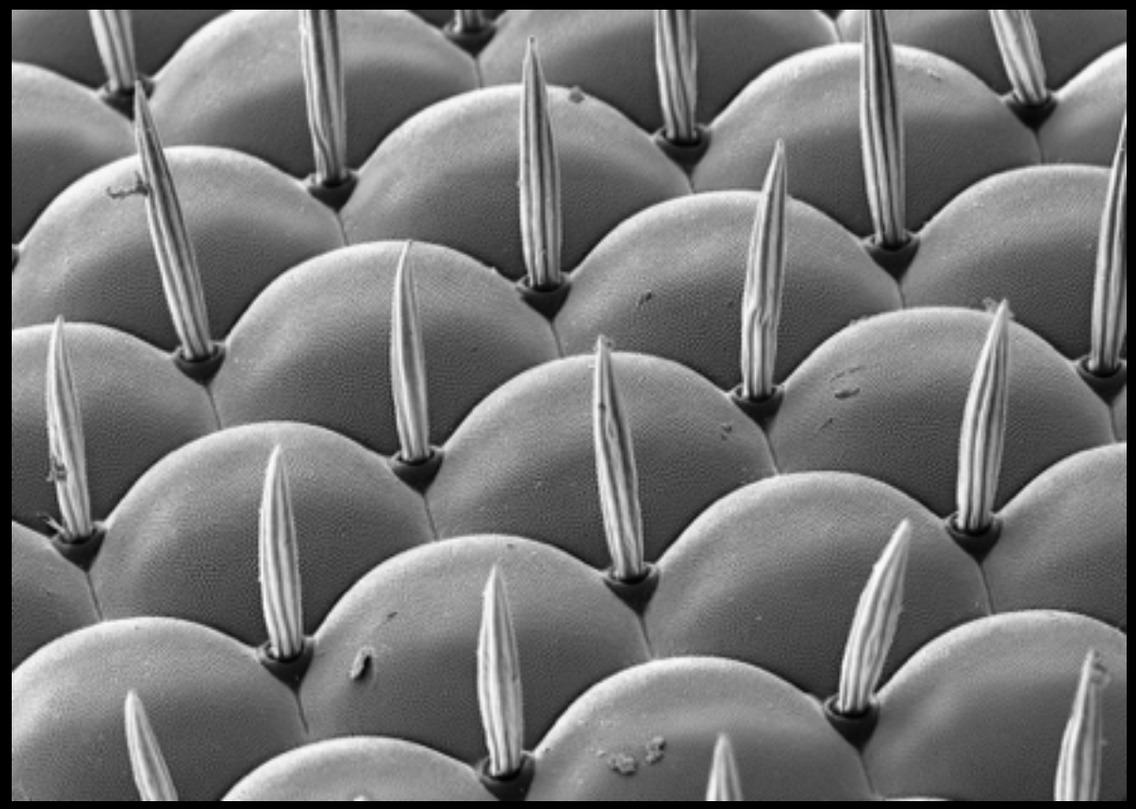




Martin Oeggerli



Ommatidium (Greek: Eyelet)



Martin Oeggerli

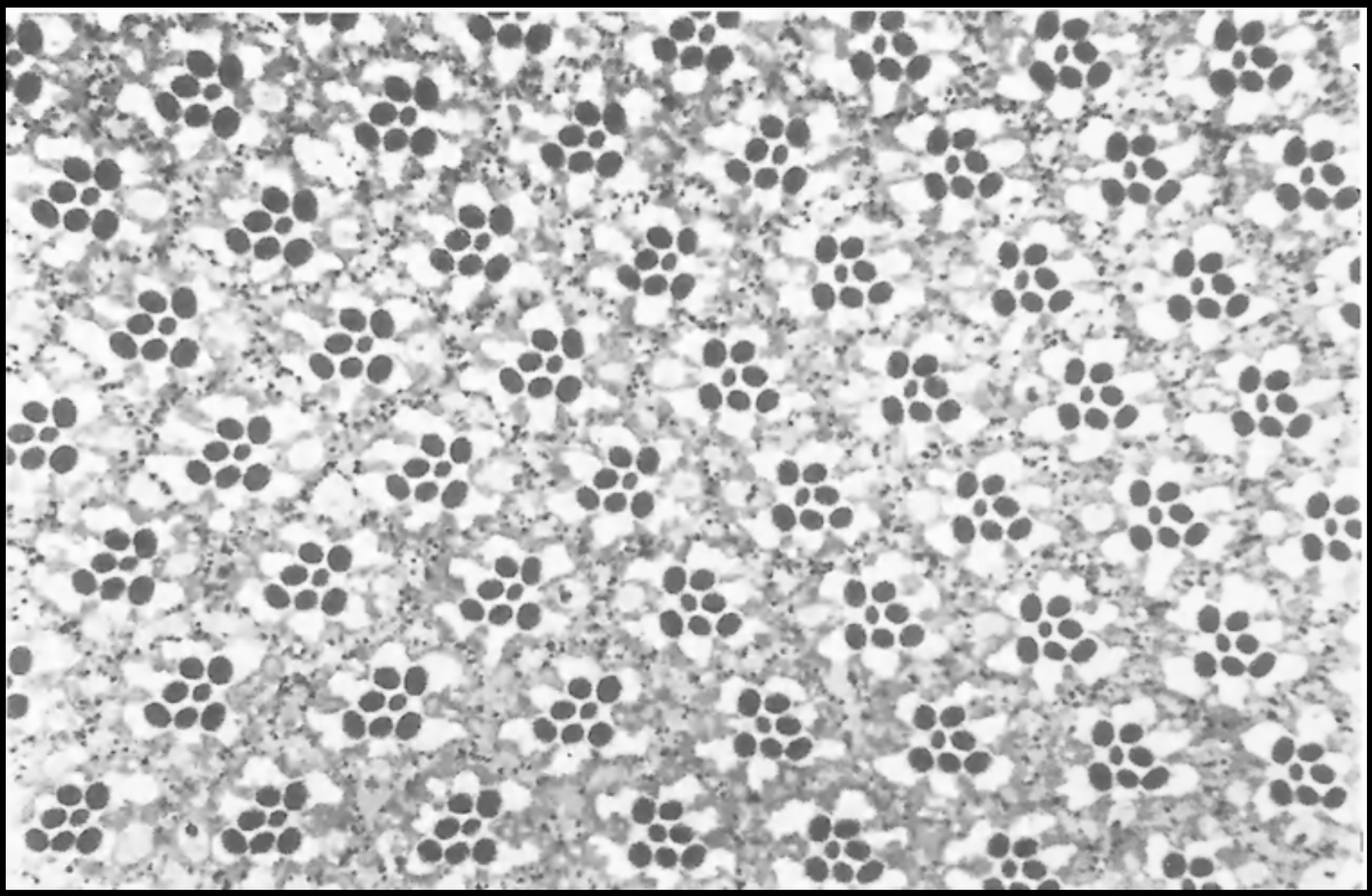
Thomas Shahan

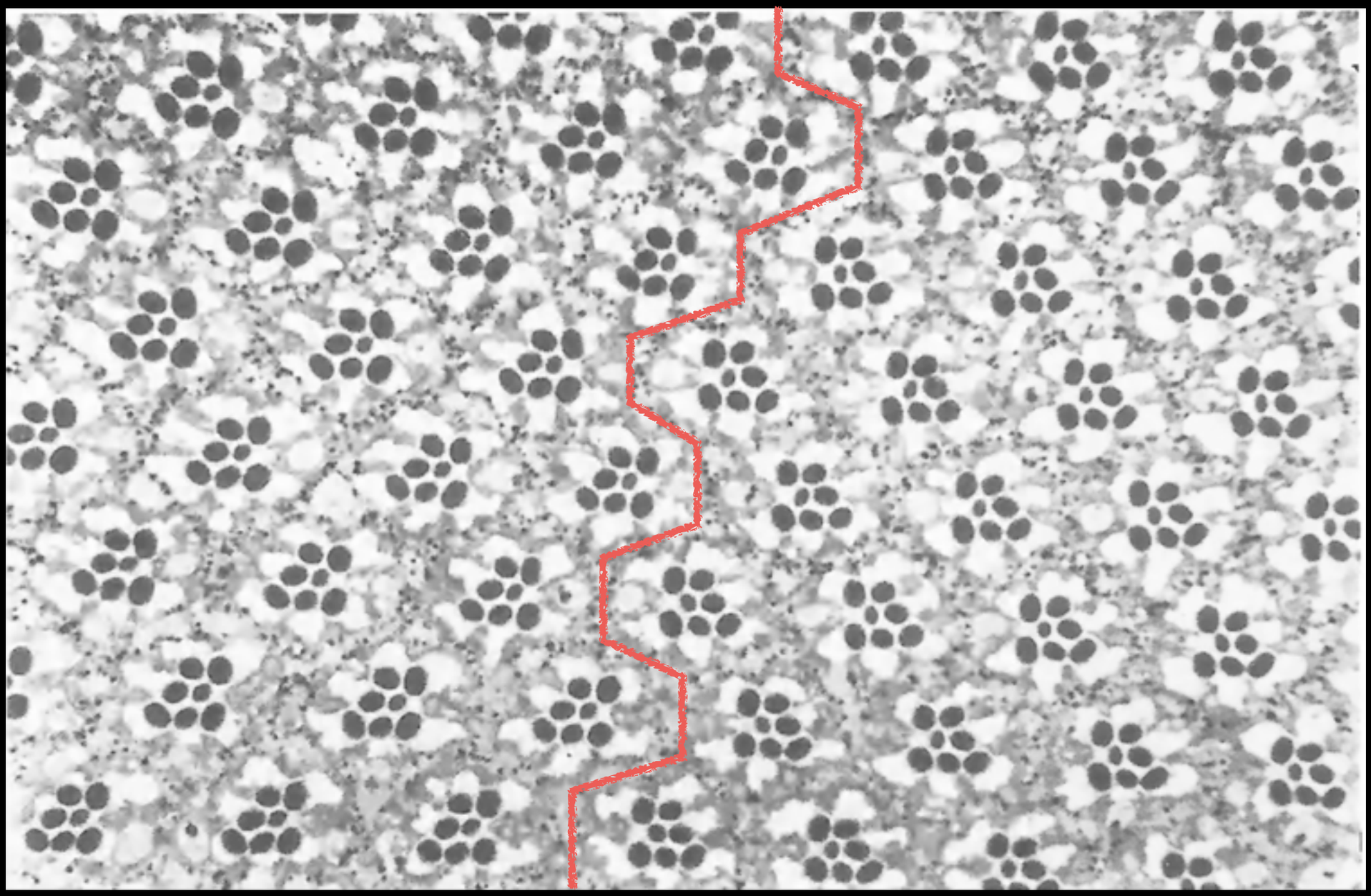
Thomas Shahan

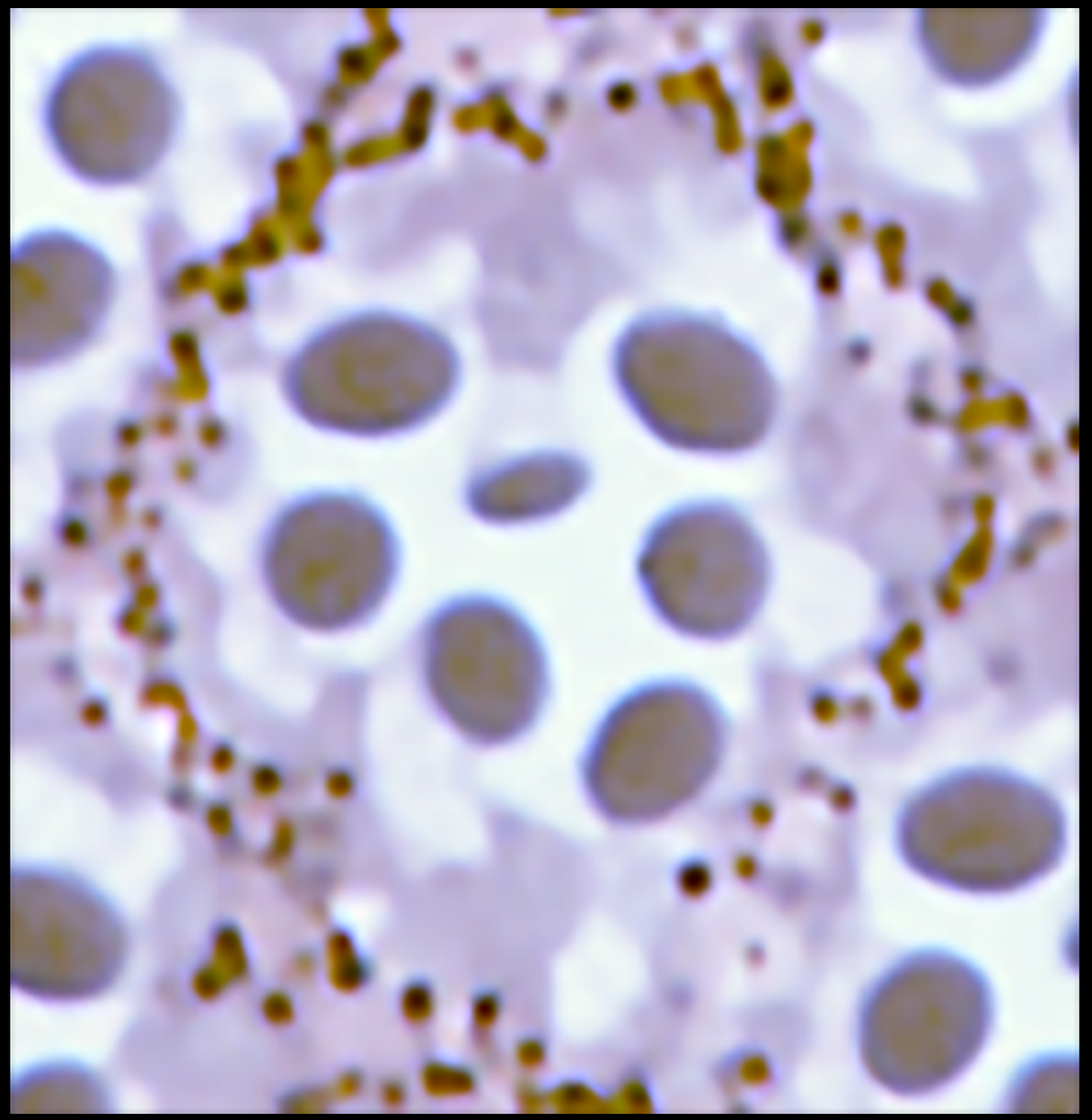
Jeff Burchler

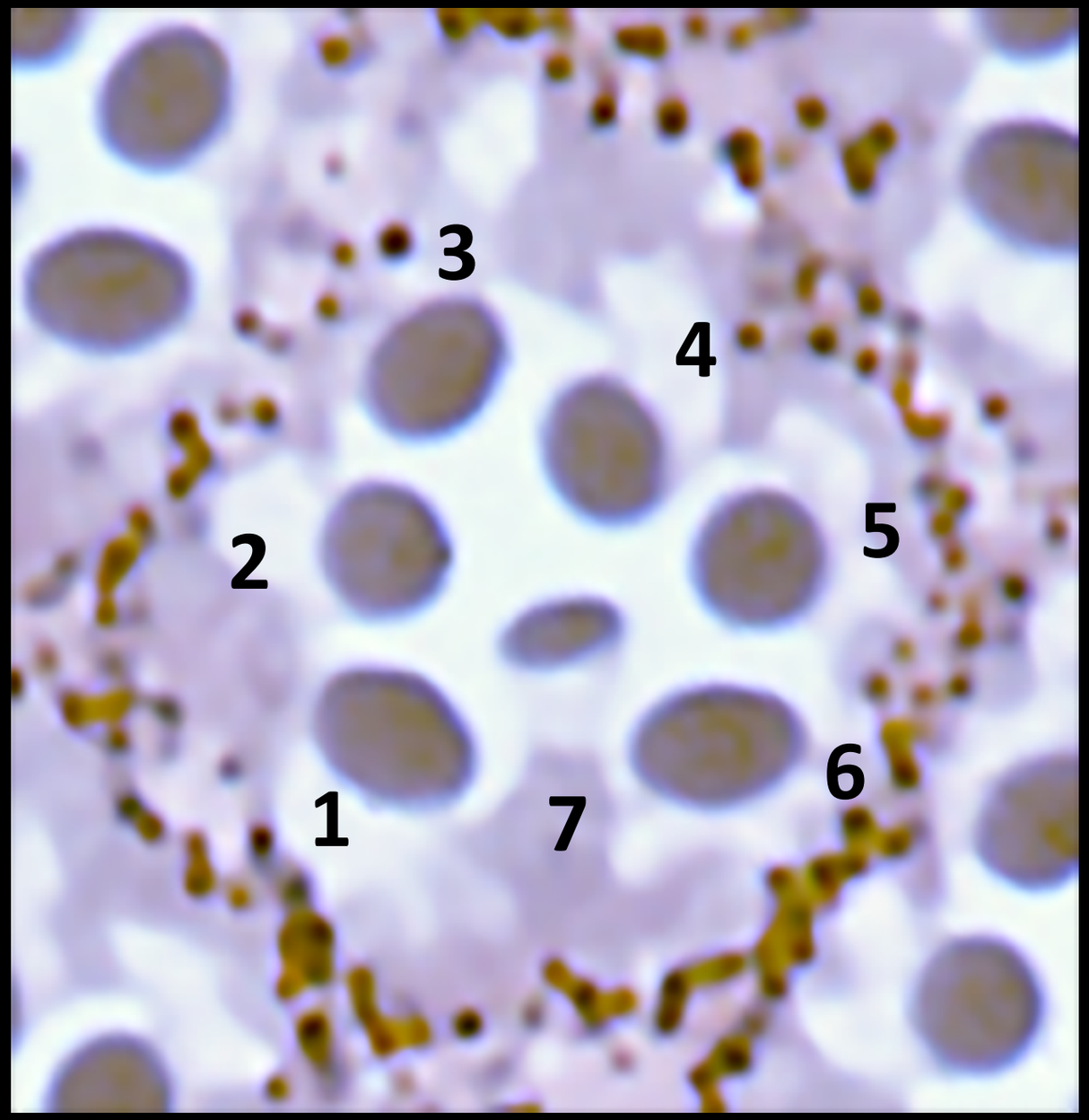
Thomas Shahan

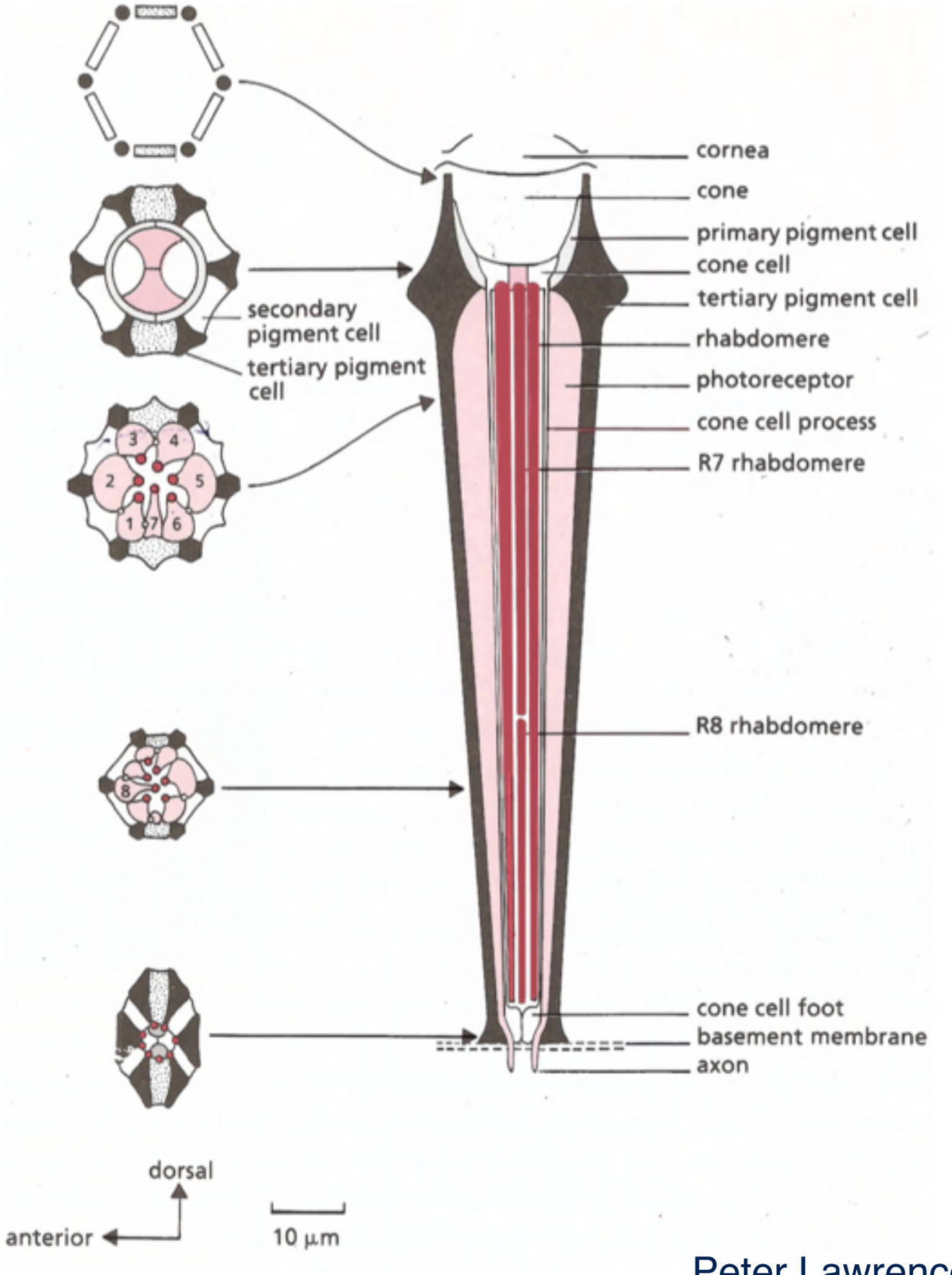
Andrew Mitchell








3
4
2
5
6
1
7

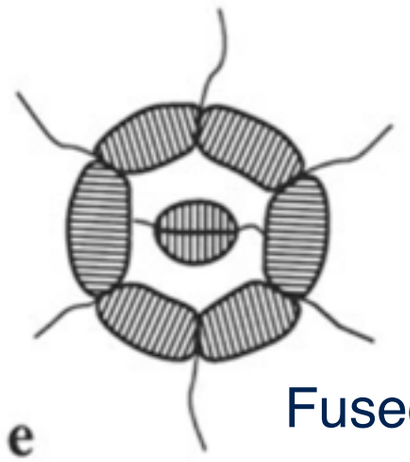


Peter Lawrence, Making of the Fly (1992)

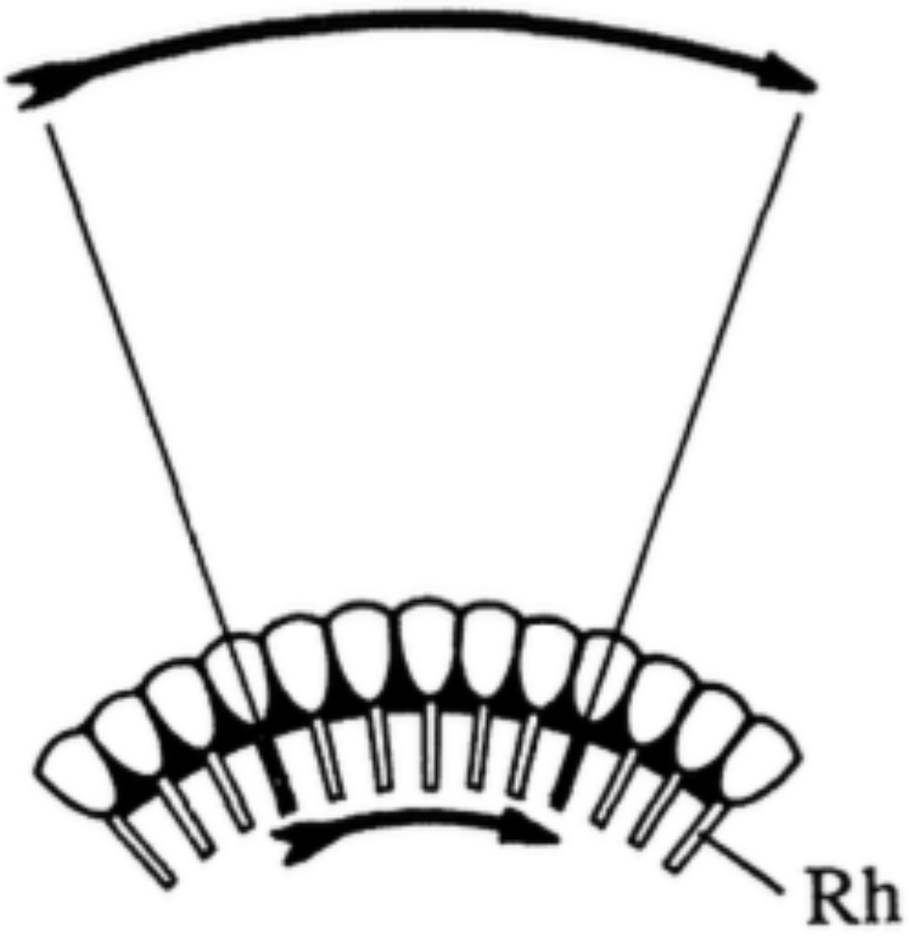
THE FAR SIDE By GARY LARSON

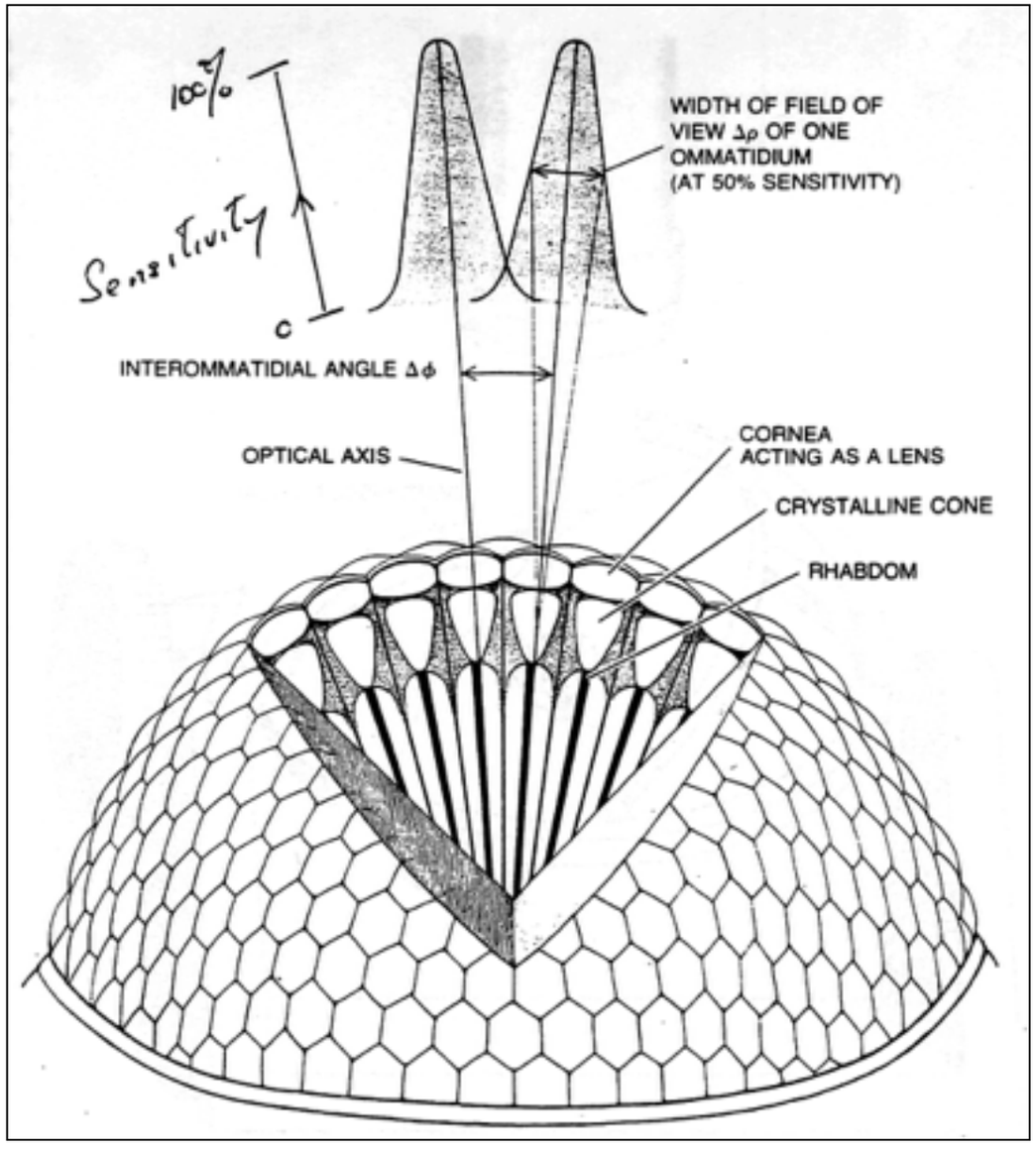
The last thing a fly ever sees

Apposition Eye



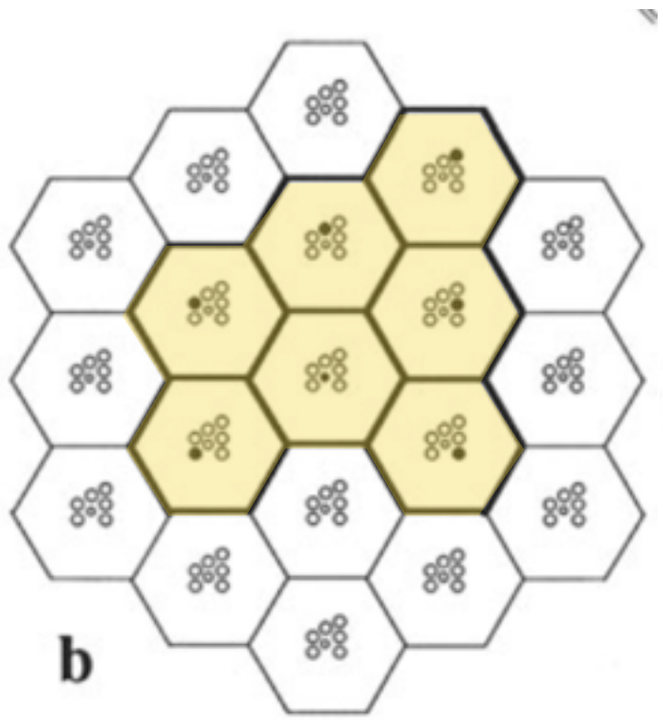
Fused Rhabdomeres - Rhabdom (Greek: Rod)

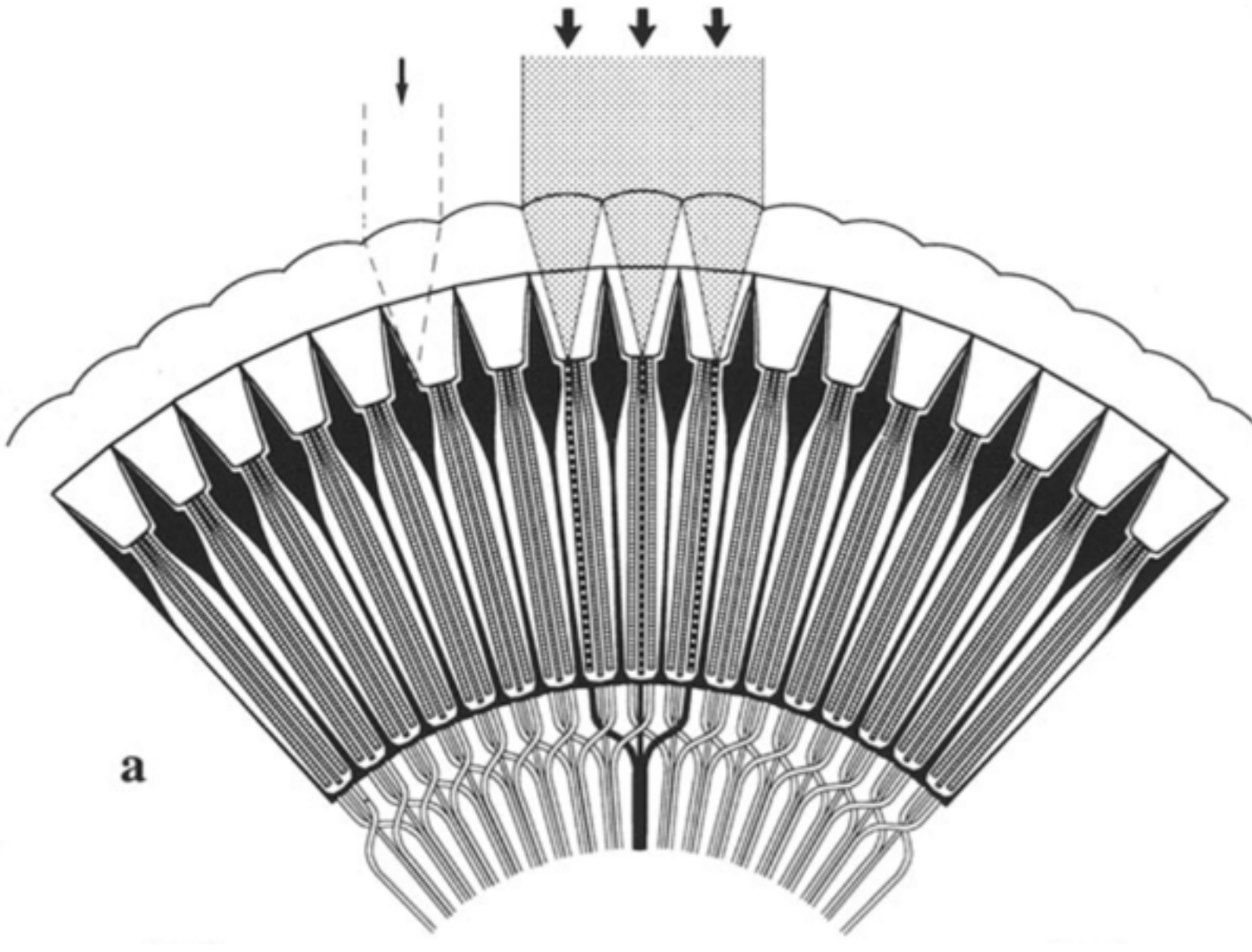


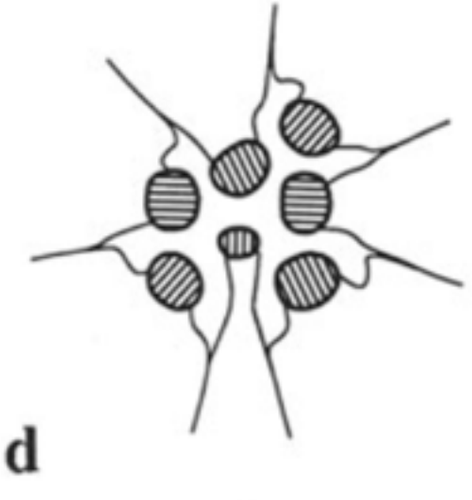


Dan-Eric Nilsson (1989)

Open Rhabdomeres - Neural Superposition Eye

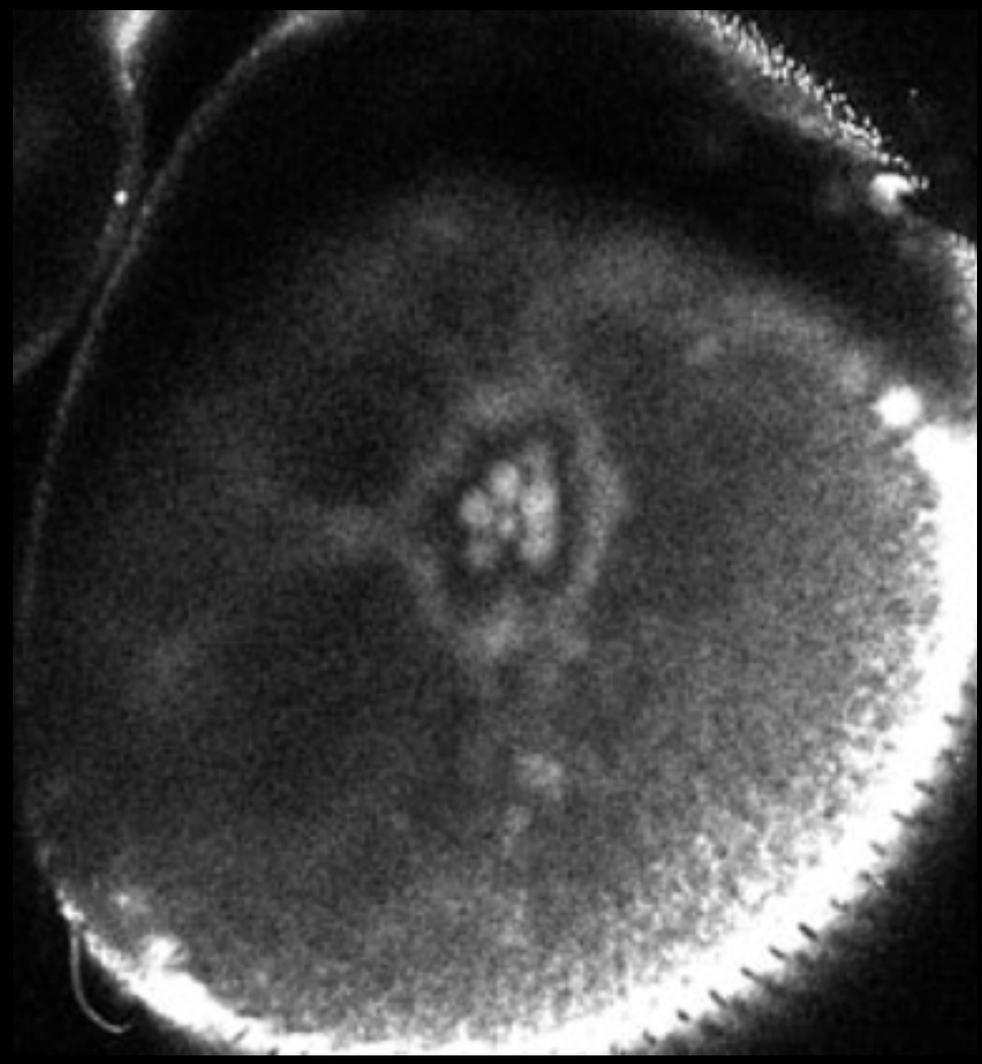






Dan-Eric Nilsson (1989)

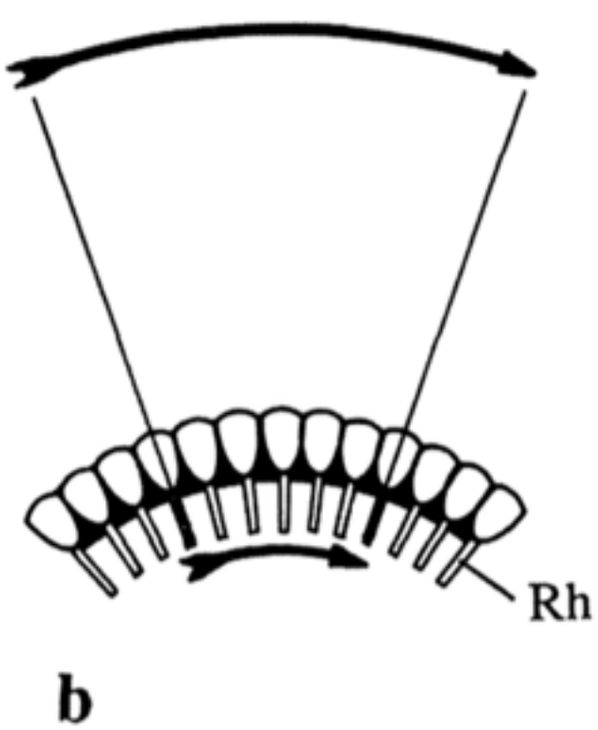
Simple pseudopupil



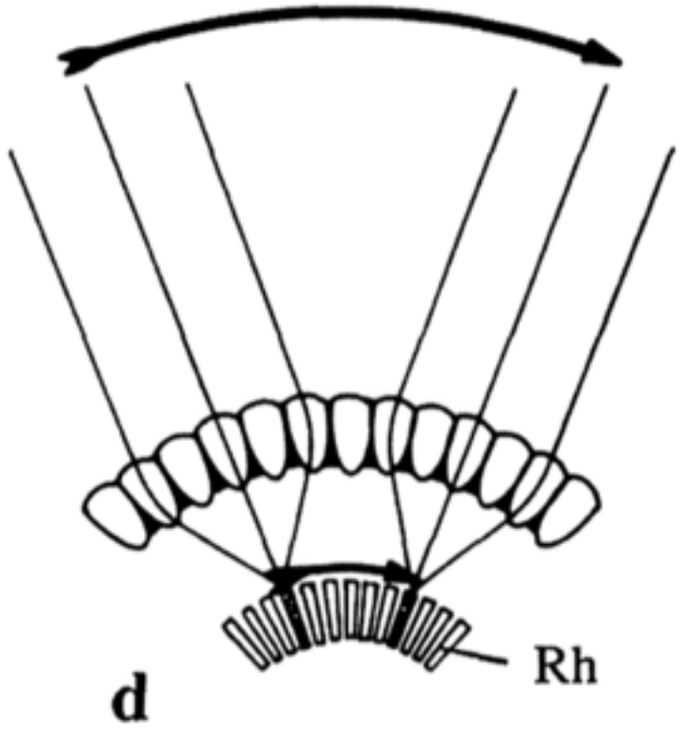
Deep pseudopupil

True Superposition Eye

Dan-Eric Nilsson (1989)



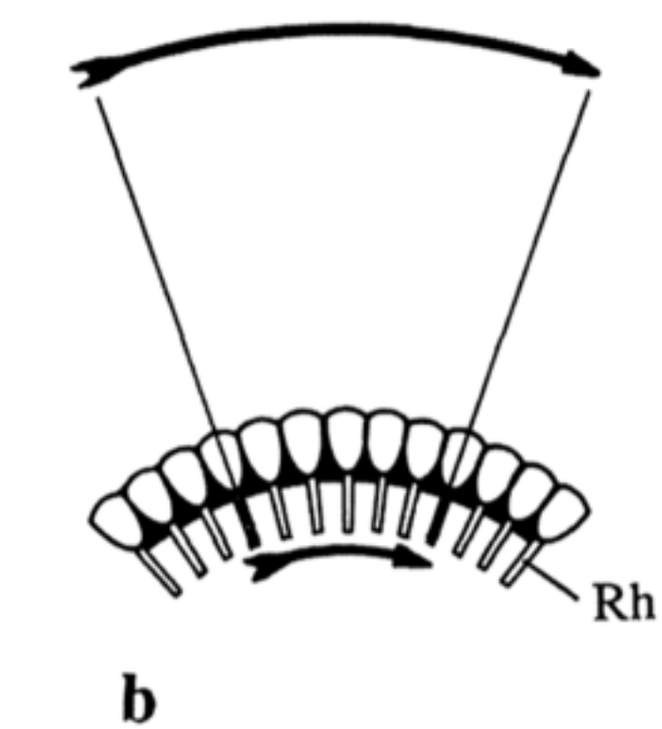
b

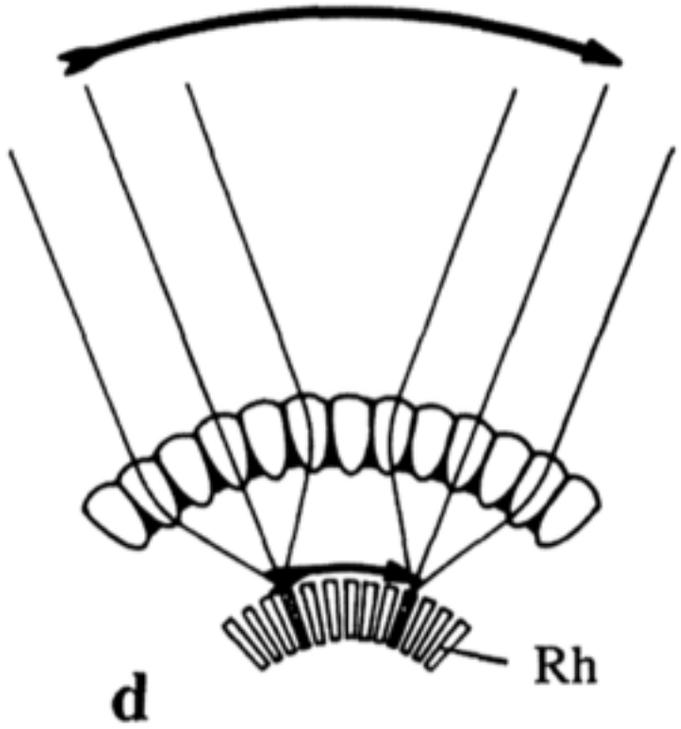


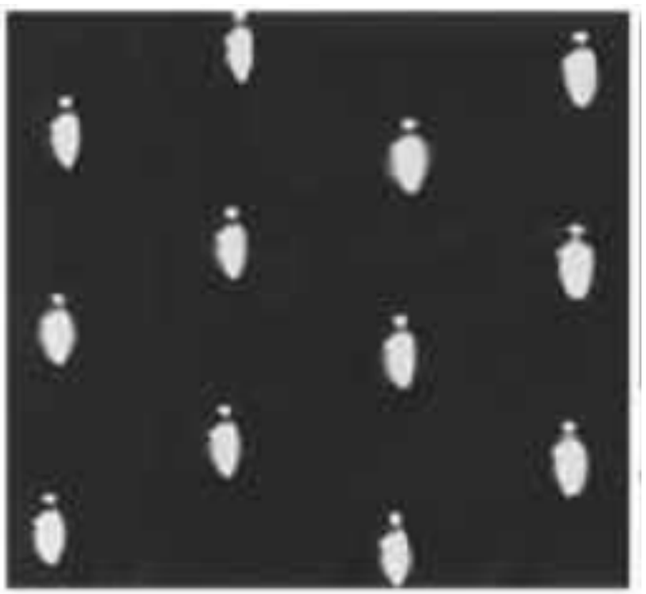
d

True Superposition Eye

Dan-Eric Nilsson (1989)



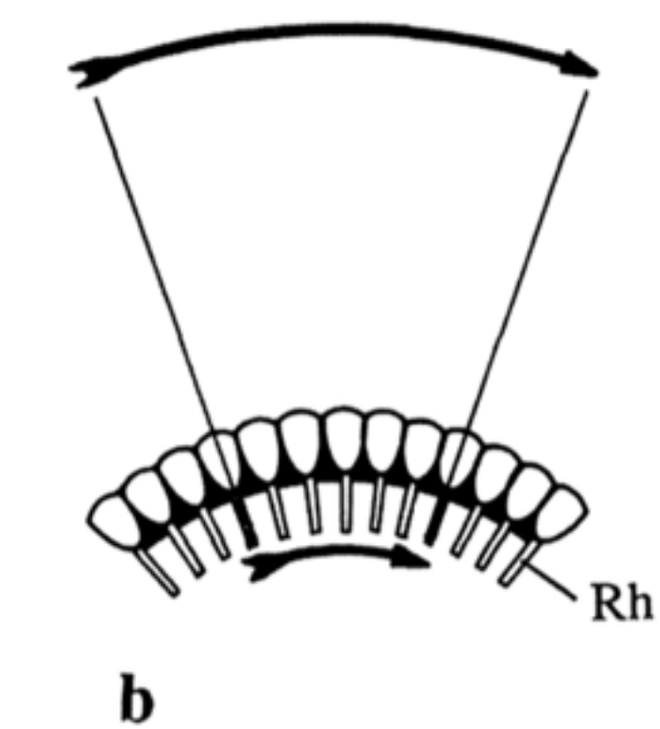


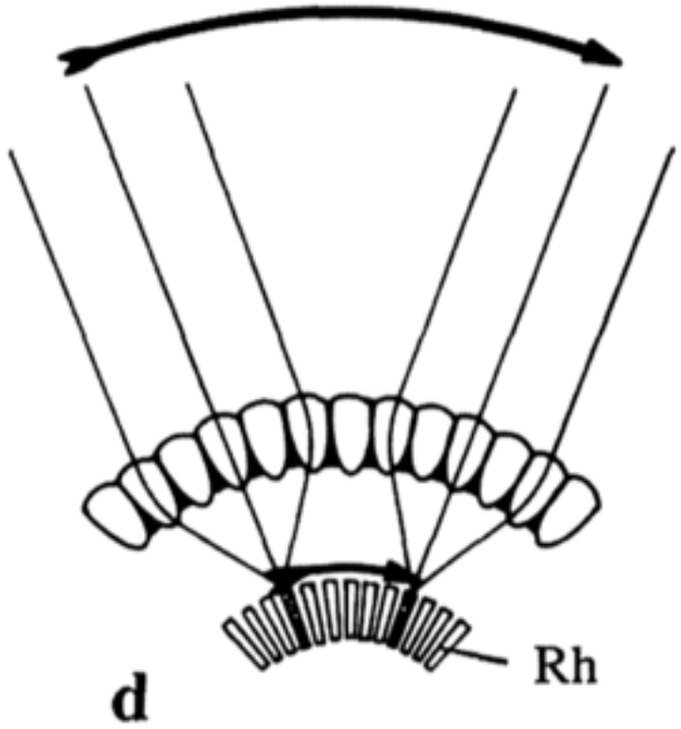


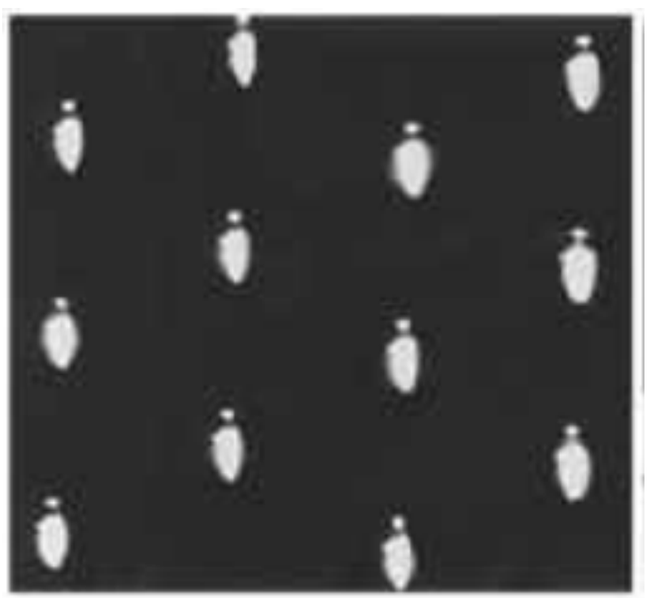
Michael Land

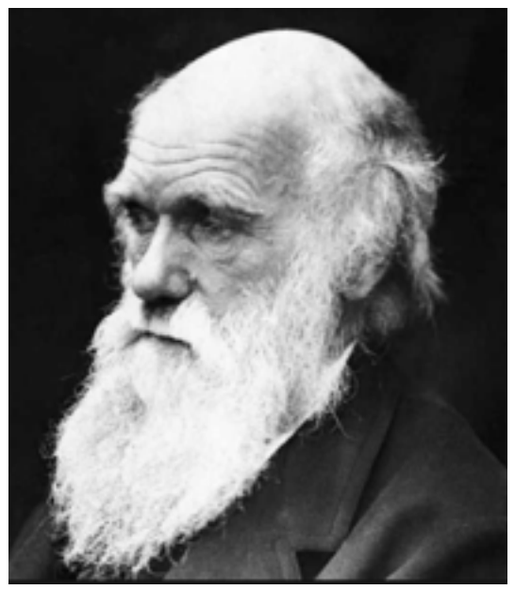
True Superposition Eye

Dan-Eric Nilsson (1989)



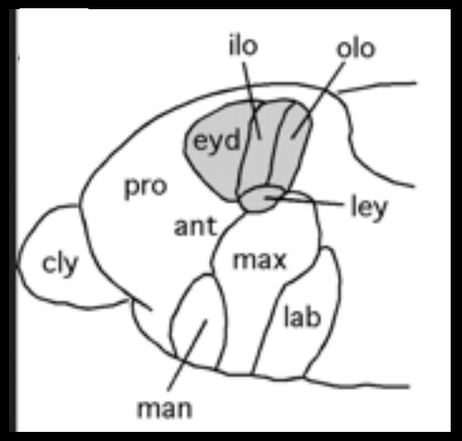


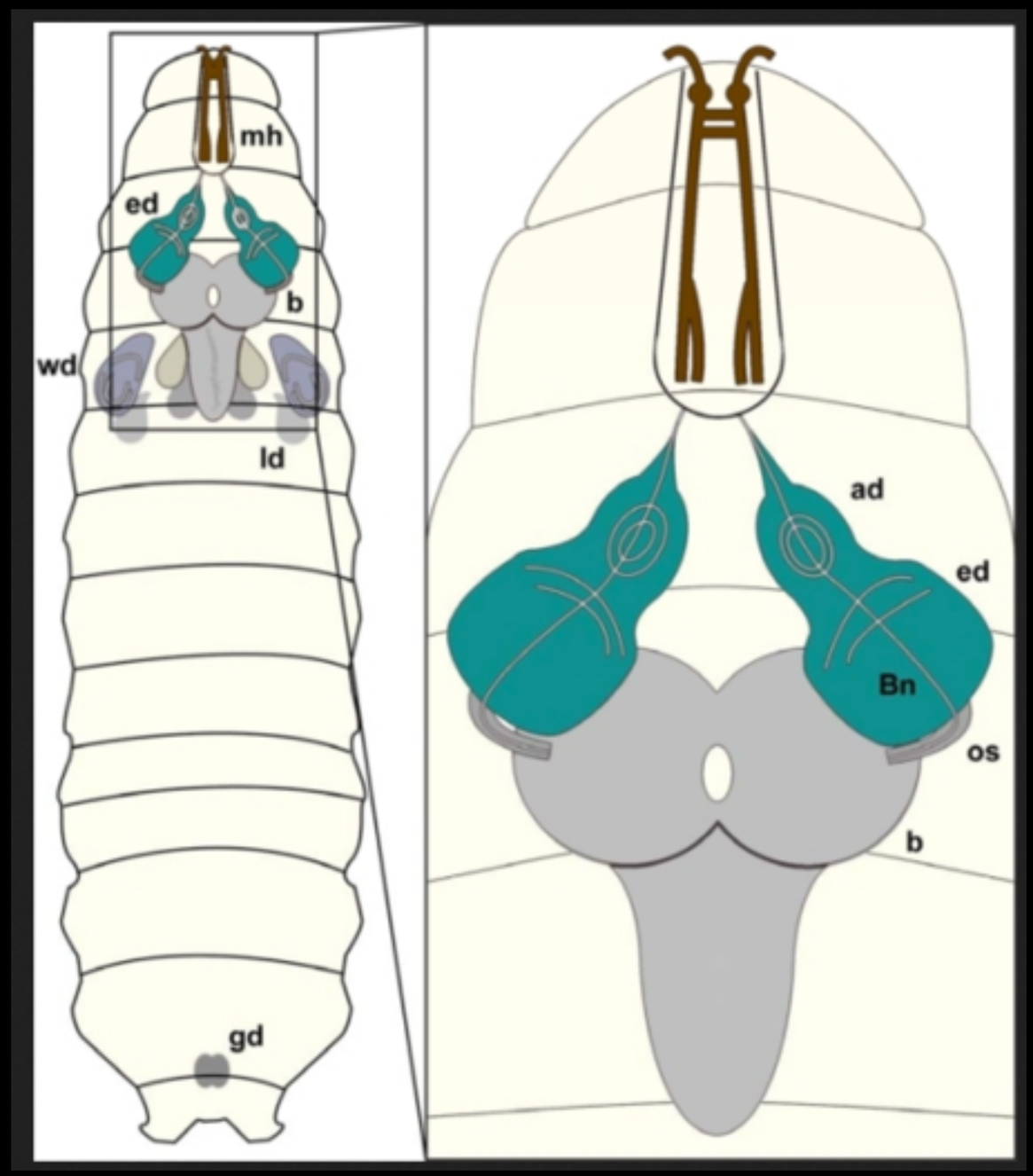




Michael Land

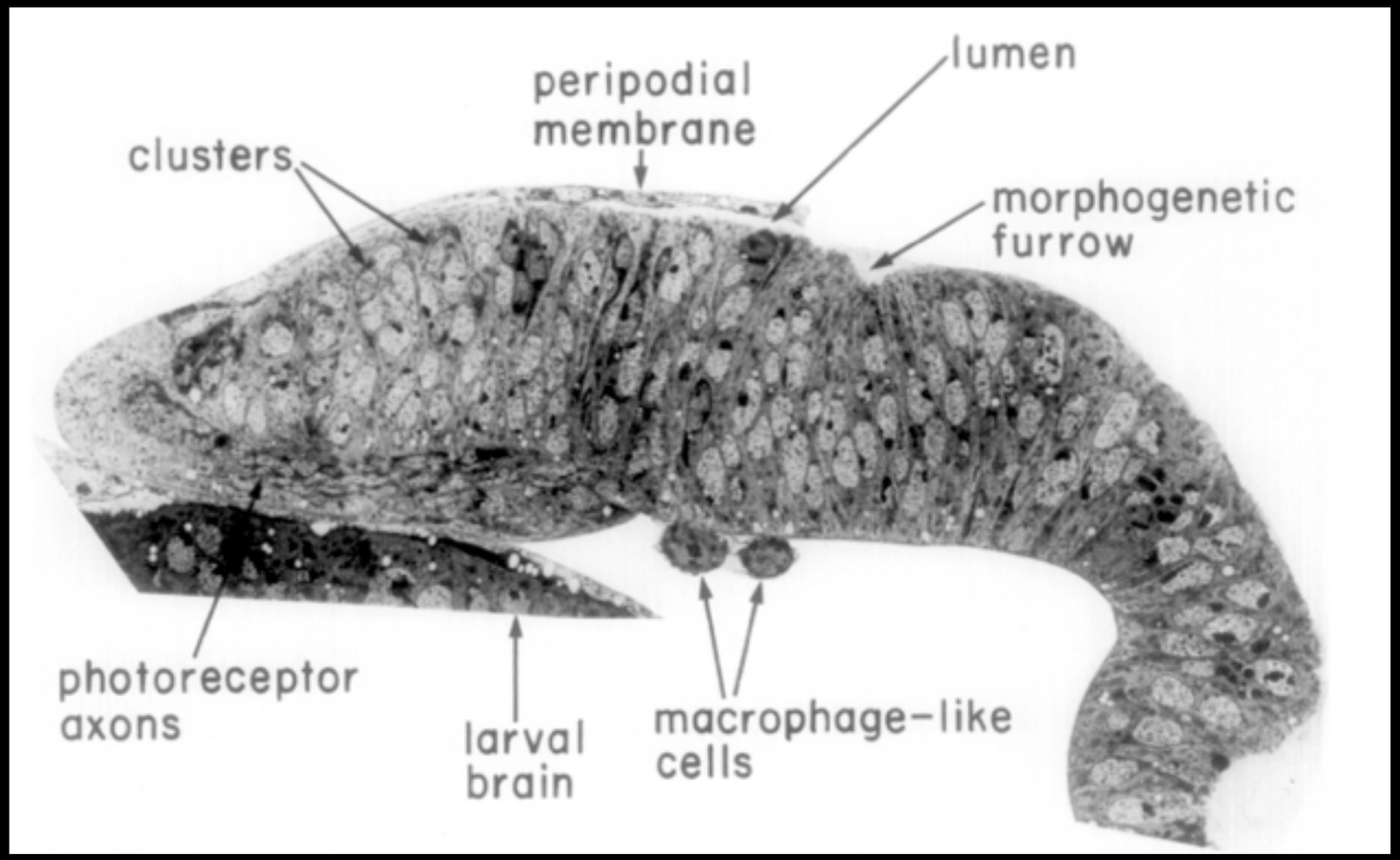
Early Development of the Drosophila Eye





Jiebmann and Paulus 2009

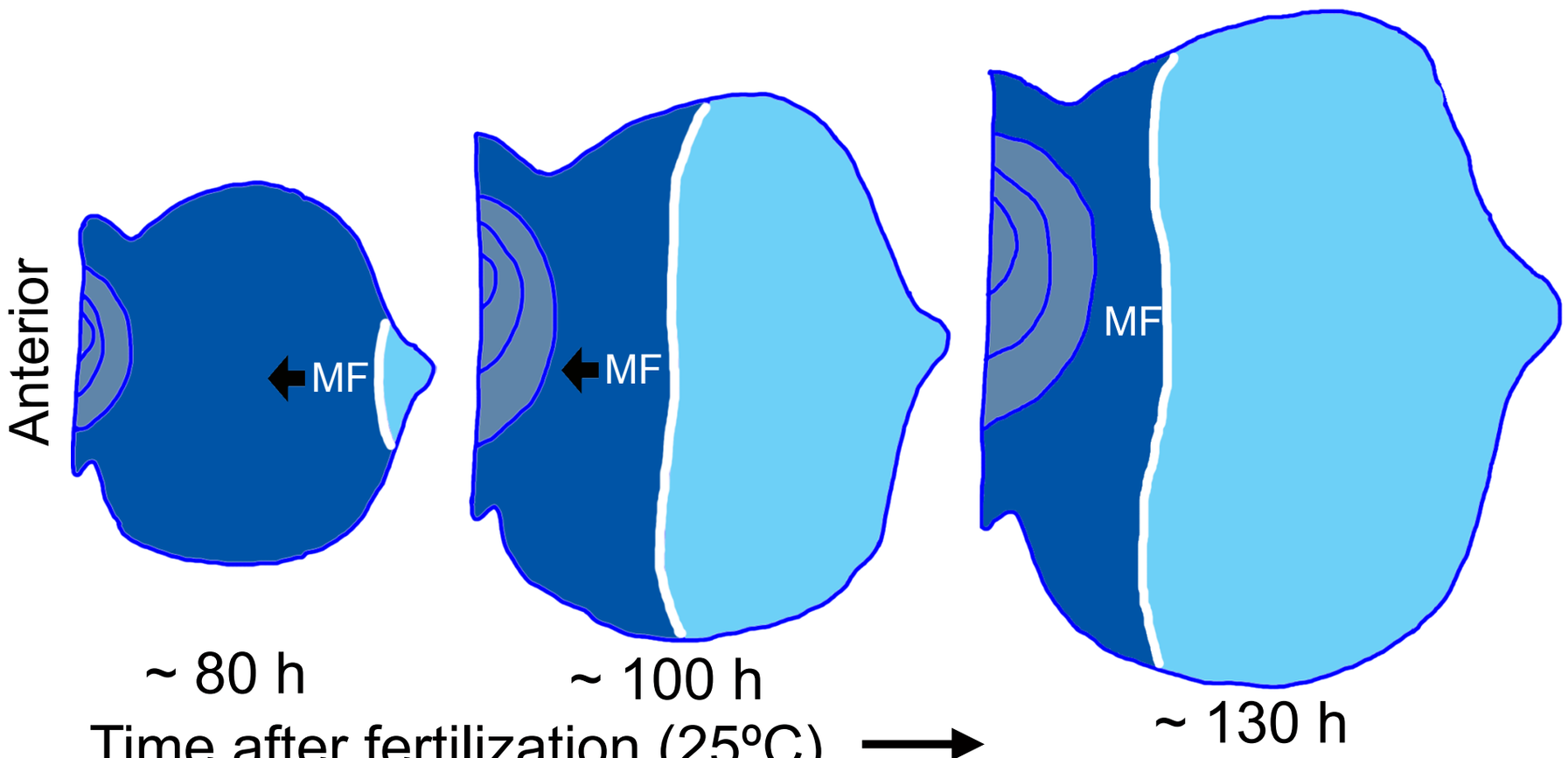
Ready, Hansen and Benzer 1976



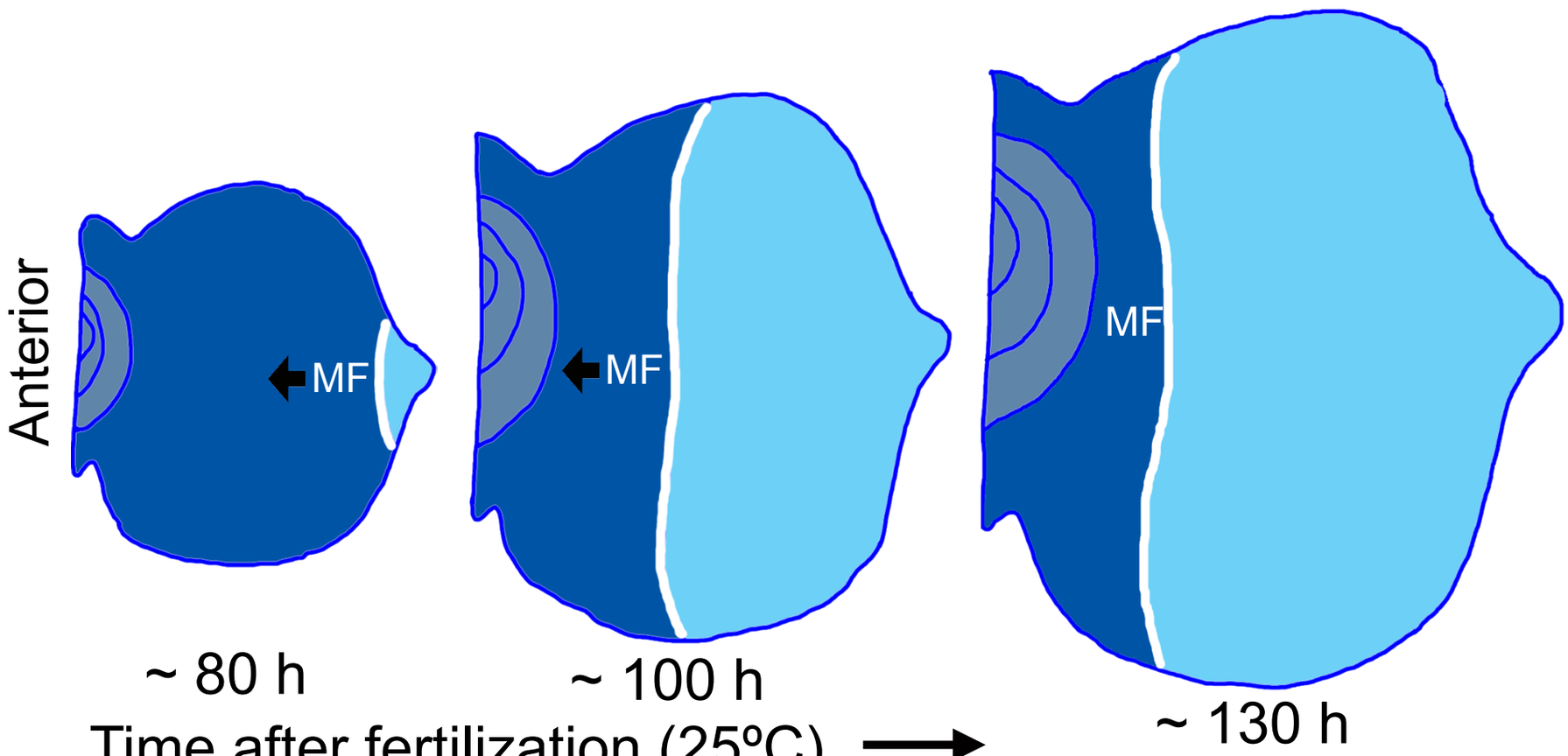
50 µm

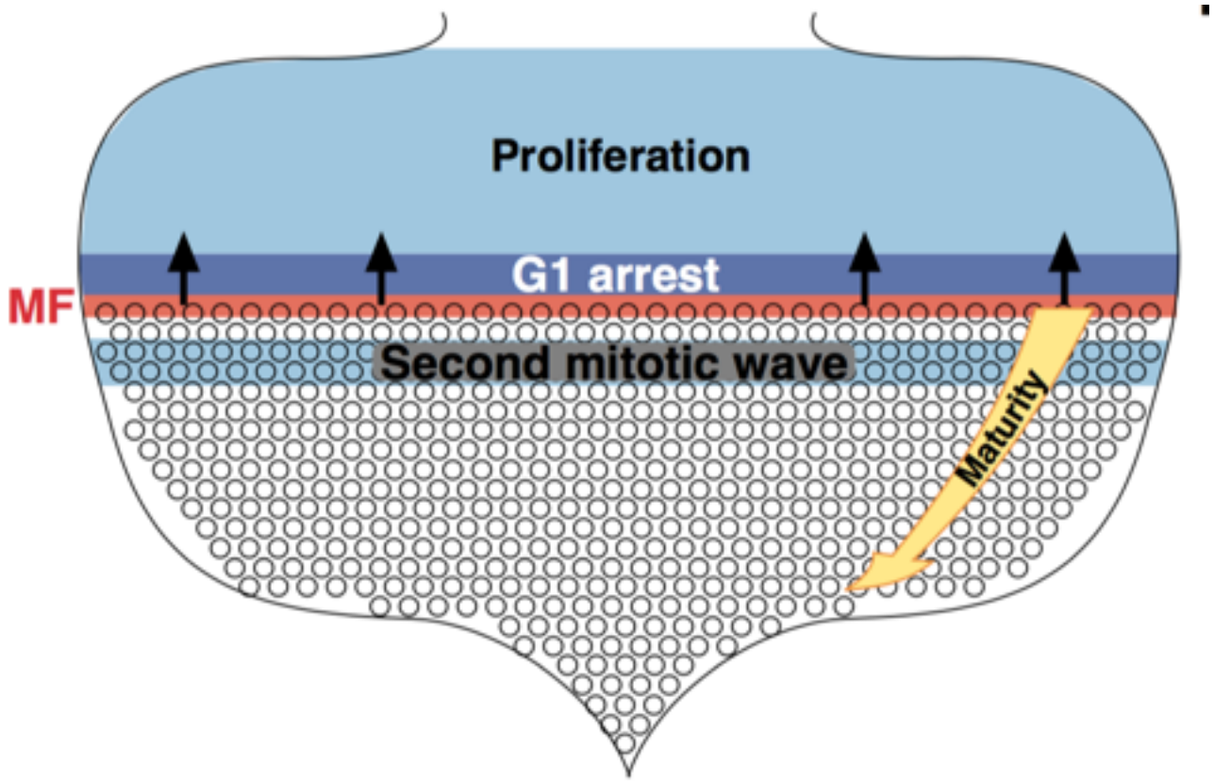
Ready, Hansen and Benzer 1976

A Moving Wave of Morphogenesis and Differentiation

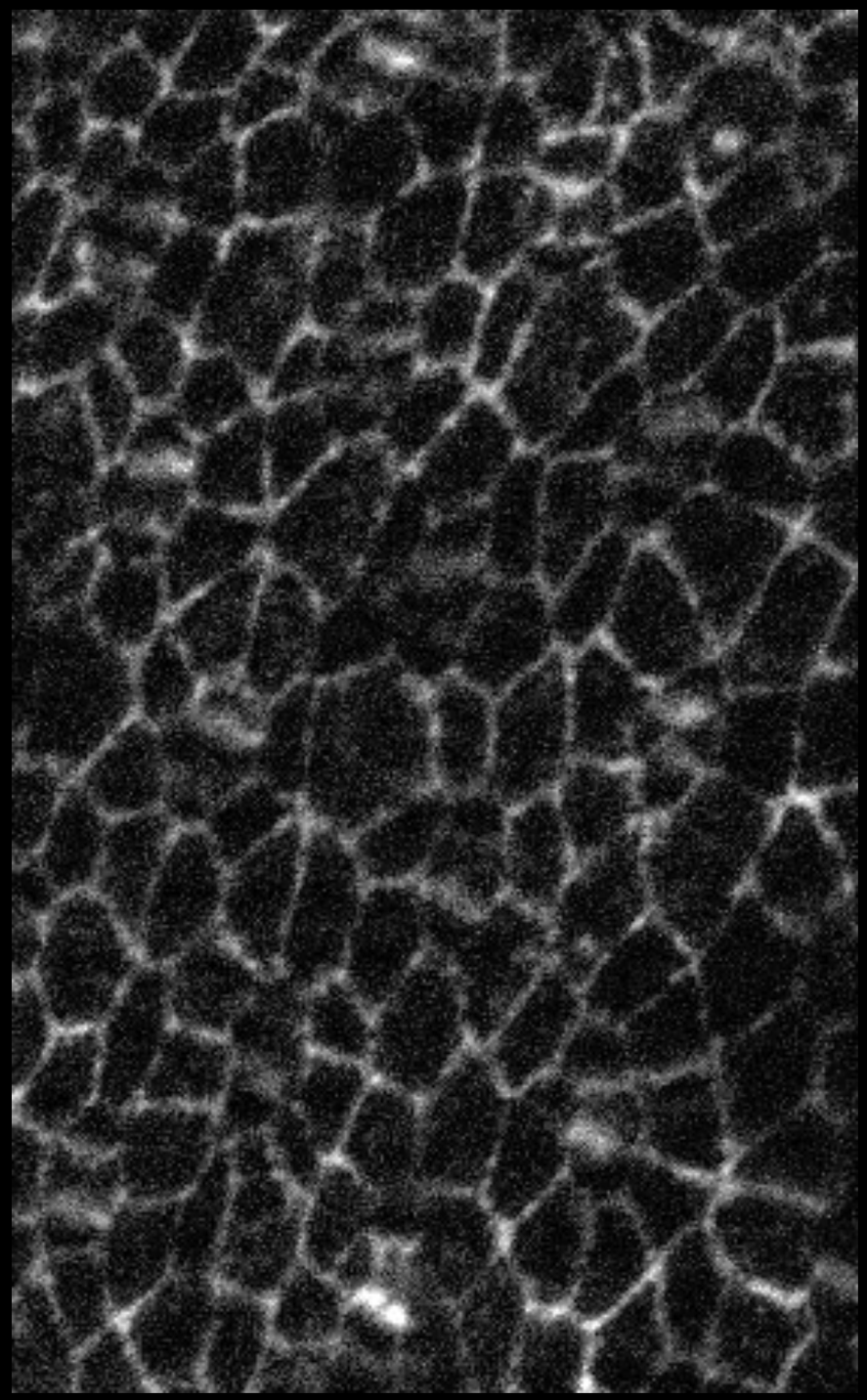


A Moving Wave of Morphogenesis and Differentiation

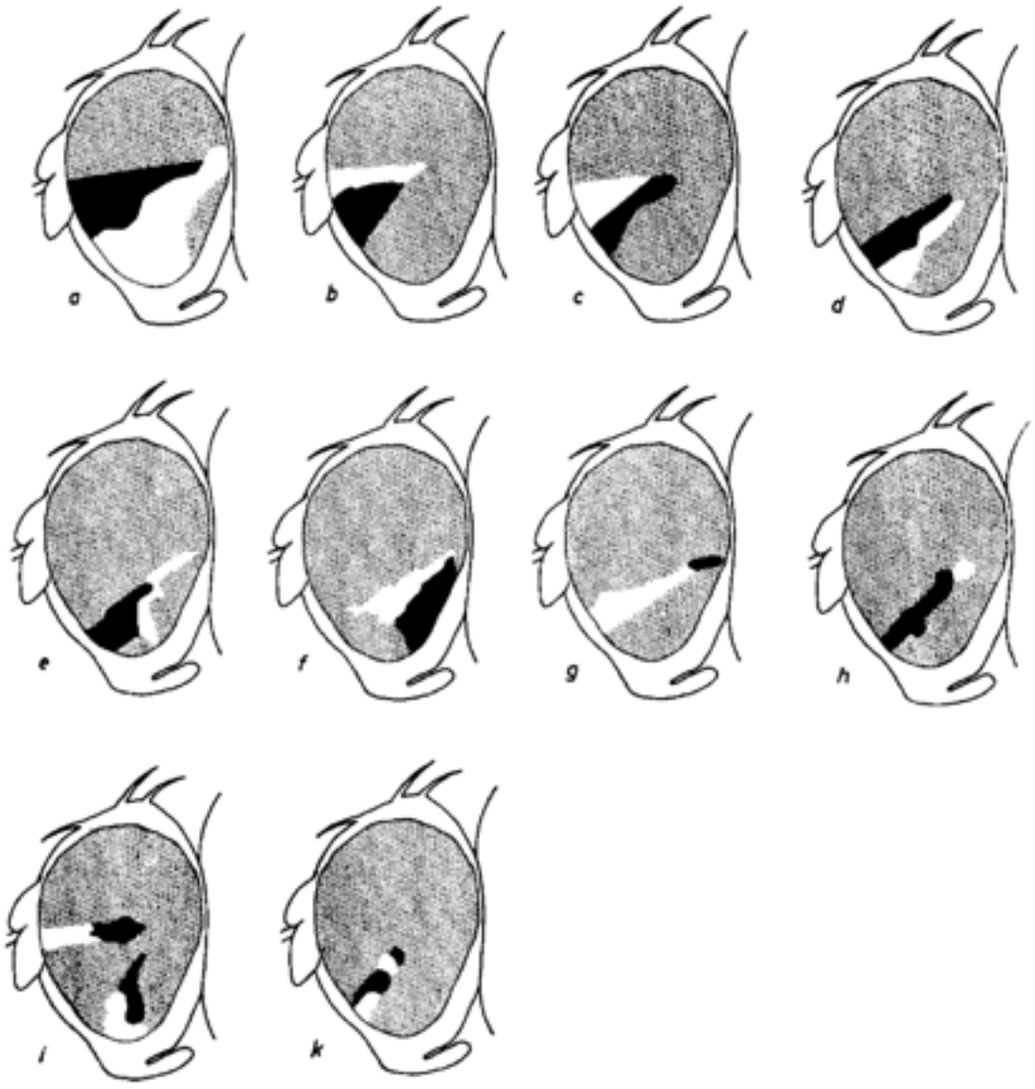


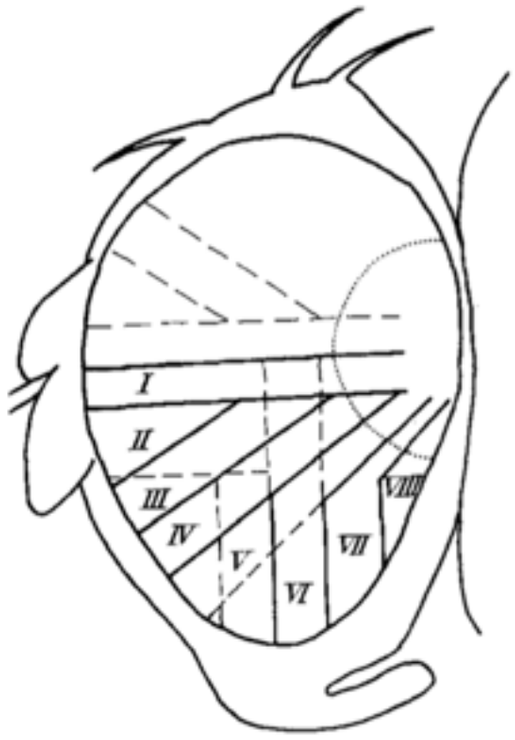


Cell Pattern After Most Growth Has Terminated



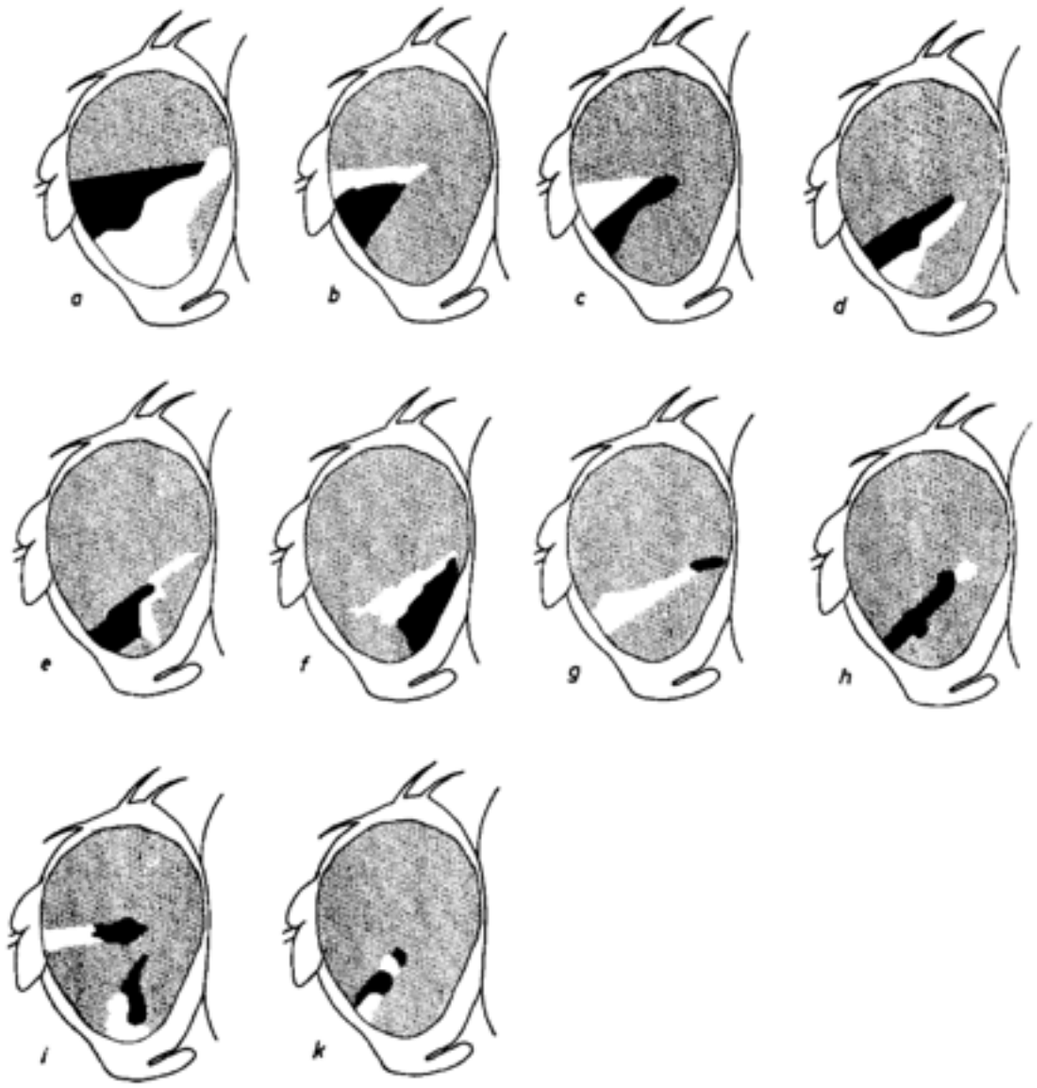
Typical Patterns of Clonal Lineage Traced Beginning 48hr AEL



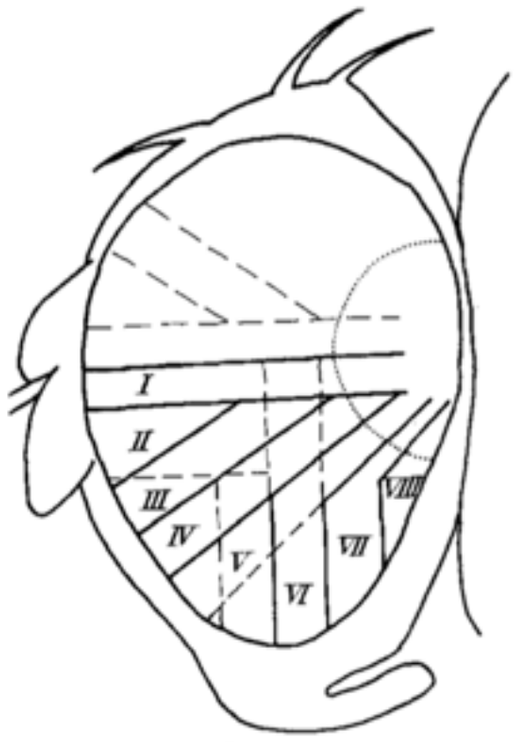


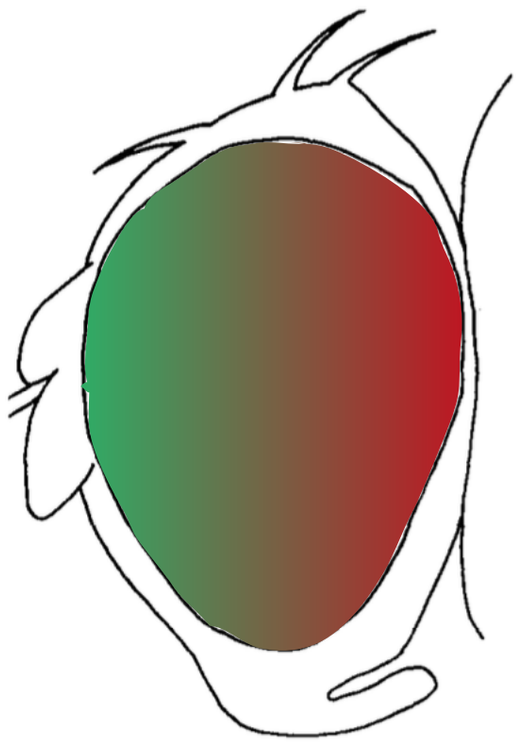
HJ Becker (1957) Mol Gen Genet

Typical Patterns of Clonal Lineage Traced Beginning 48hr AEL



HJ Becker (1957) Mol Gen Genet



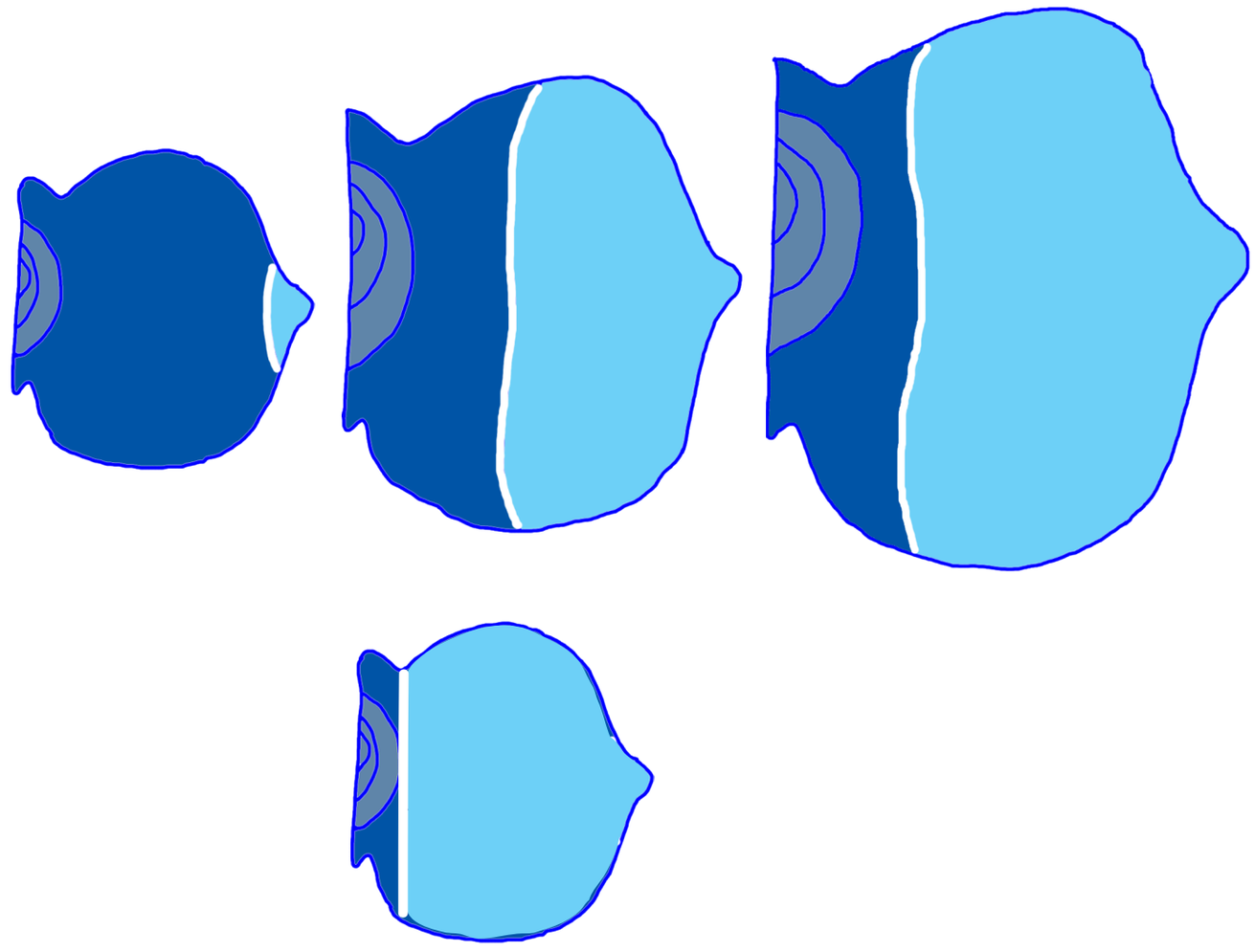


Number of Cell Divisions

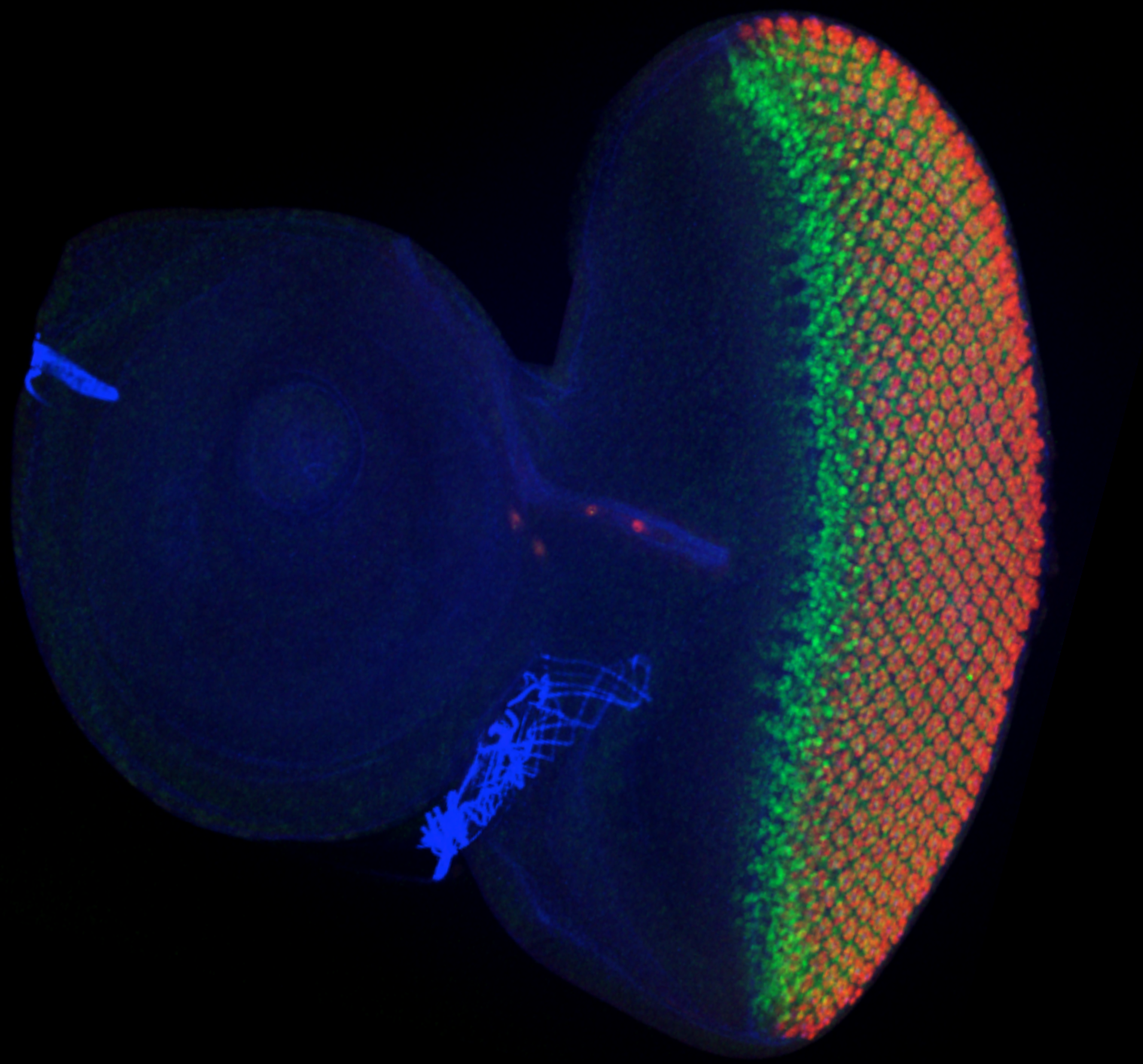
High Low

Furrow moves ~ 2 cell diameters / hr

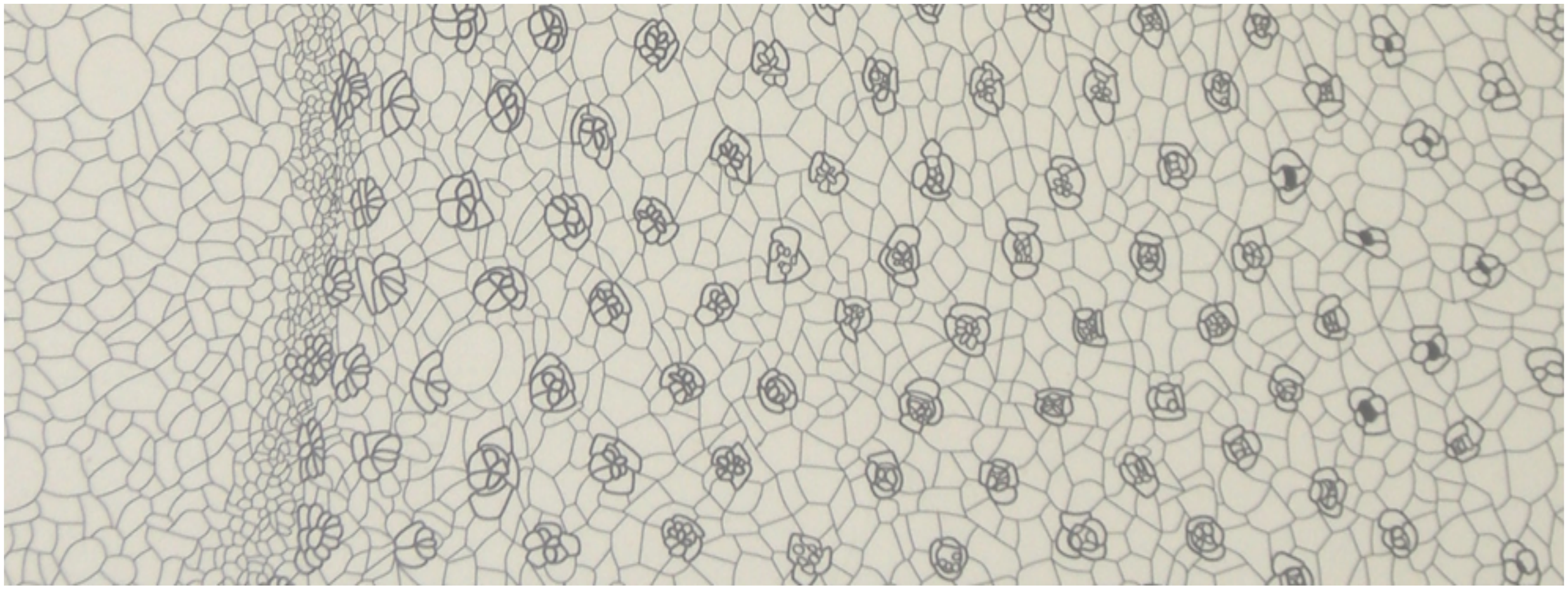
Average cell cycle time = 8 - 10 hr



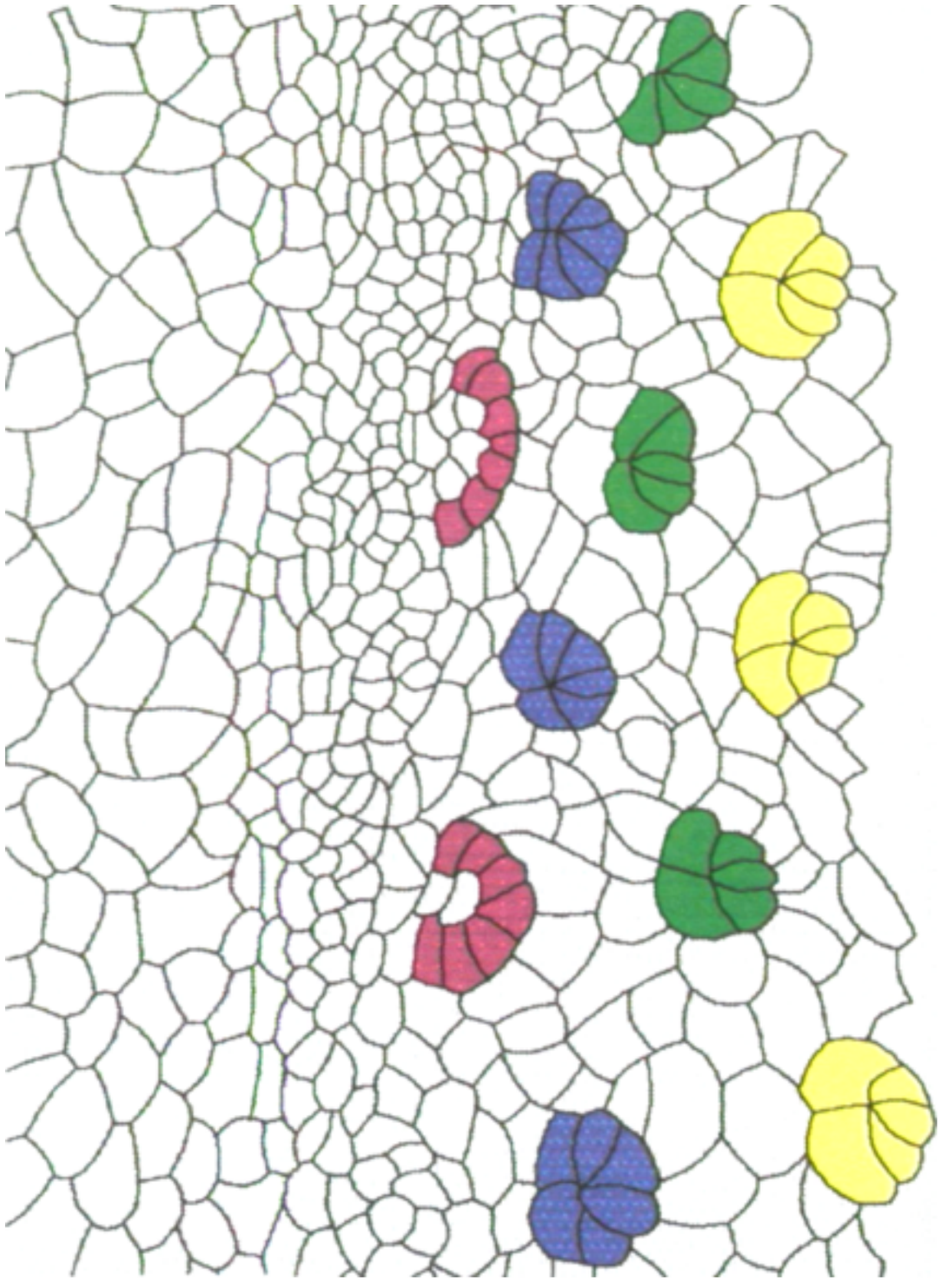
A Moving Wave of Morphogenesis and Differentiation



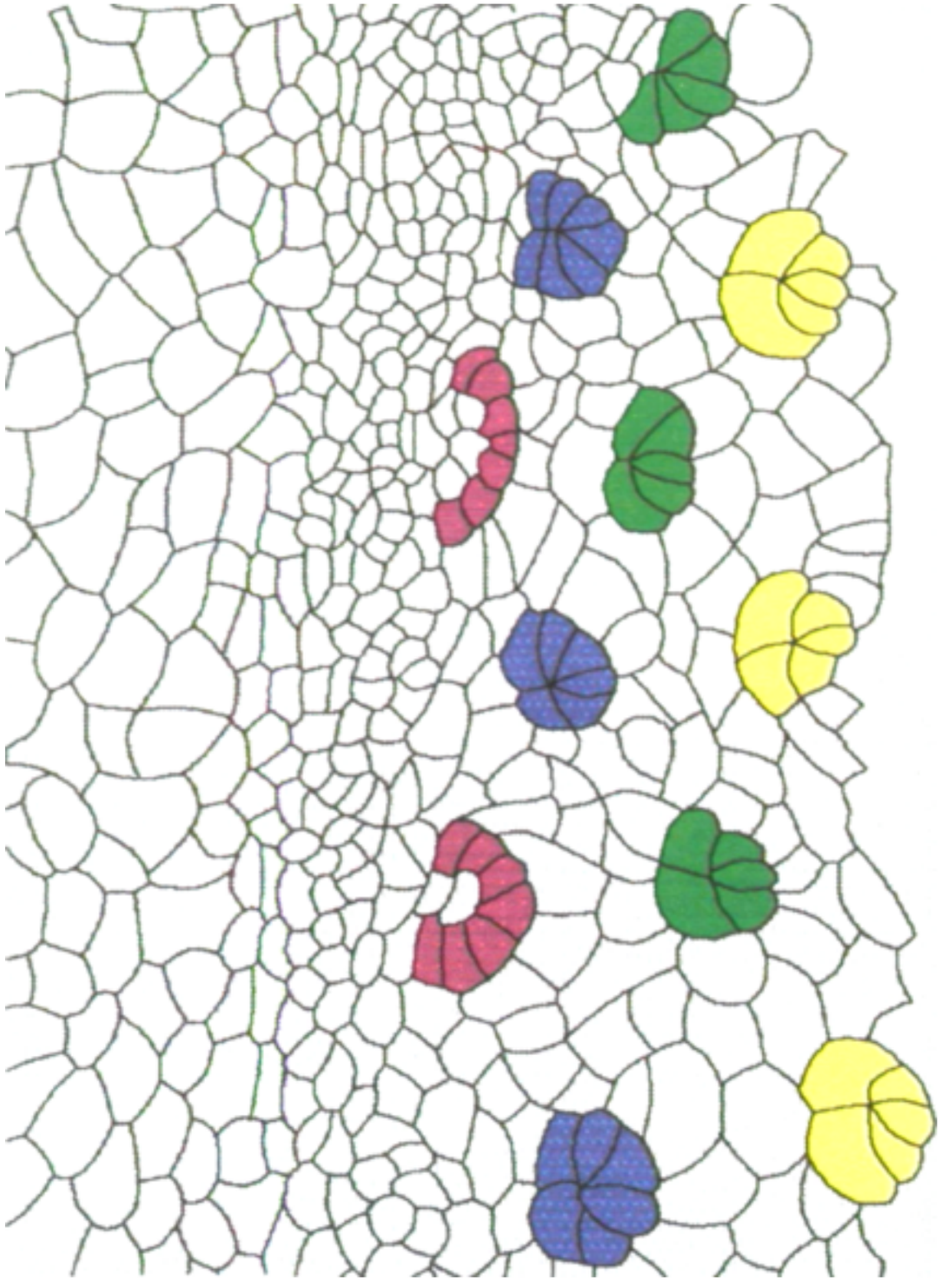
A Moving Wave of Morphogenesis and Differentiation

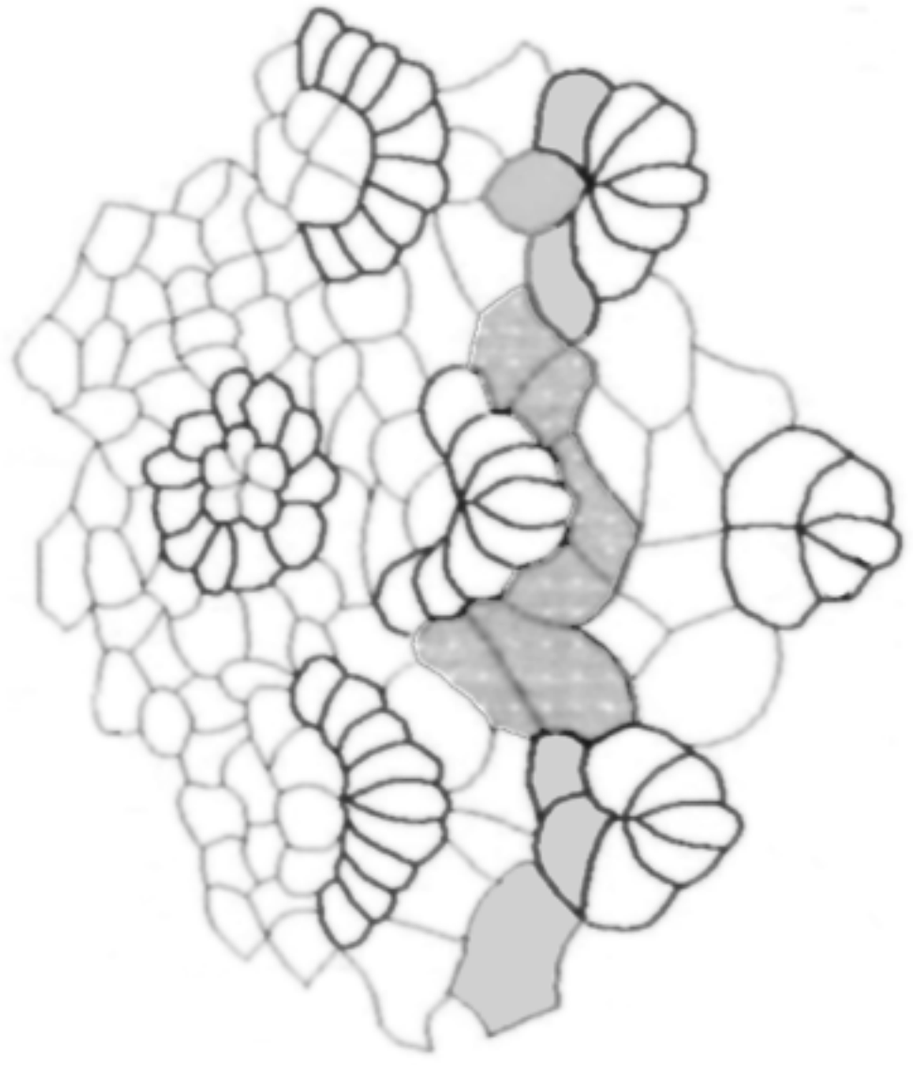


Wolff and Ready (1991)

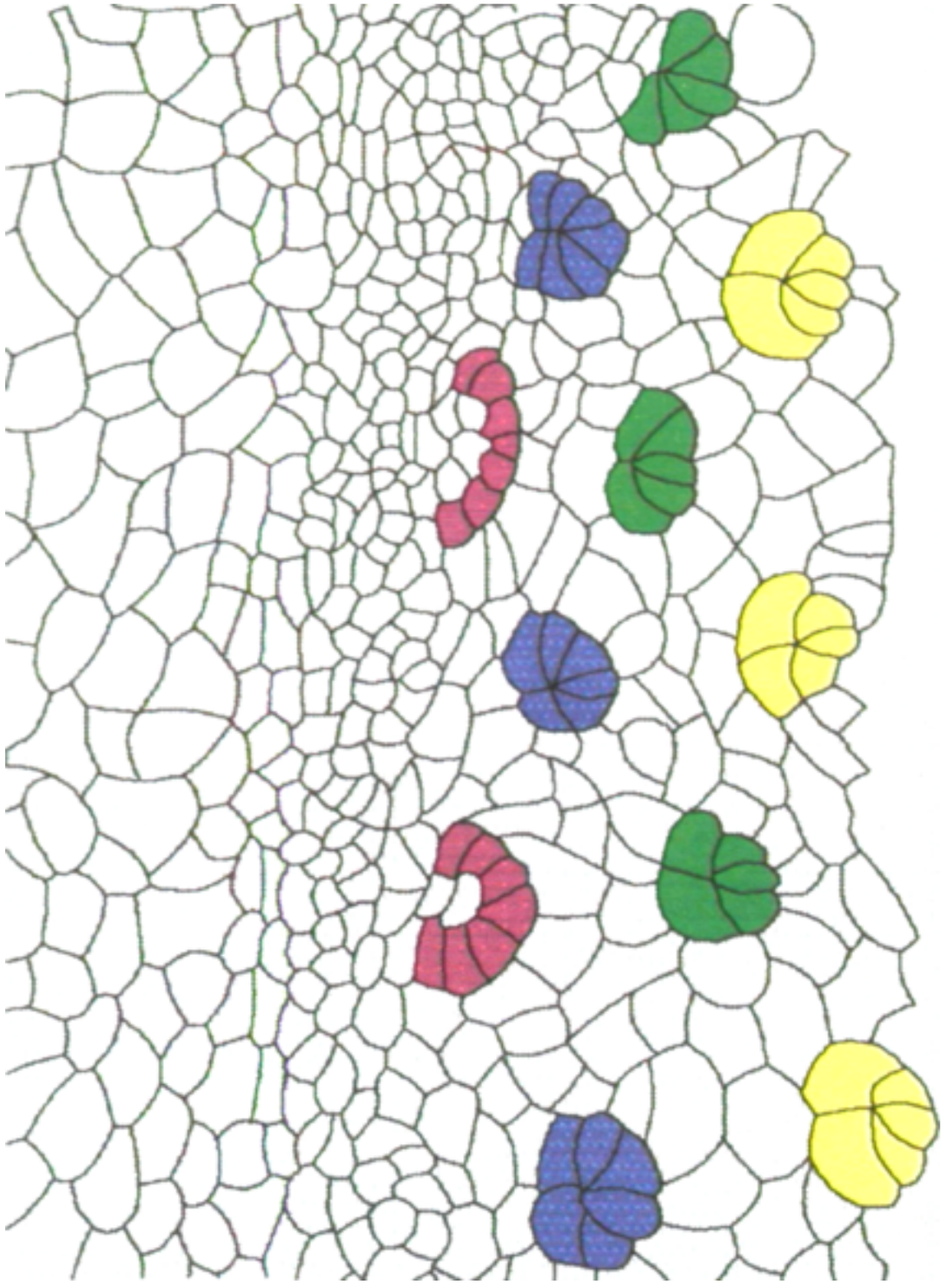


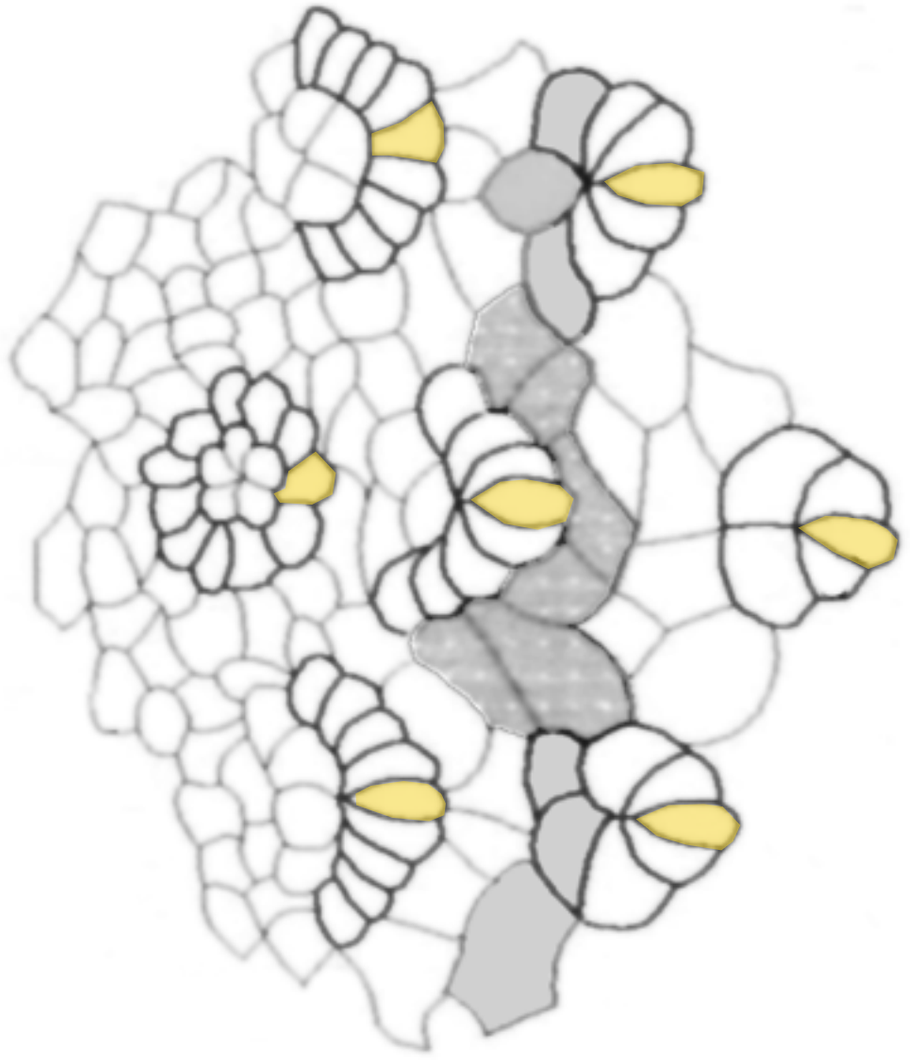
Wolff and Ready (1991)





Wolff and Ready (1991)





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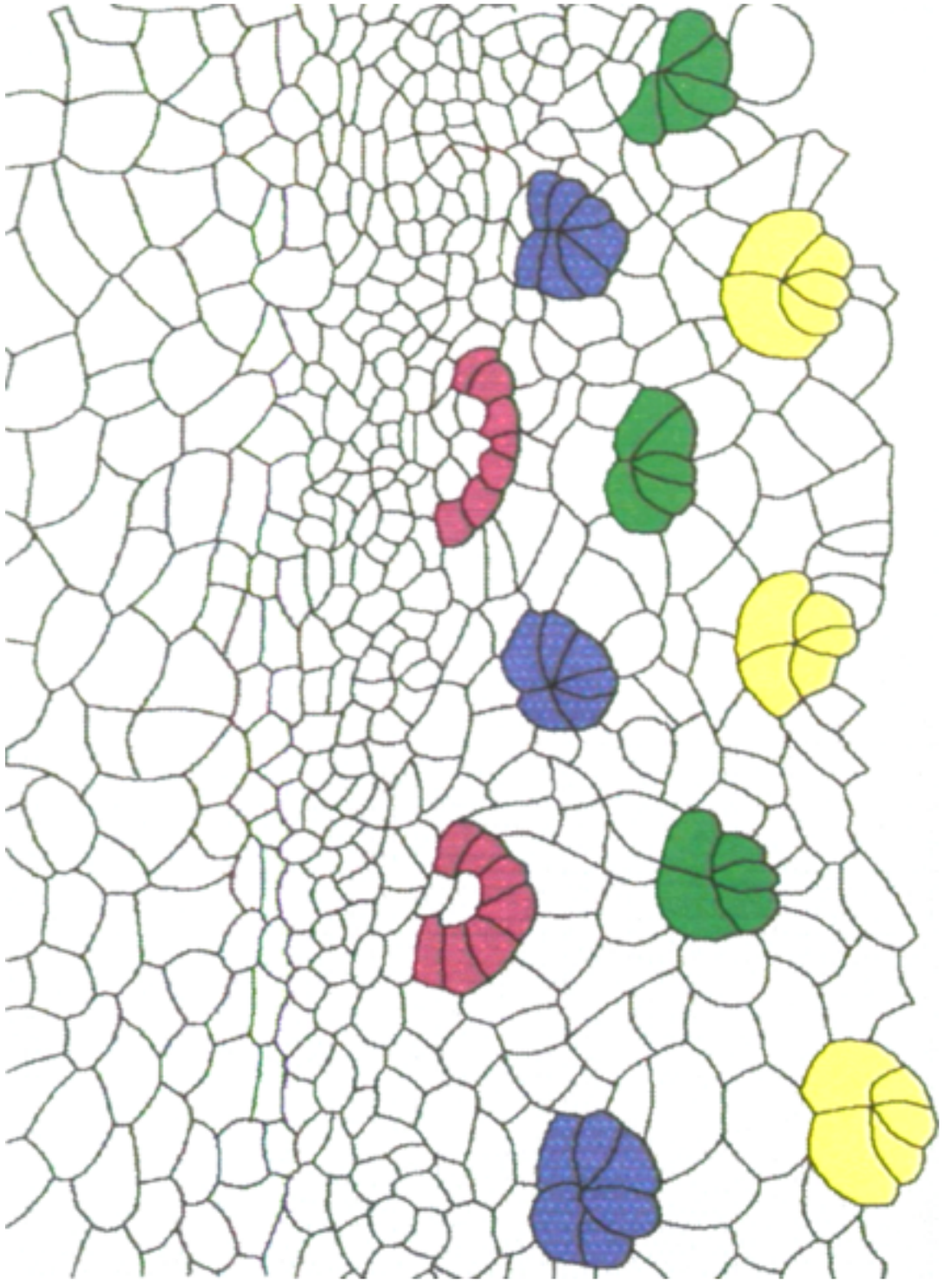
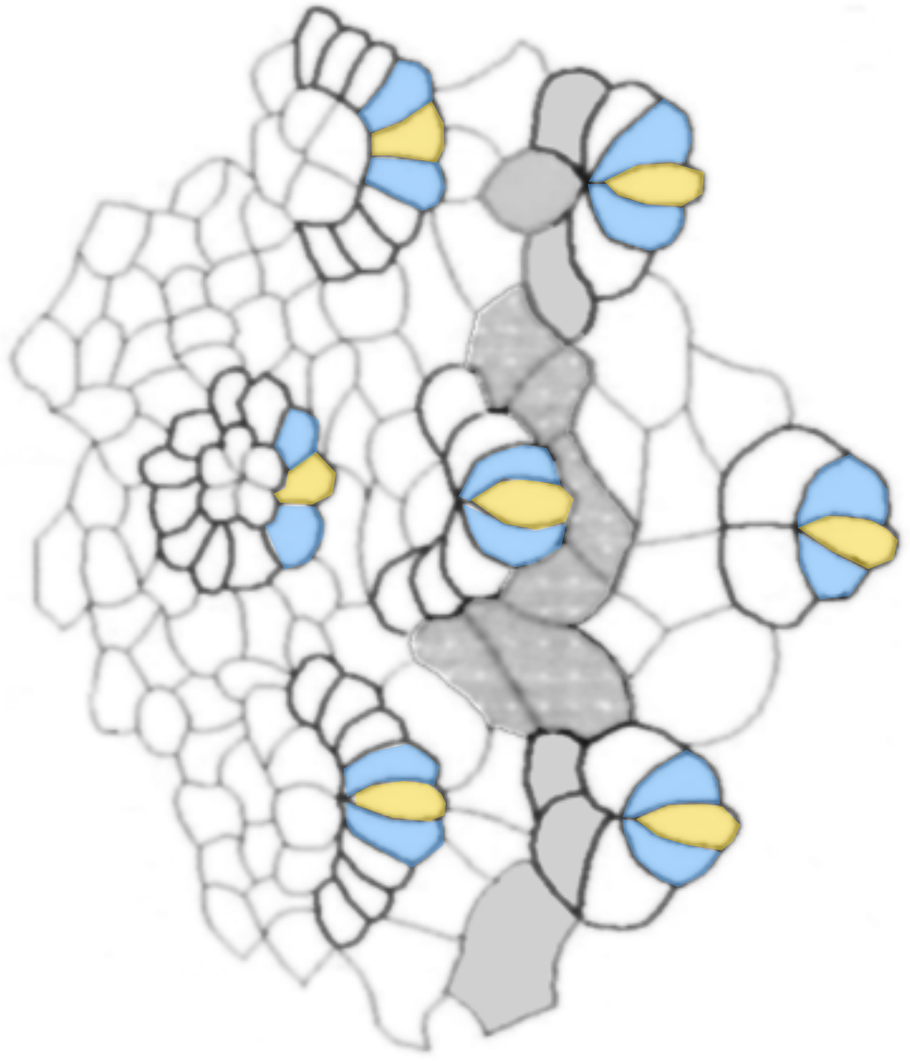
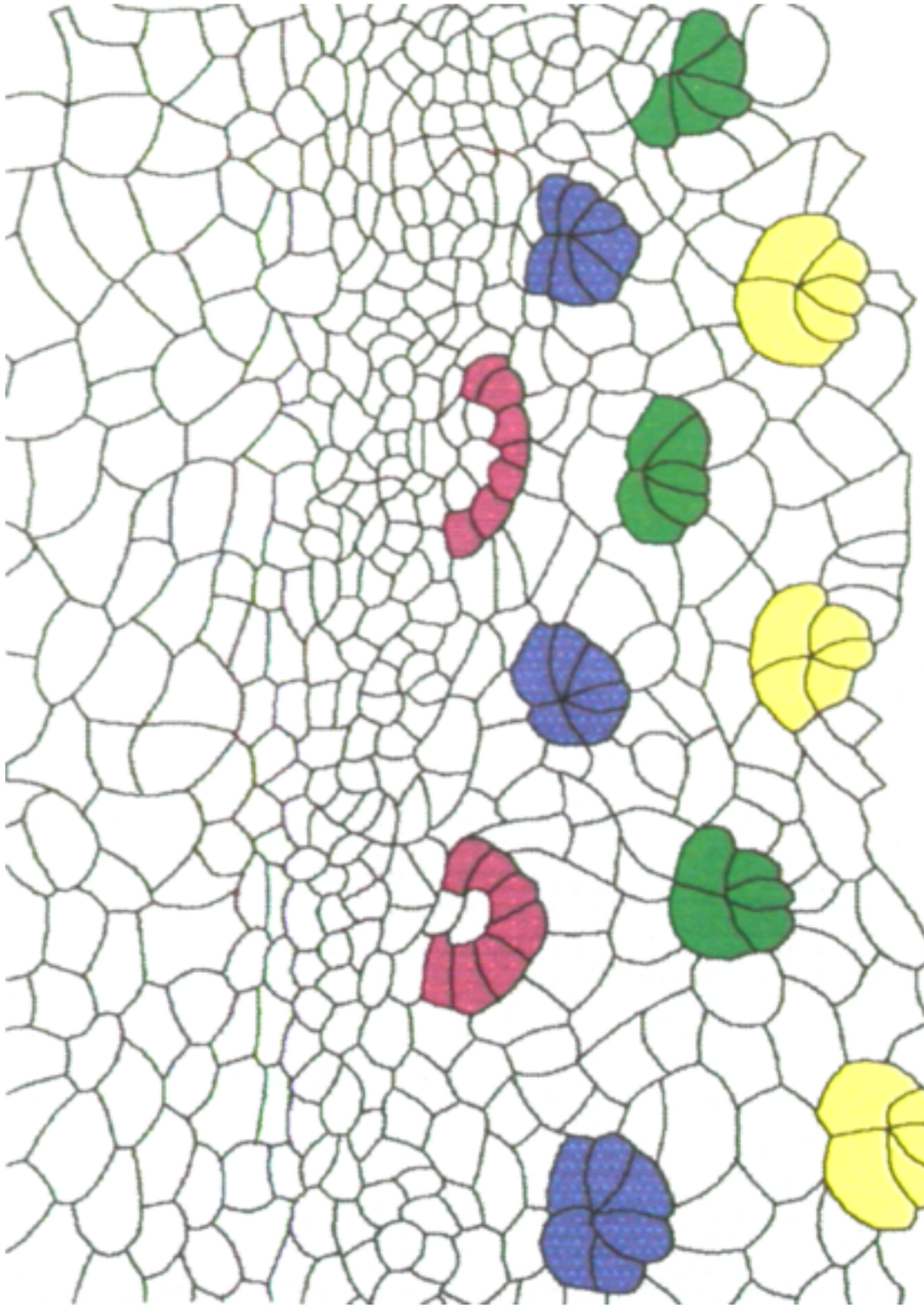
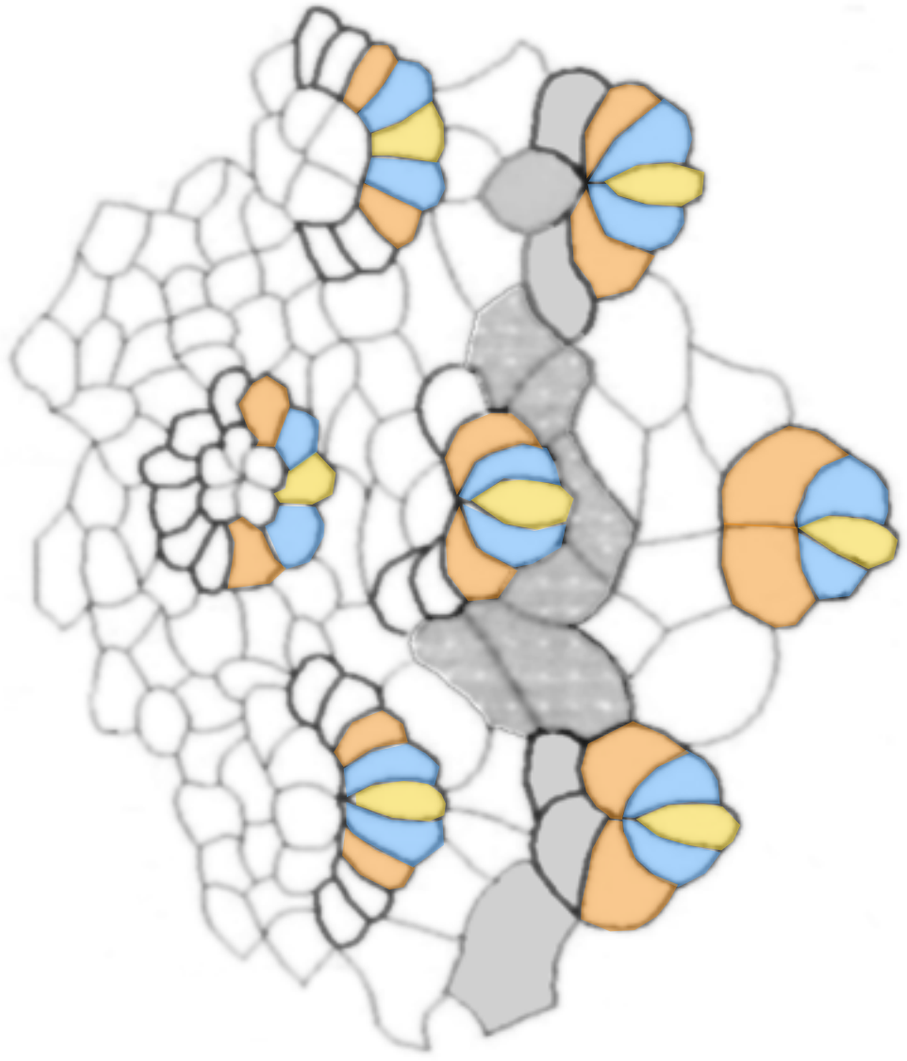


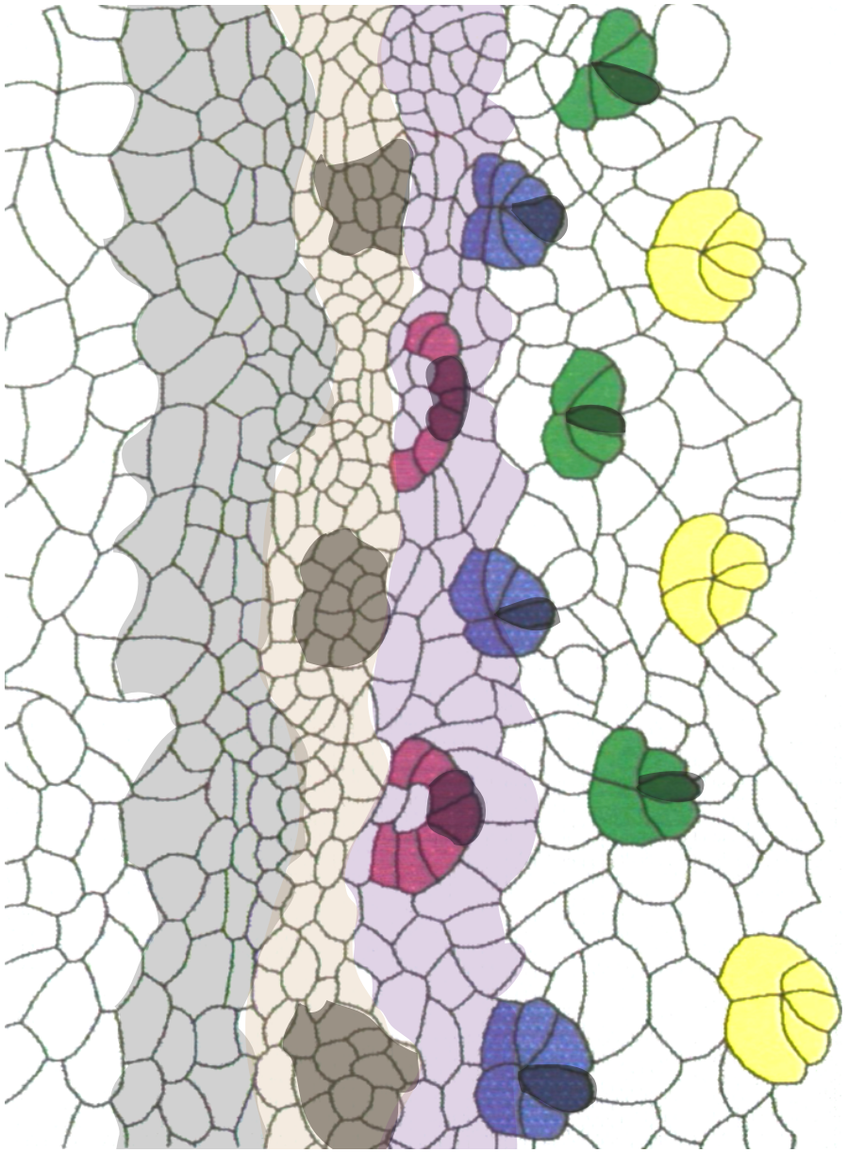


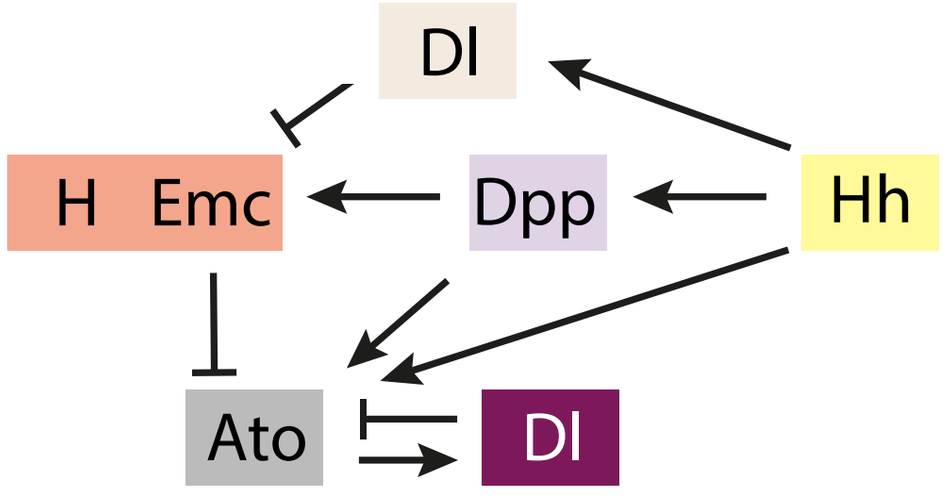
Wolff and Ready (1991)

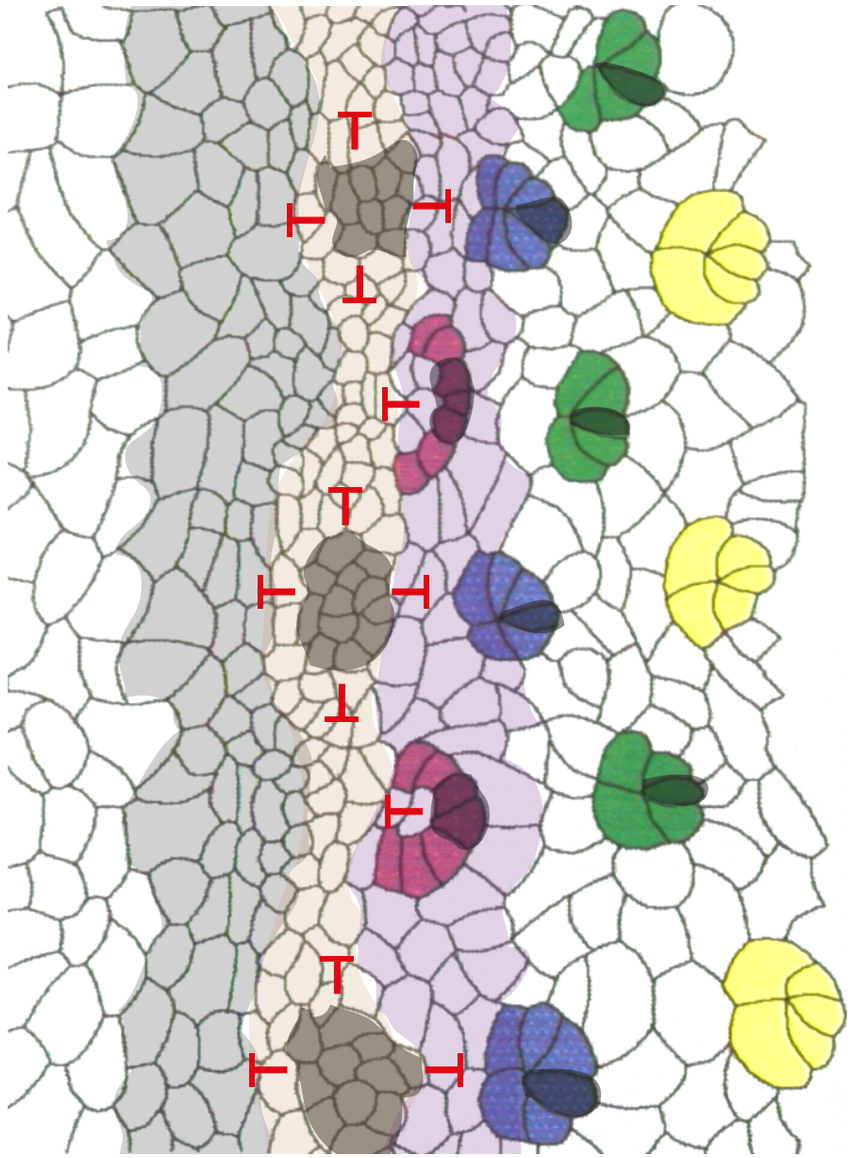


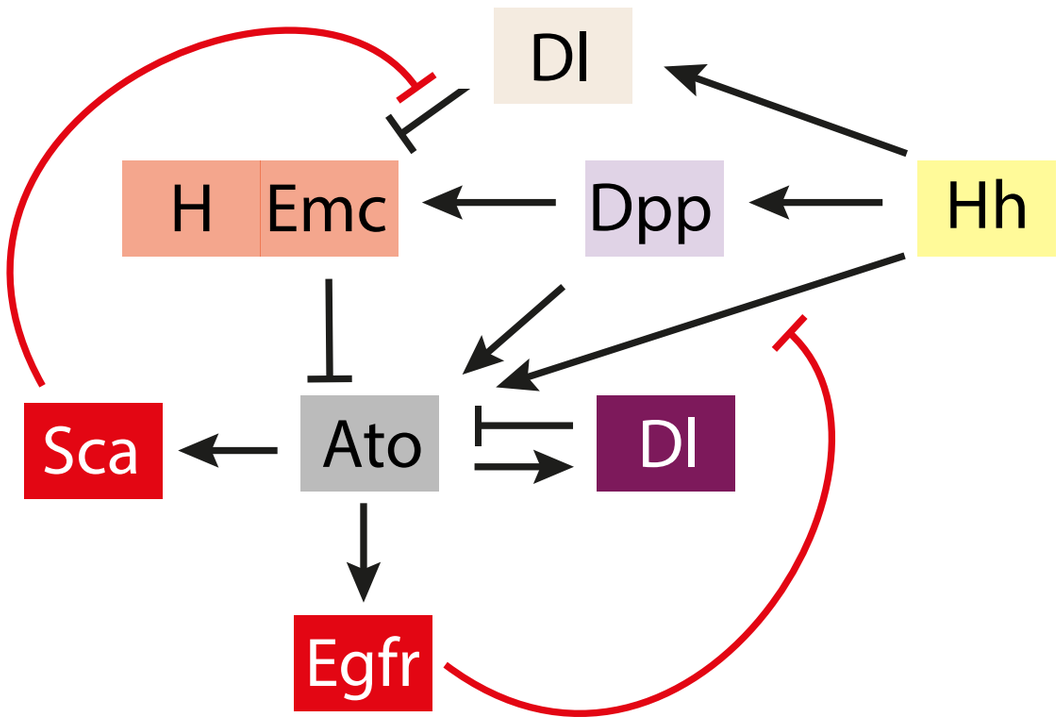


Wolff and Ready (1991)

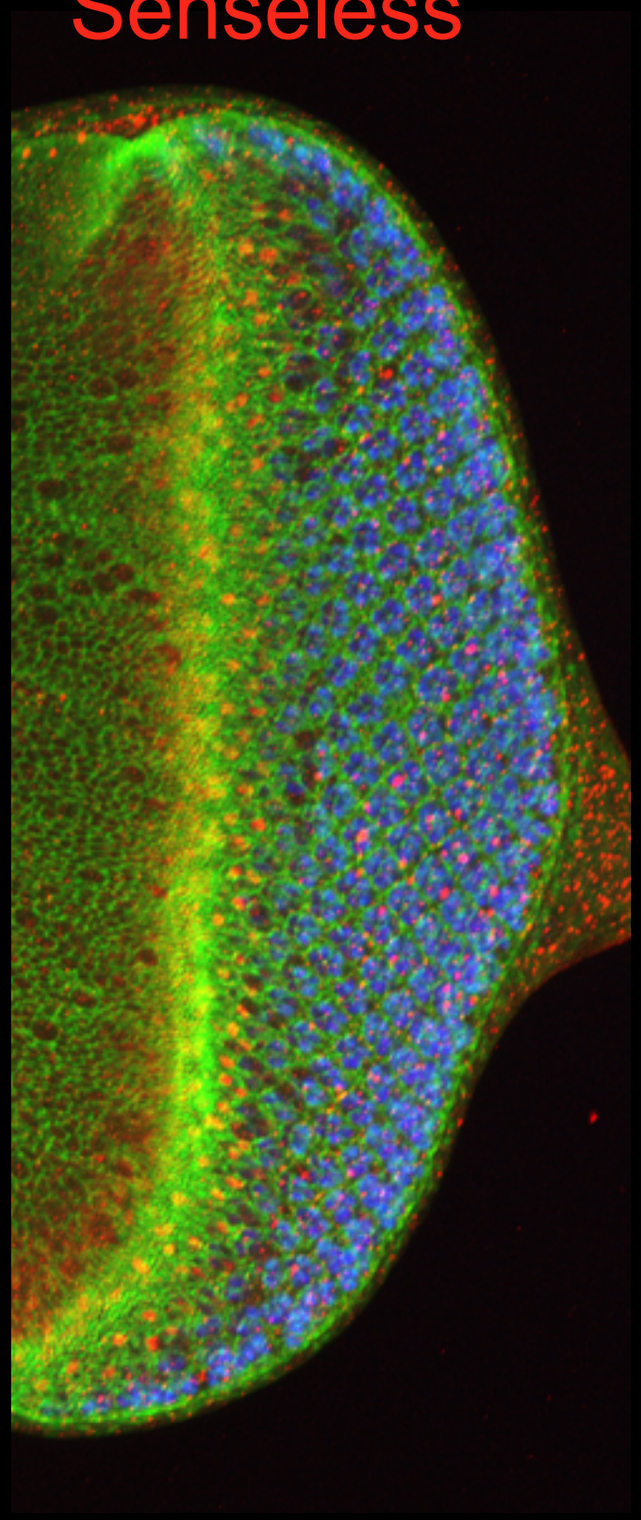



Dl
H
Emc
Dpp
Hh
Ato
Dl

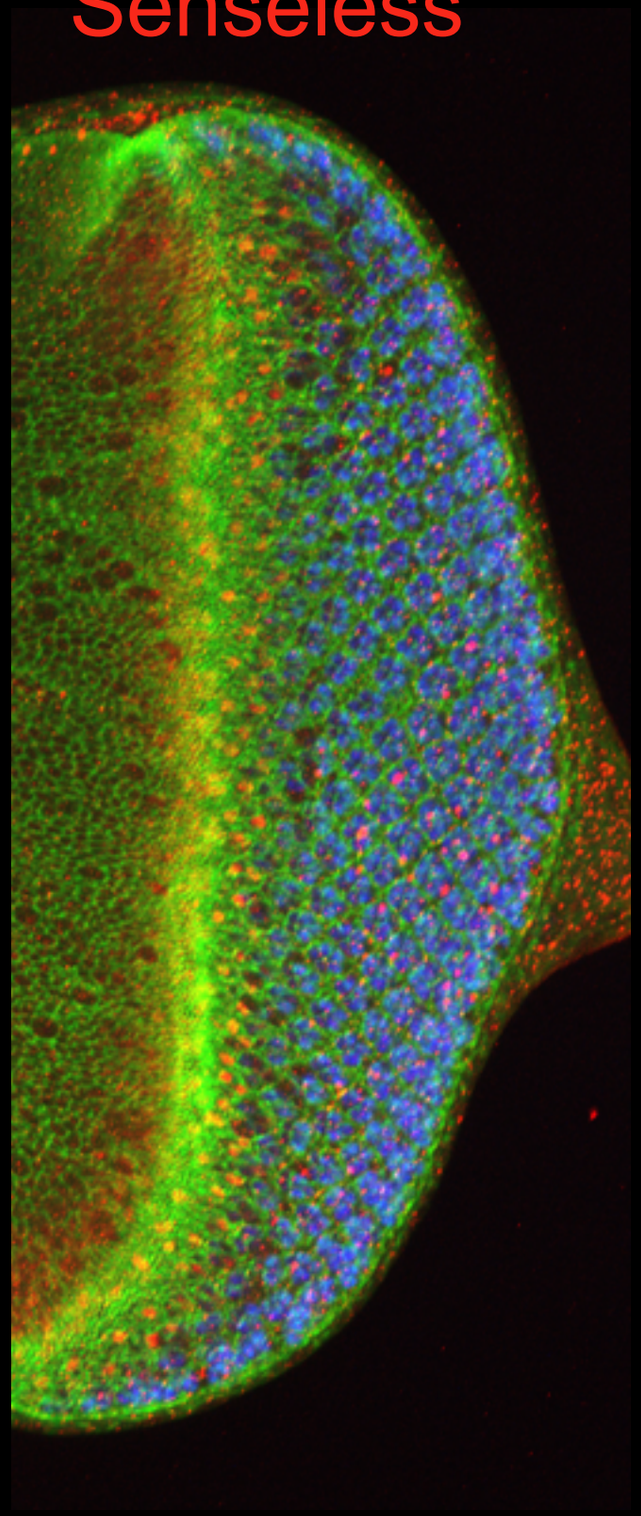



Dl
H
Emc
Dpp
Hh
Sca
Ato
Dl
Egfr

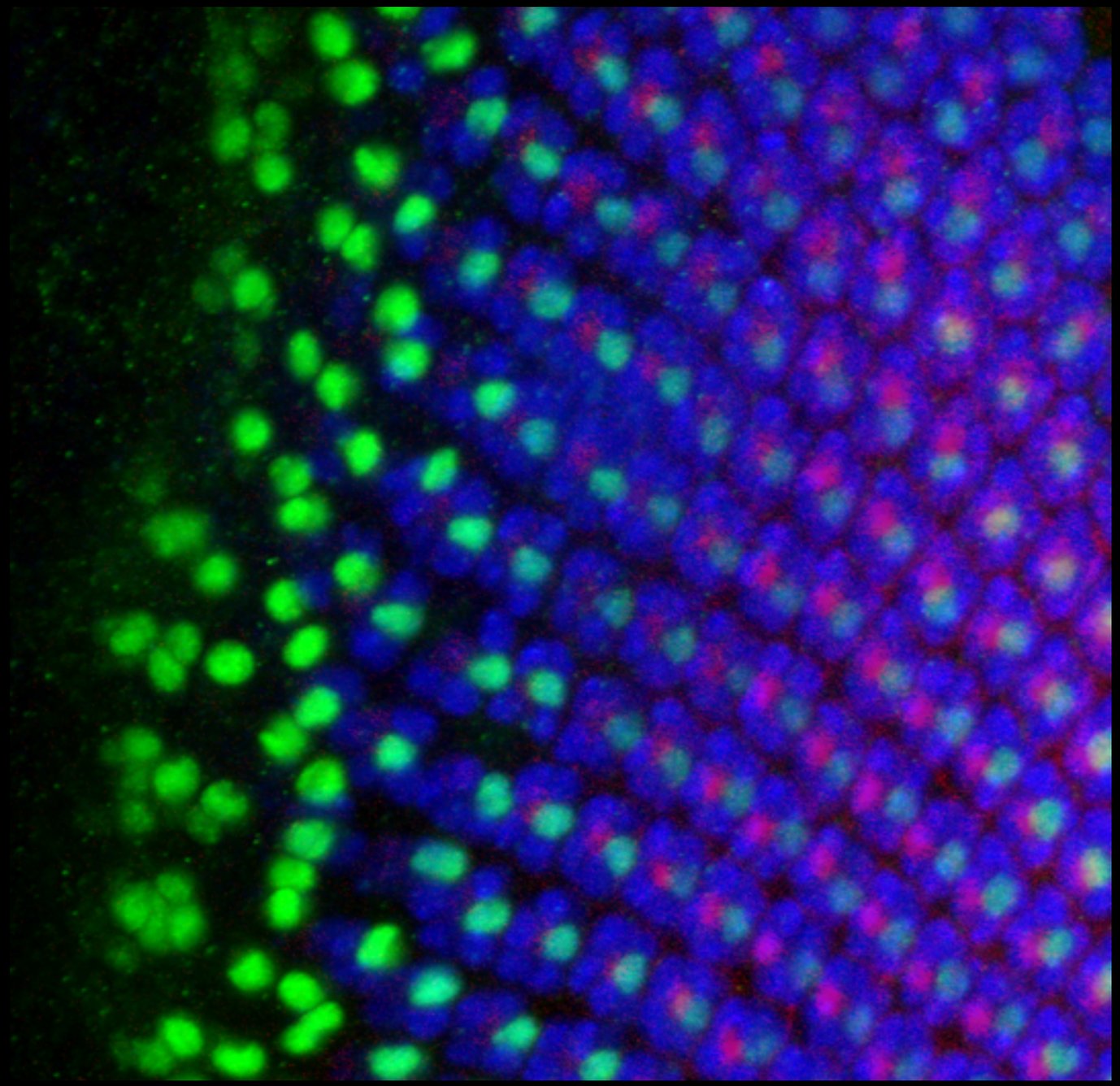
Beta-Catenin
Photoreceptors
Senseless

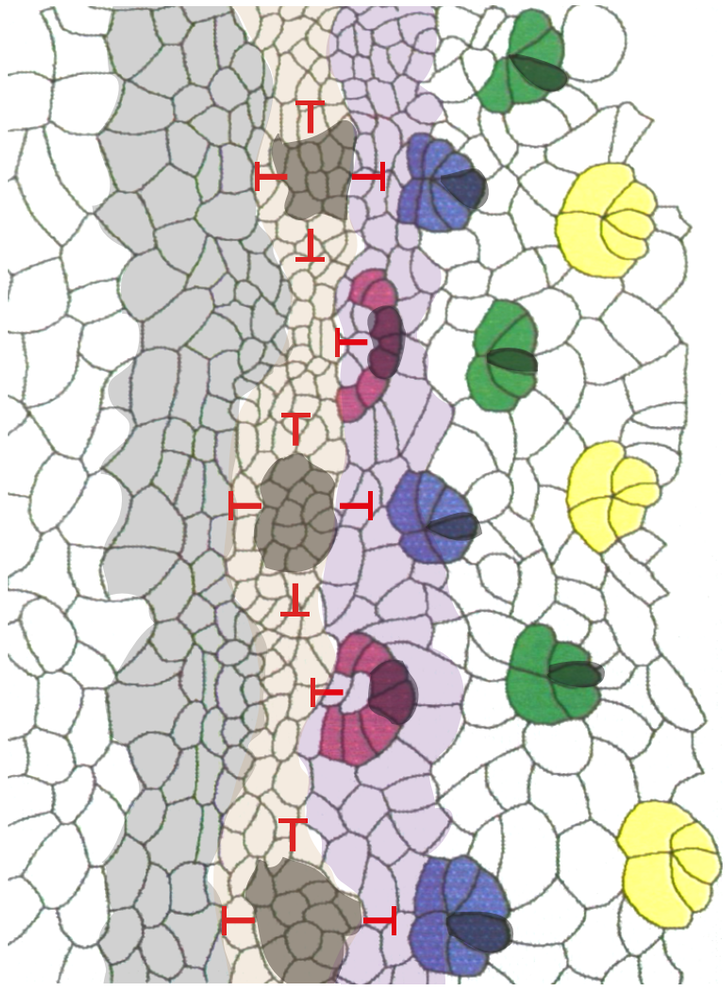


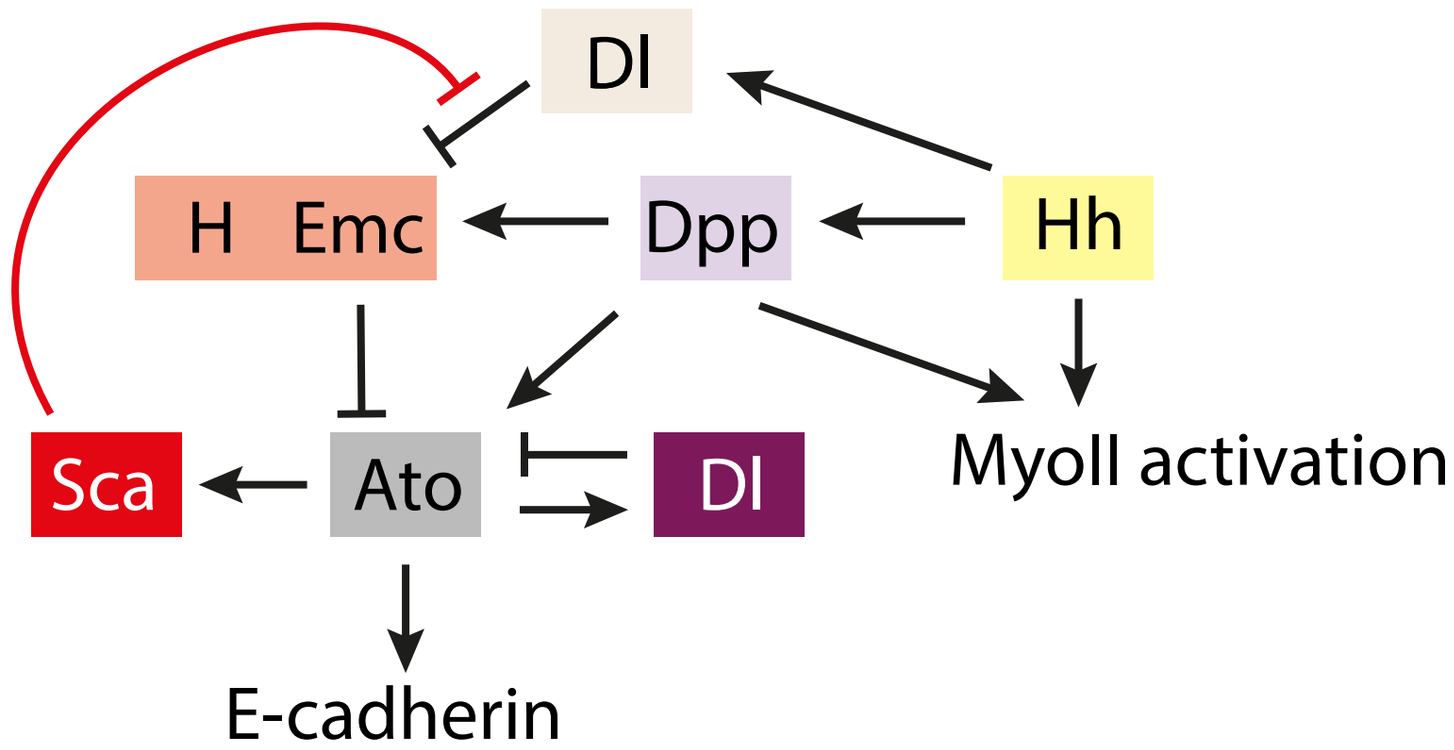
Beta-Catenin
Photoreceptors
Senseless

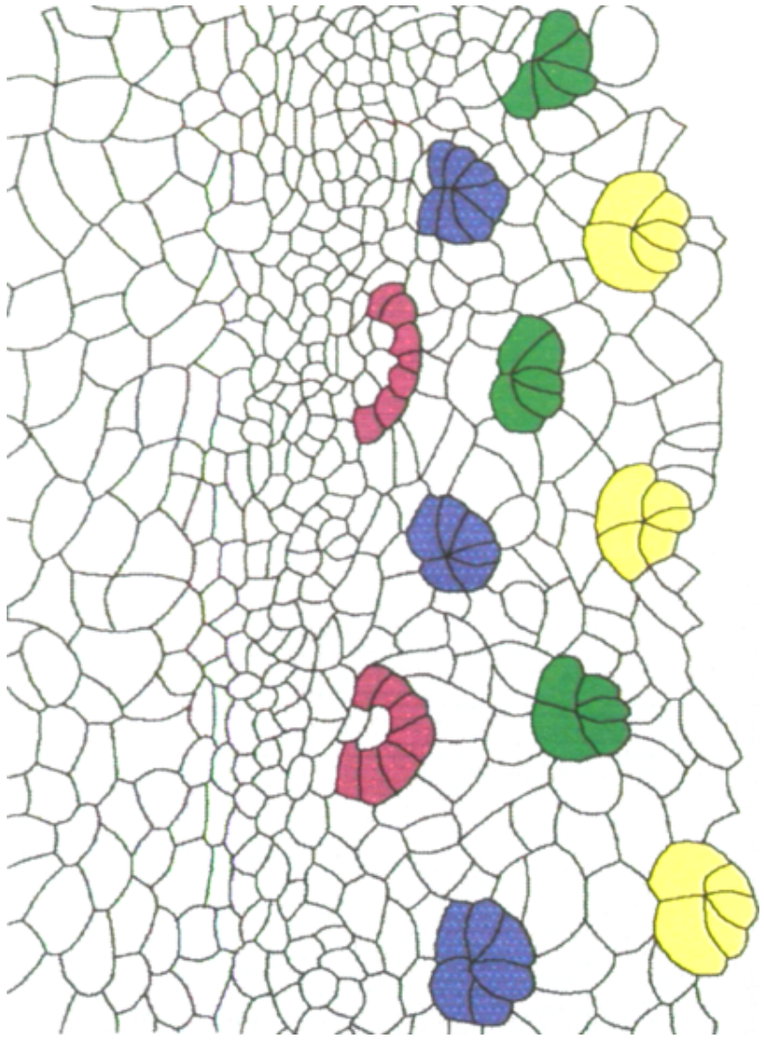


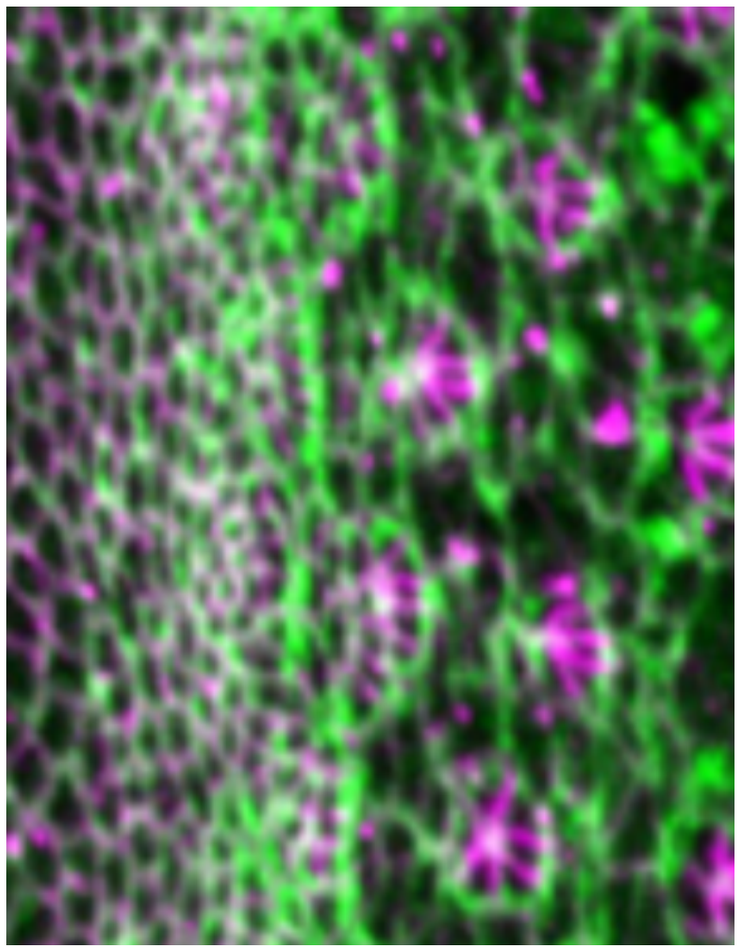
Photoreceptors
Senseless





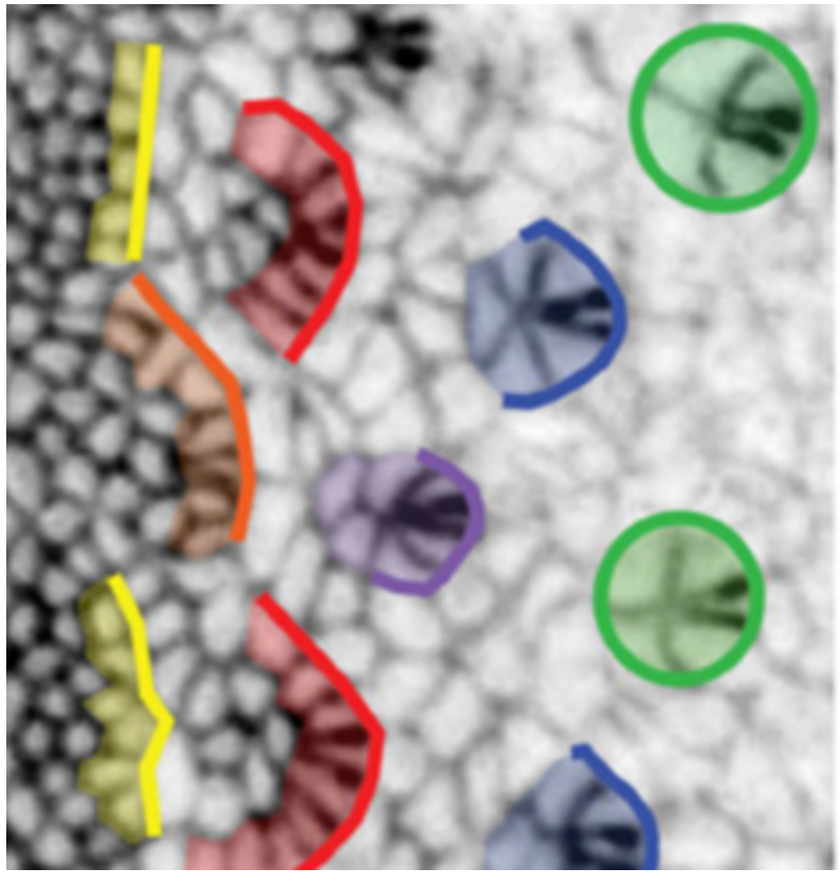

Dl
H Emc
Dpp
Hh
Sca
Ato
Dl
Myoll activation
E-cadherin



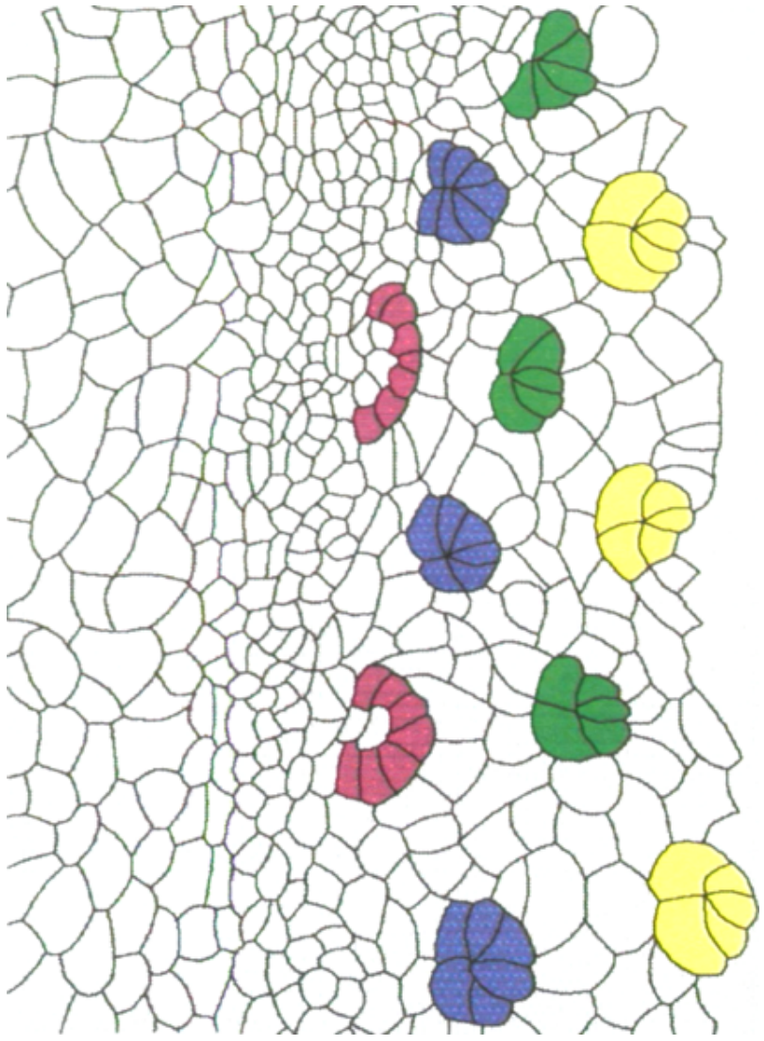


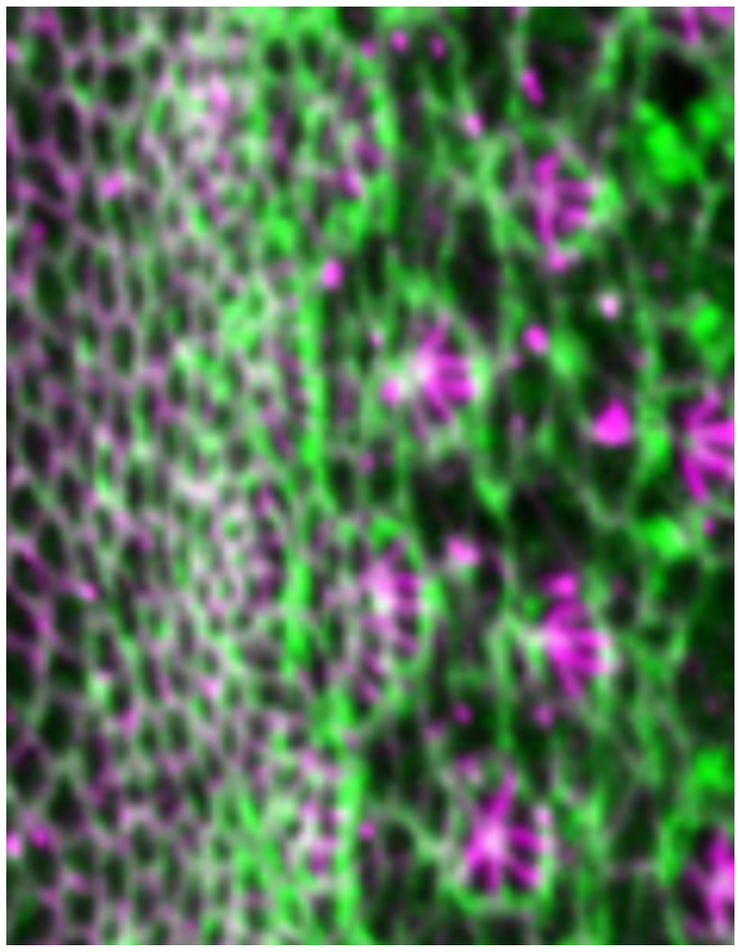
E-cadherin

Sqh-GFP



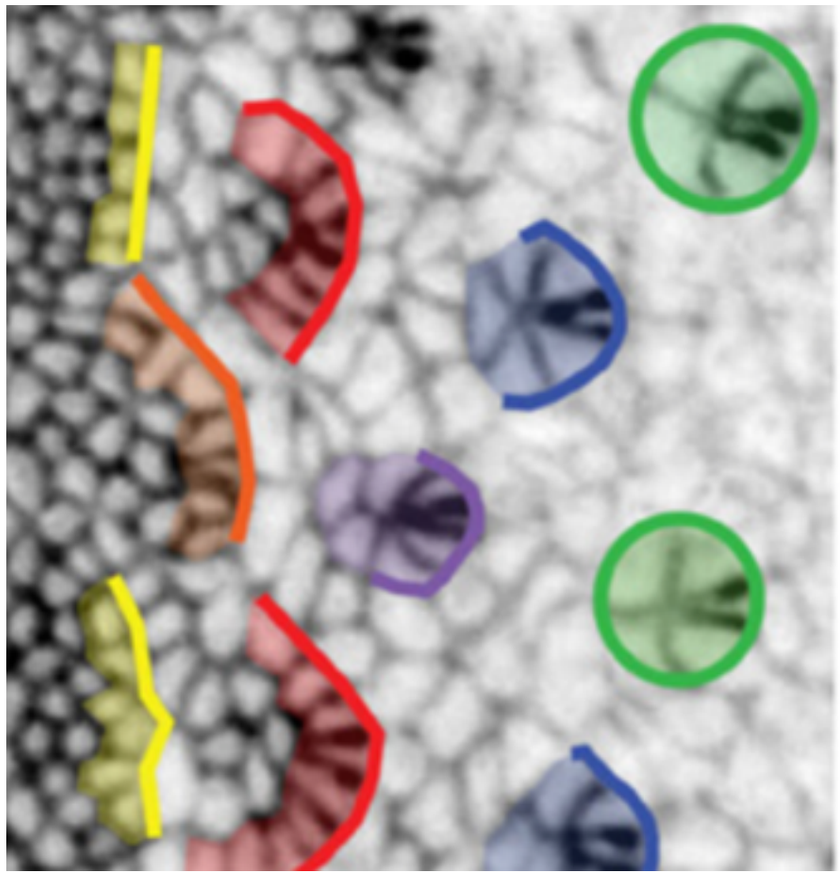
Escudero et al (2007)



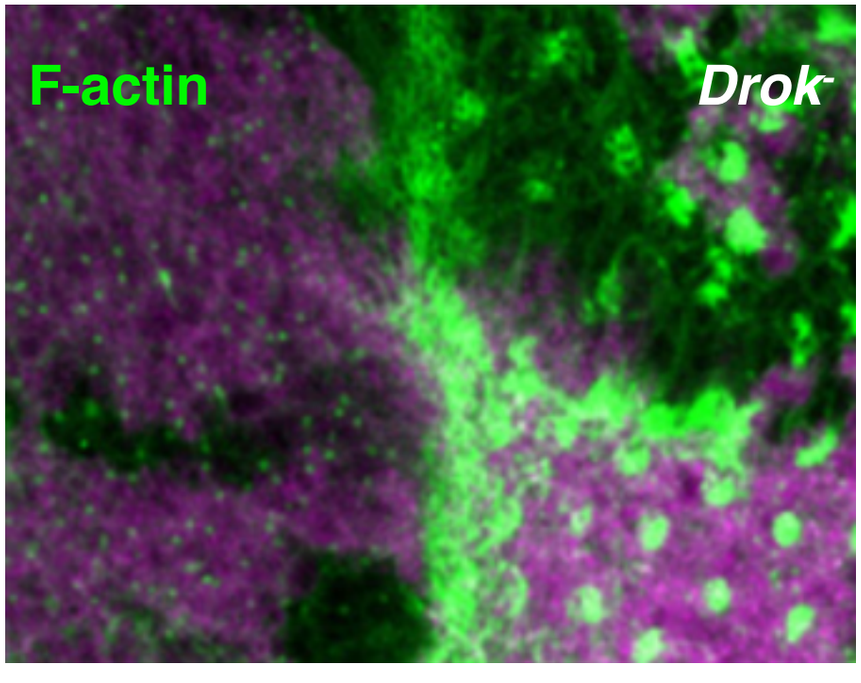


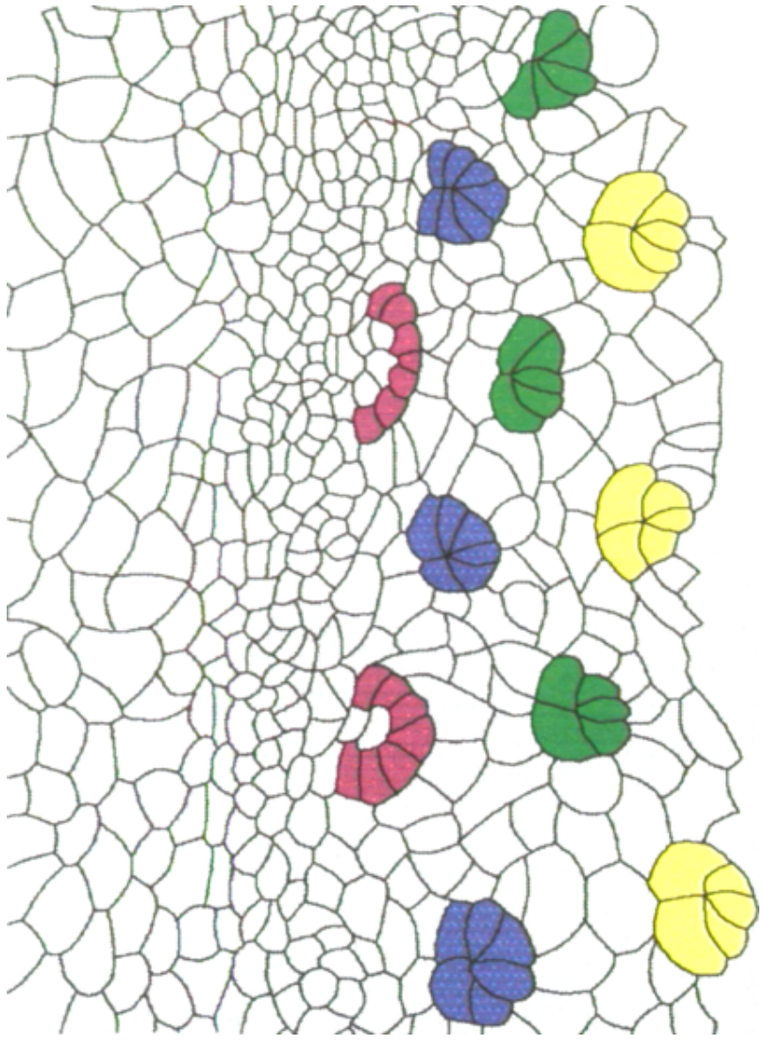
E-cadherin

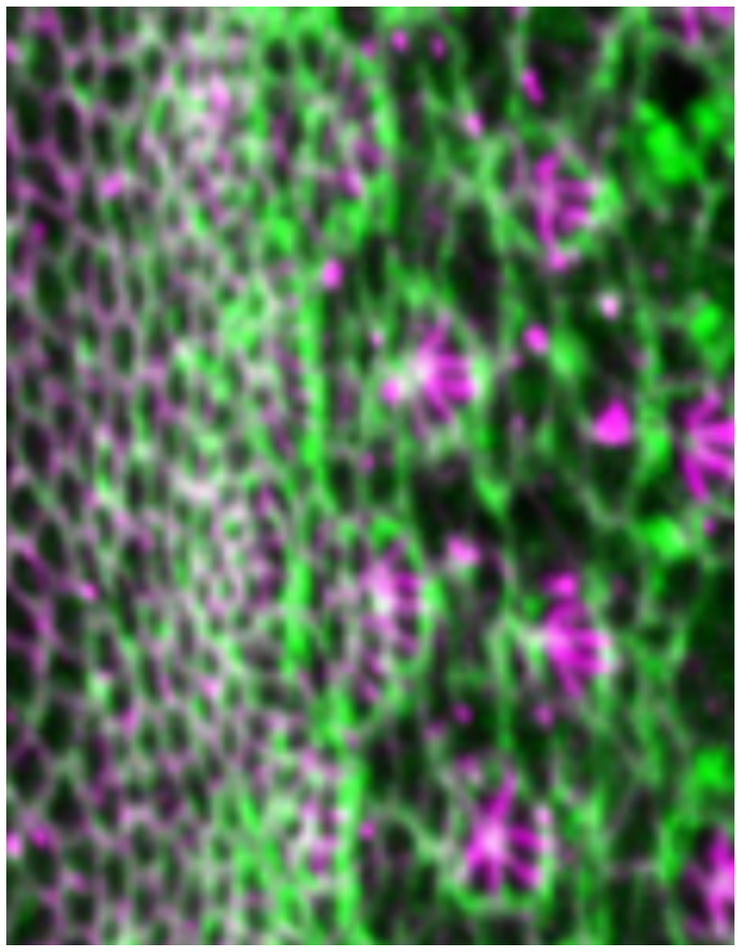
Sqh-GFP



Escudero et al (2007)

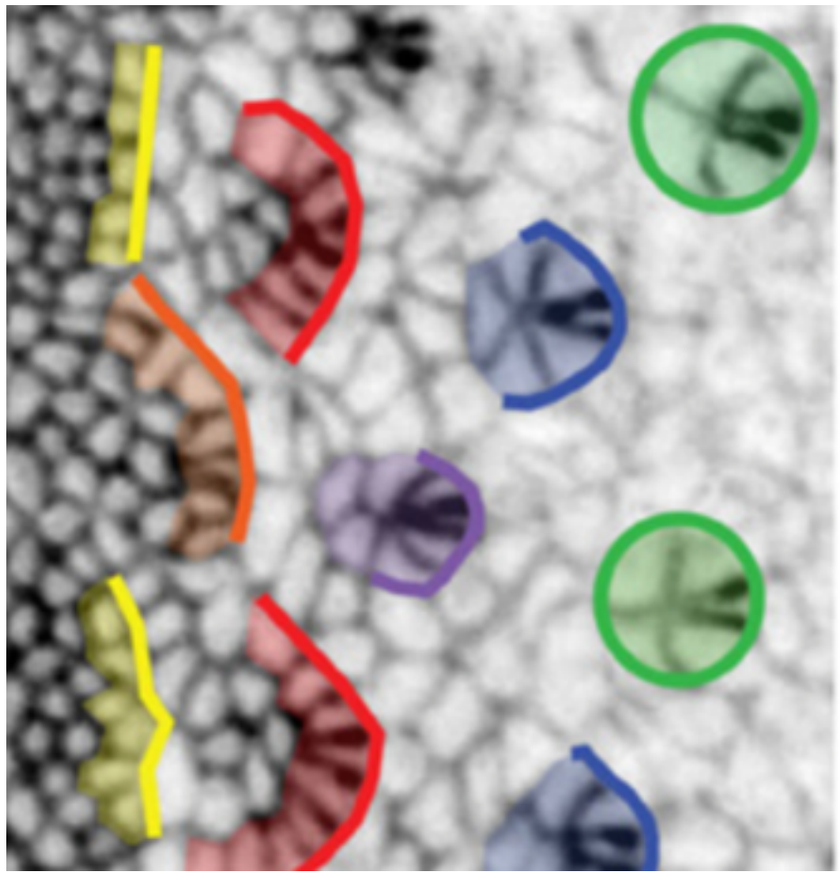






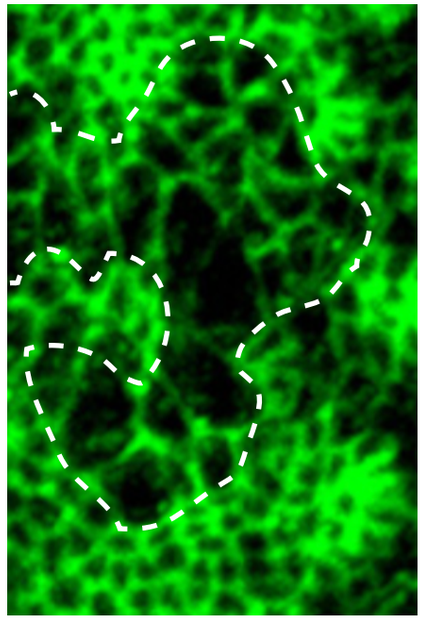
E-cadherin

Sqh-GFP

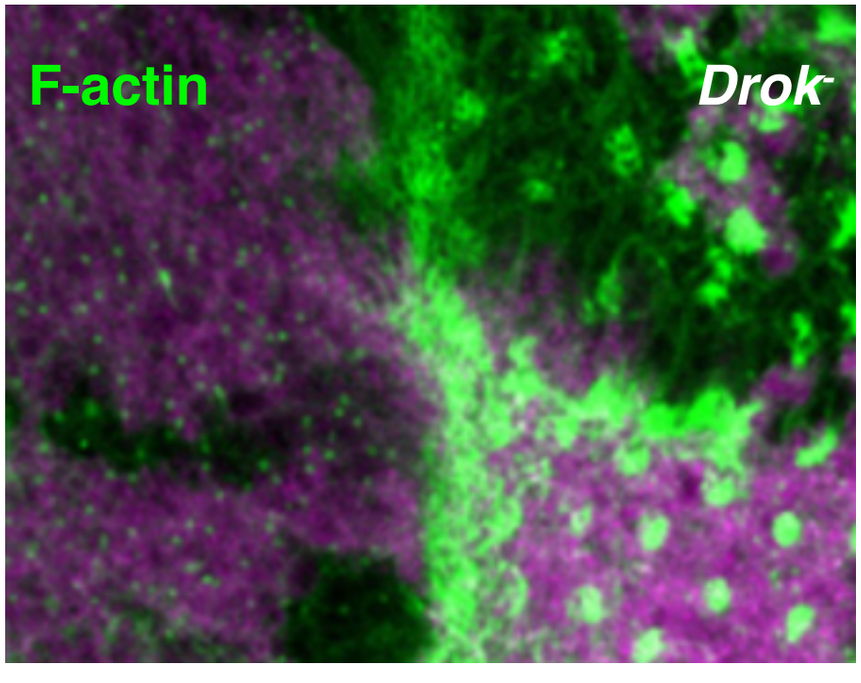


Escudero et al (2007)

Myo-DN

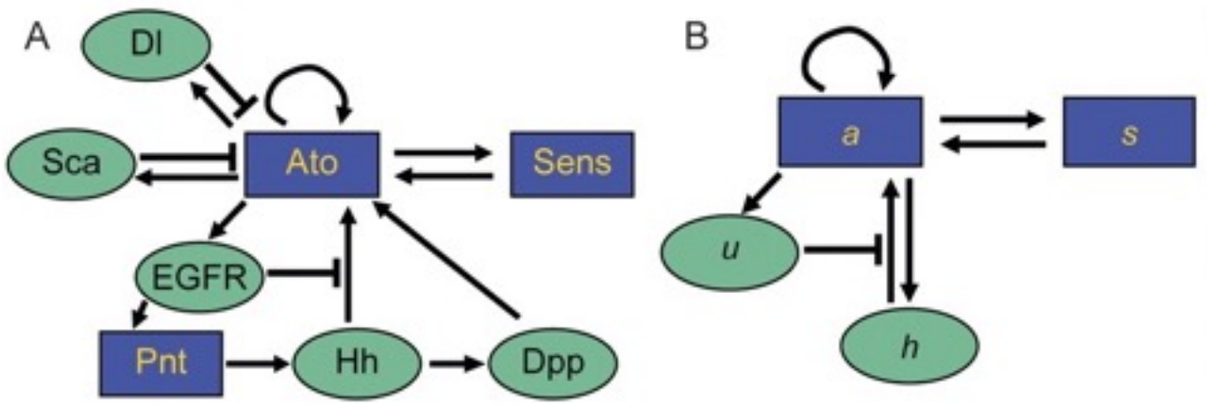


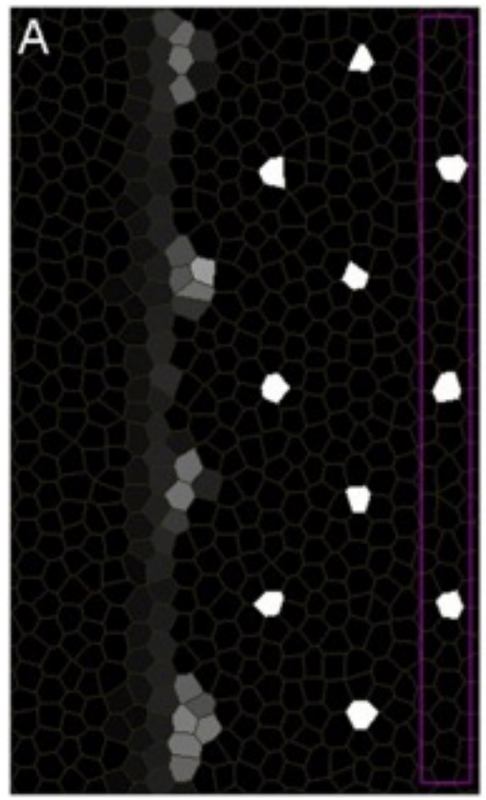
β-catenin



Why is a morphogenic deformation coupled to a chemical wave?

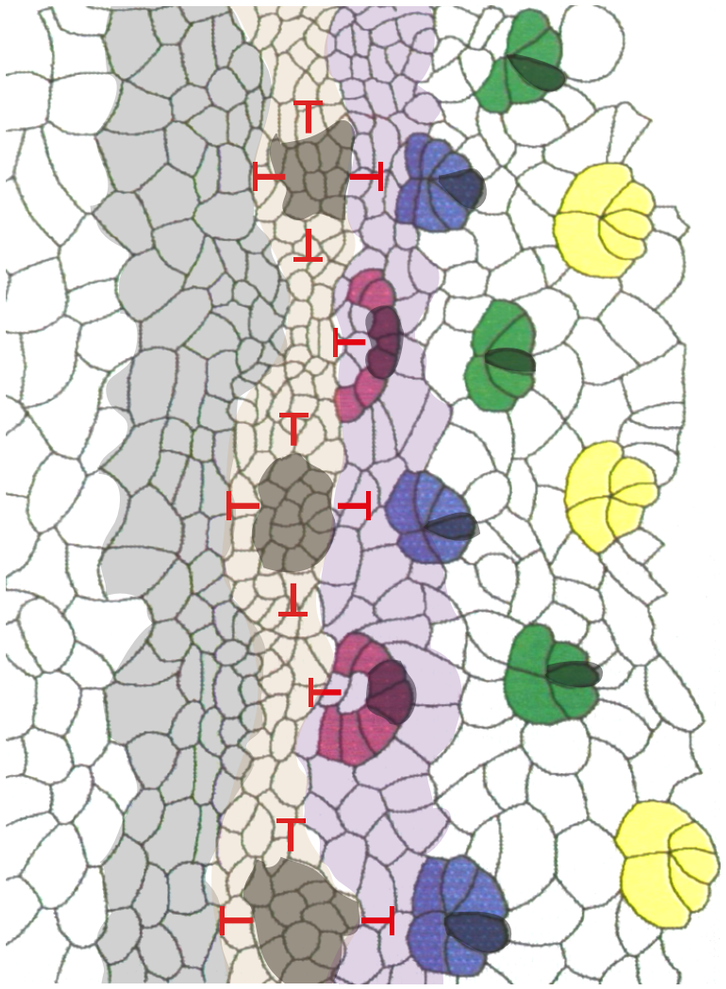
Why is a morphogenic deformation coupled to a chemical wave?

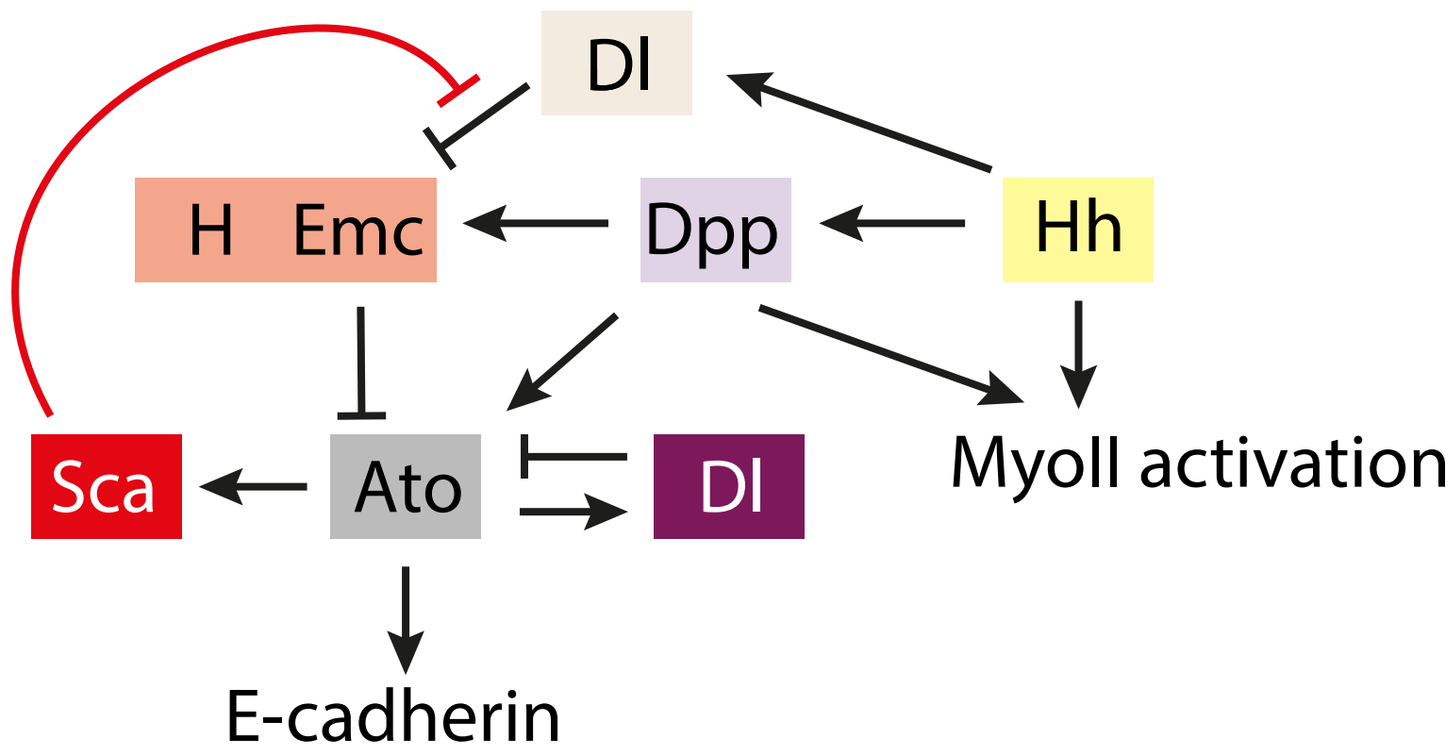




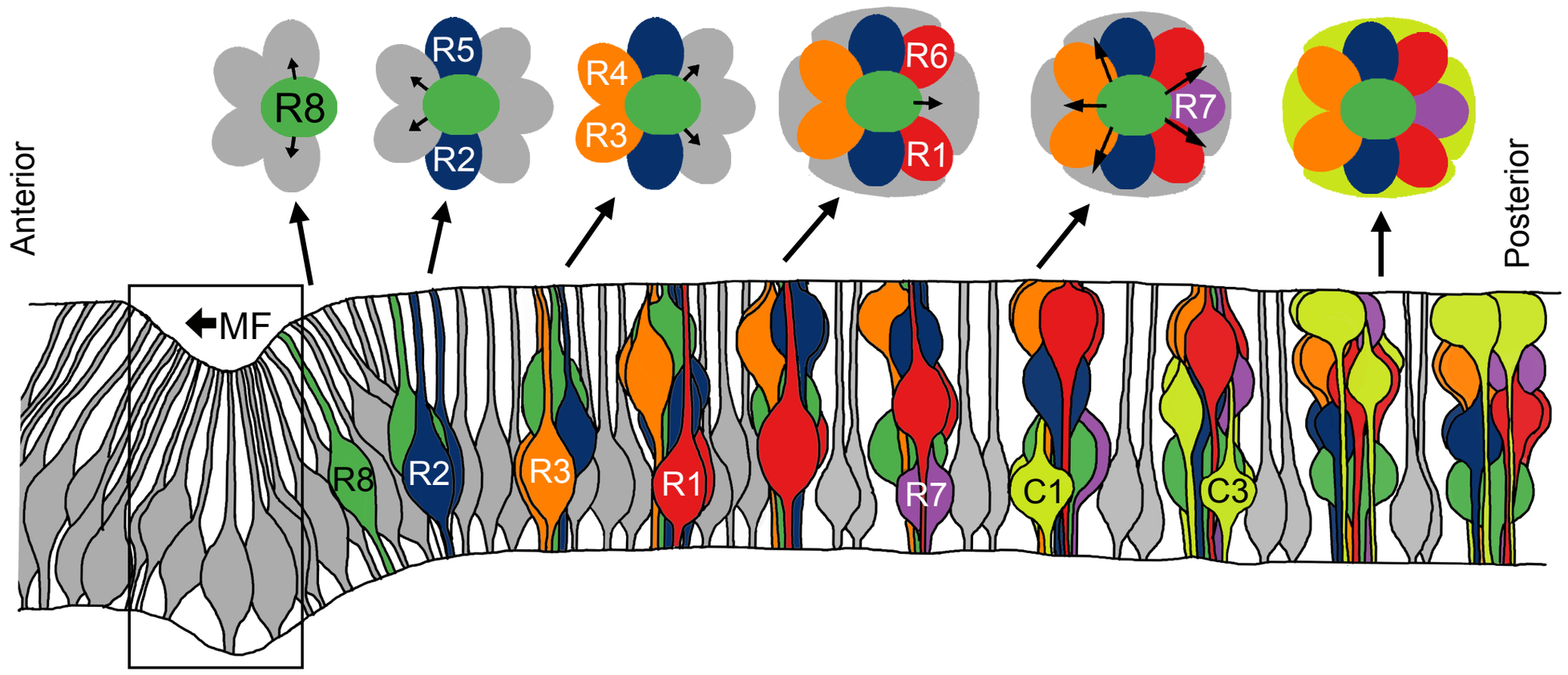
Lubensky et al (2011) PNAS

Feedback in the furrow?

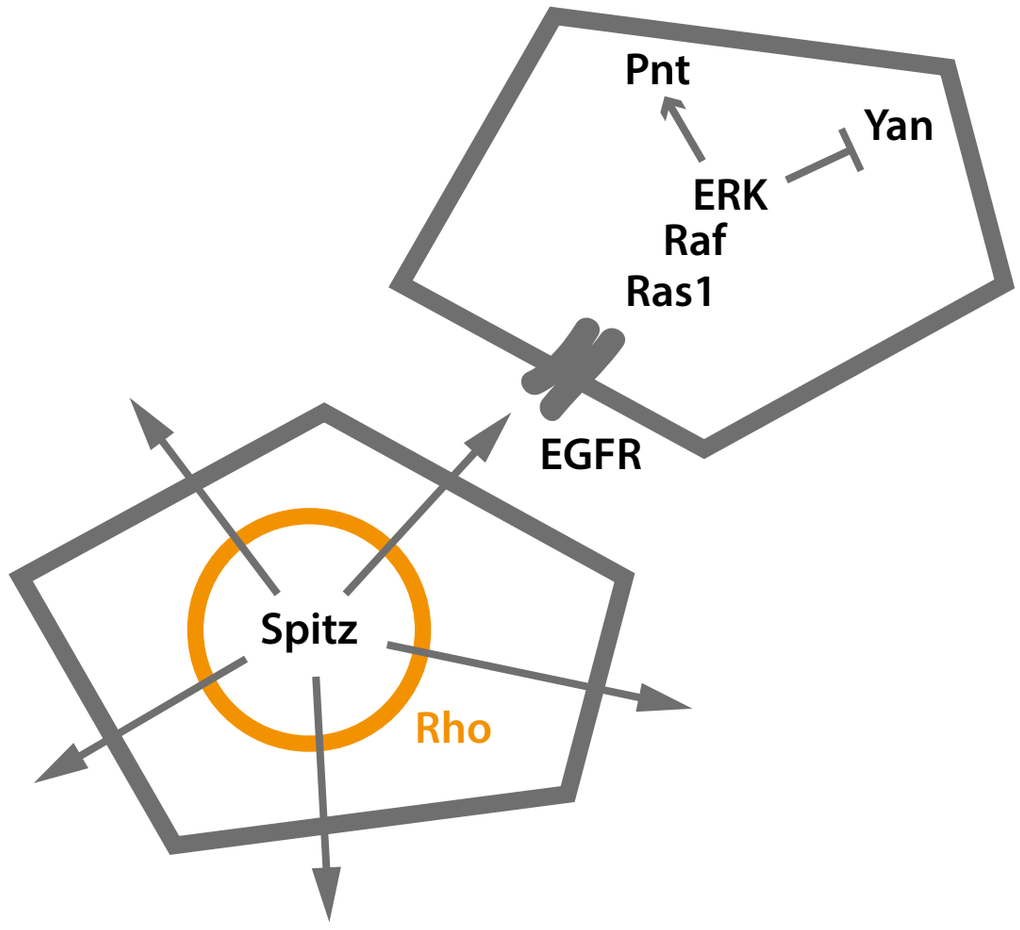




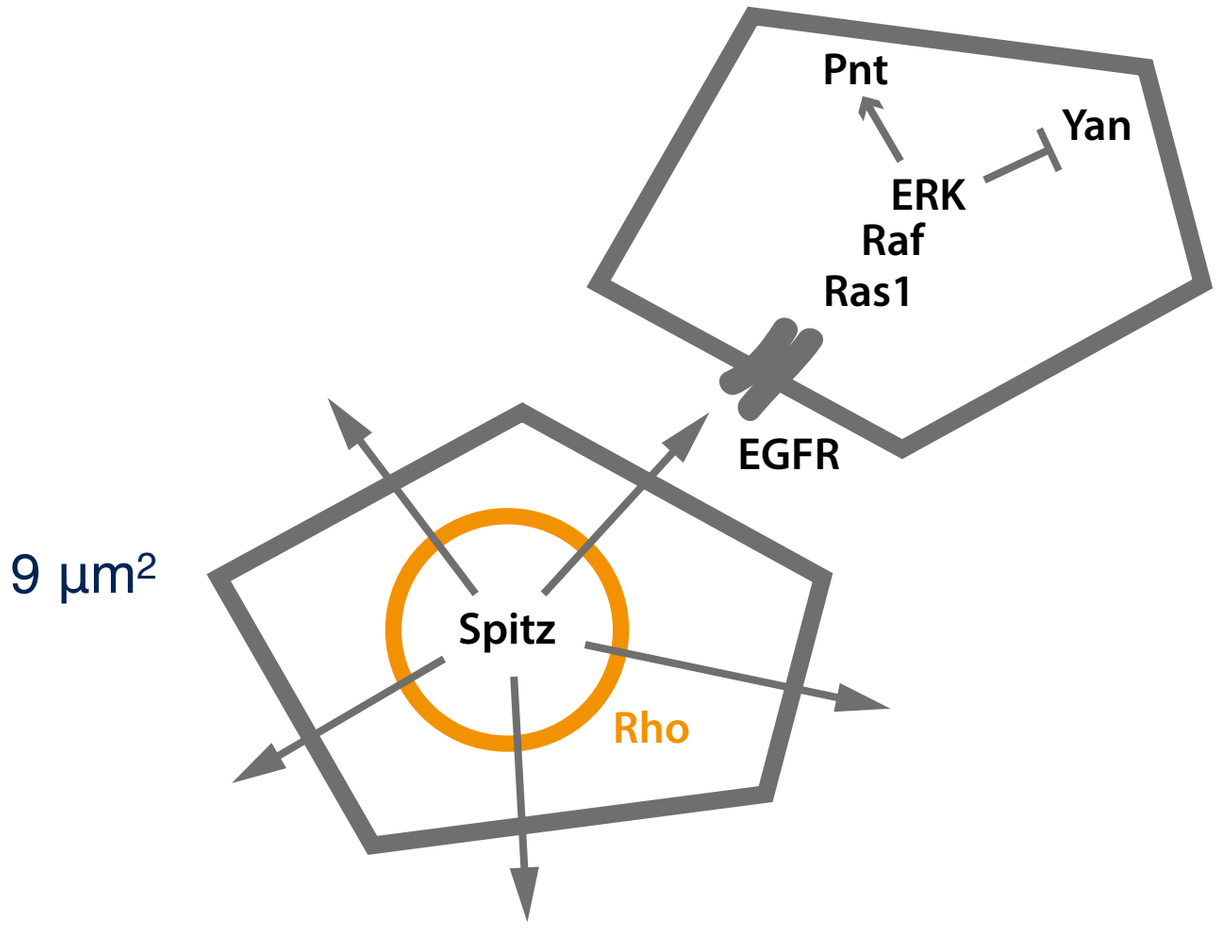
Local Induction of Cell Fates by R8



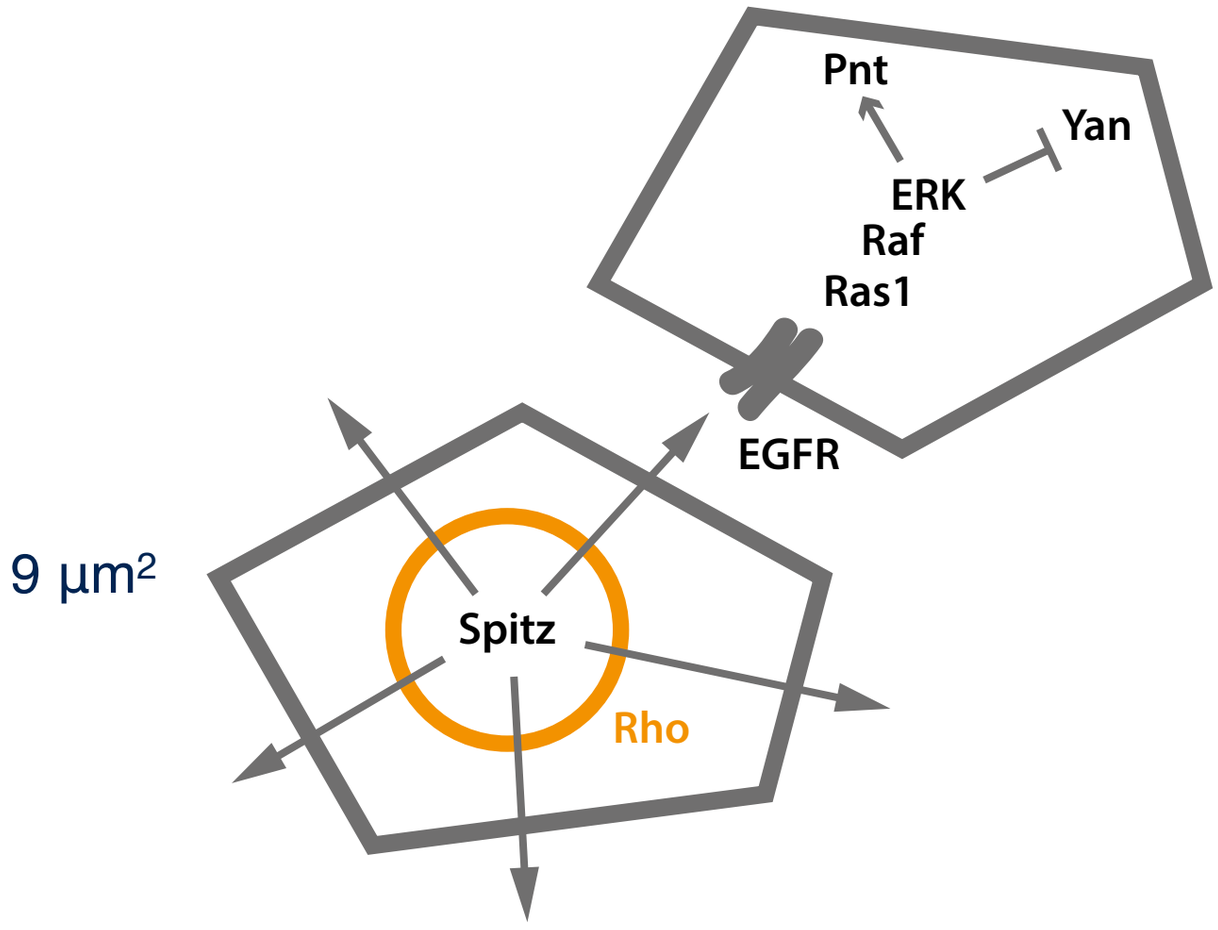
R8 Secretes Spitz to Activate EGFR and Trigger Differentiation



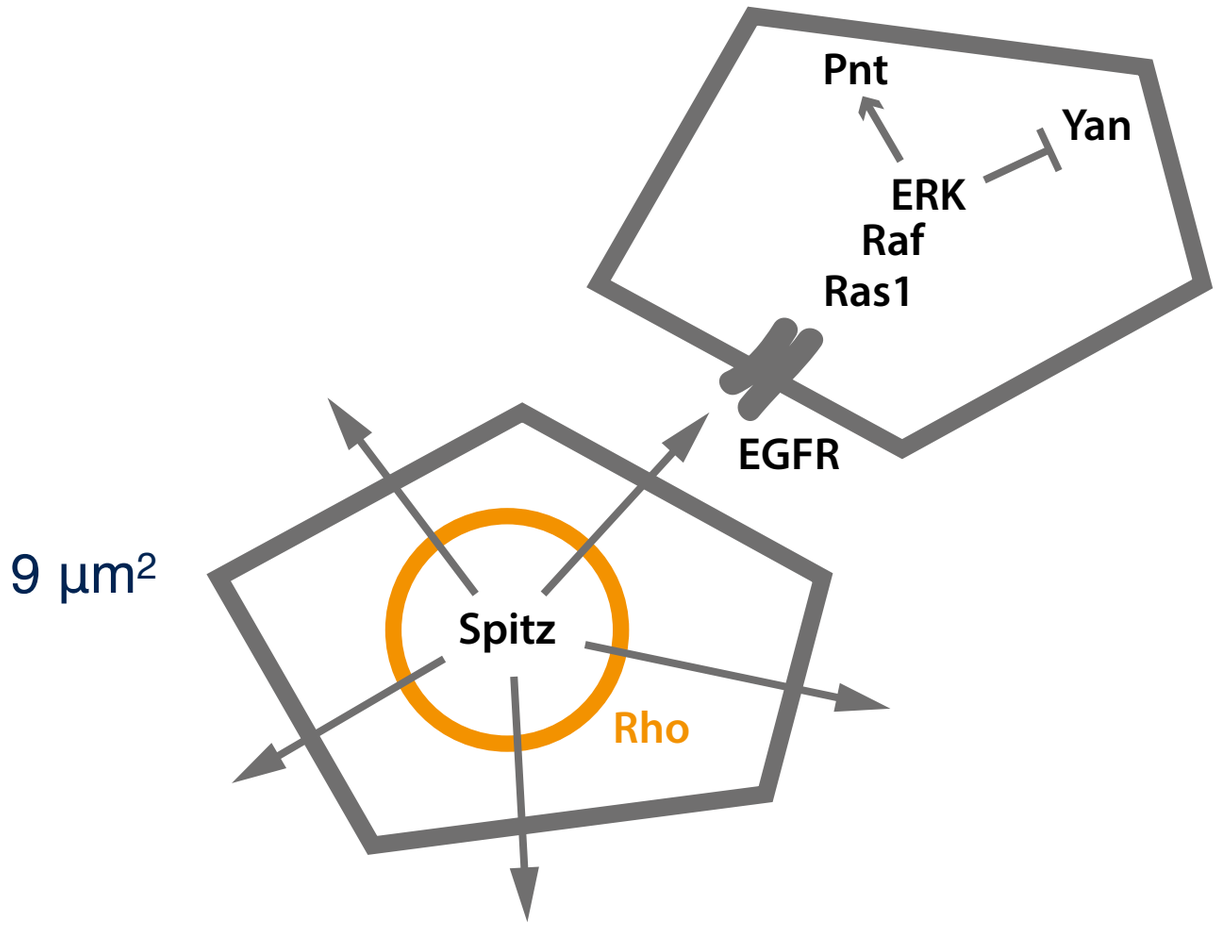
R8 Secretes Spitz to Activate EGFR and Trigger Differentiation

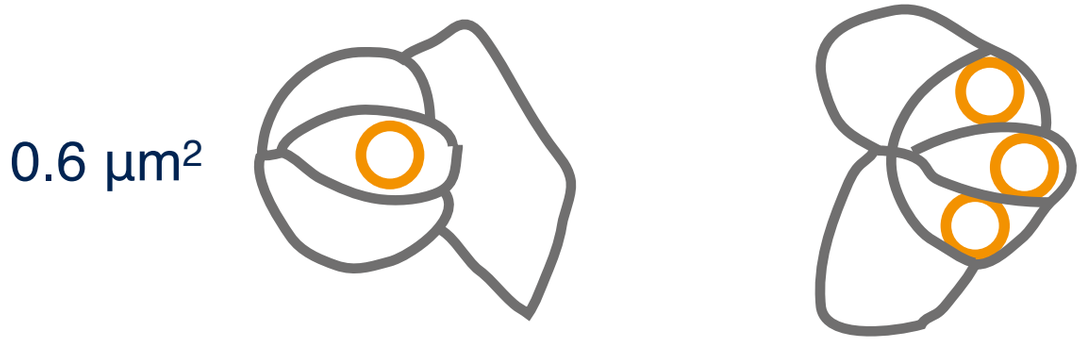


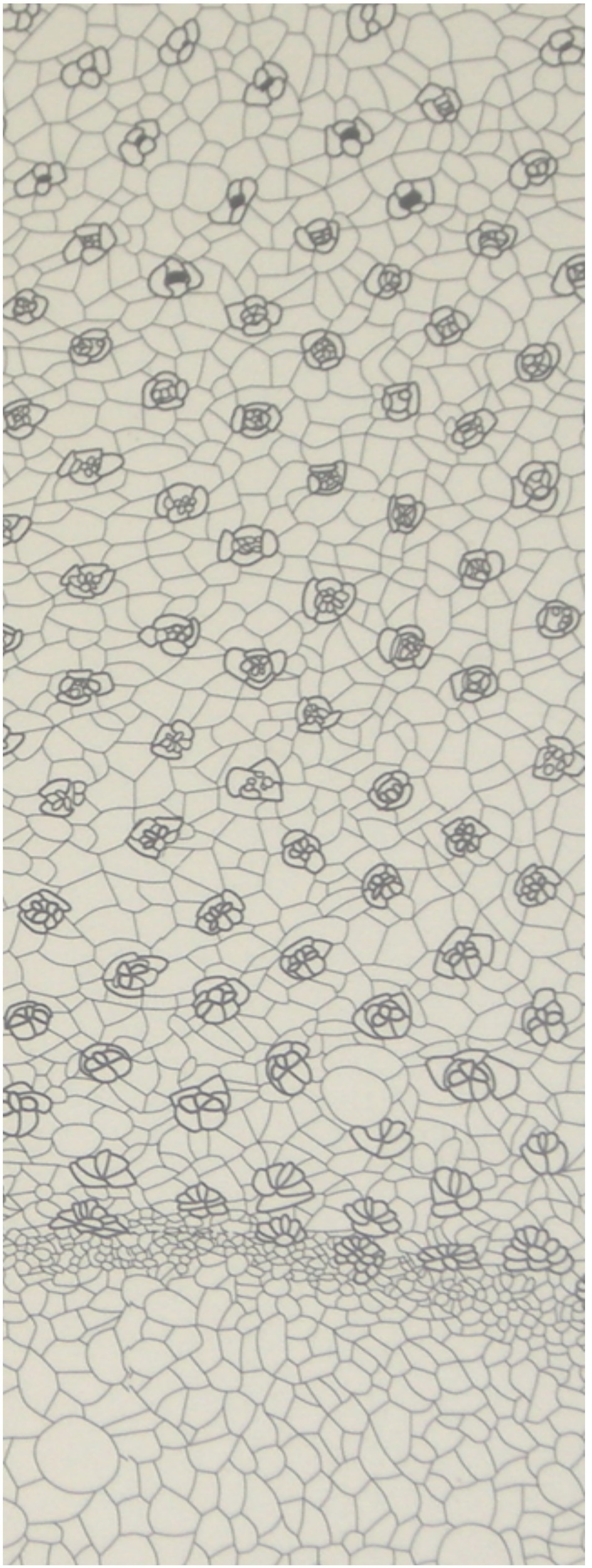
R8 Secretes Spitz to Activate EGFR and Trigger Differentiation

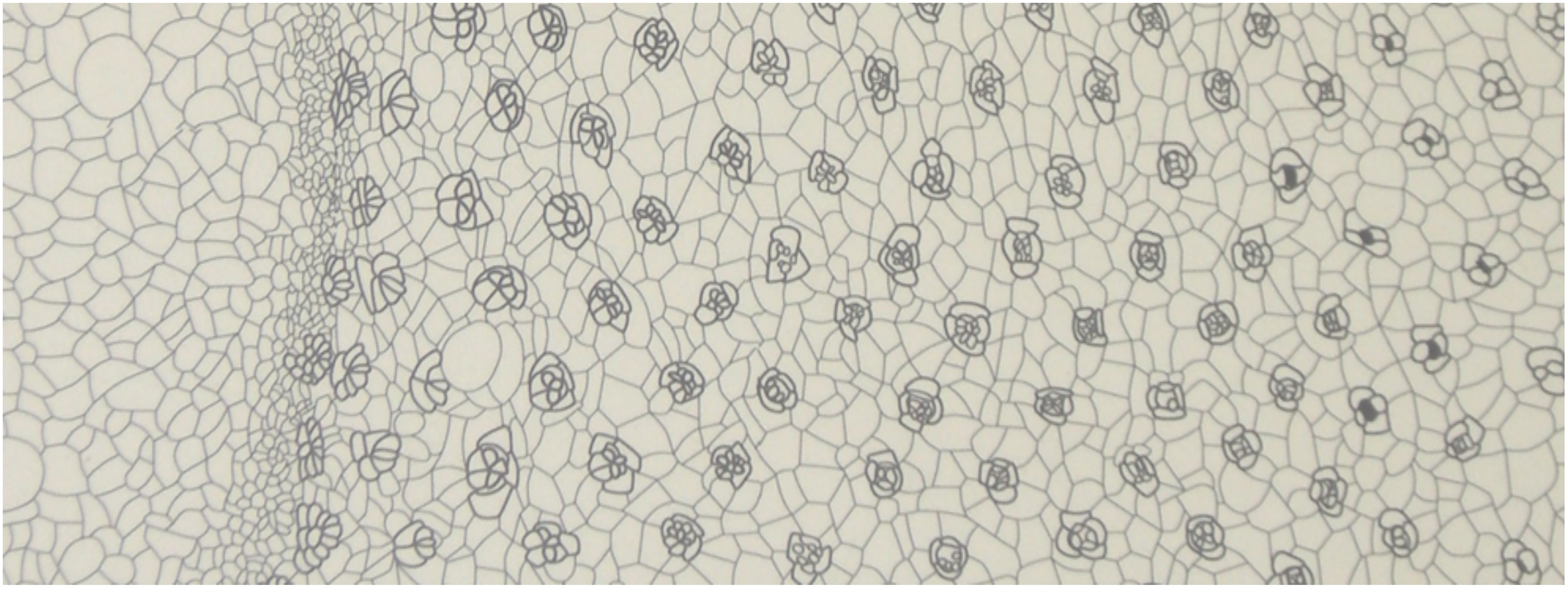


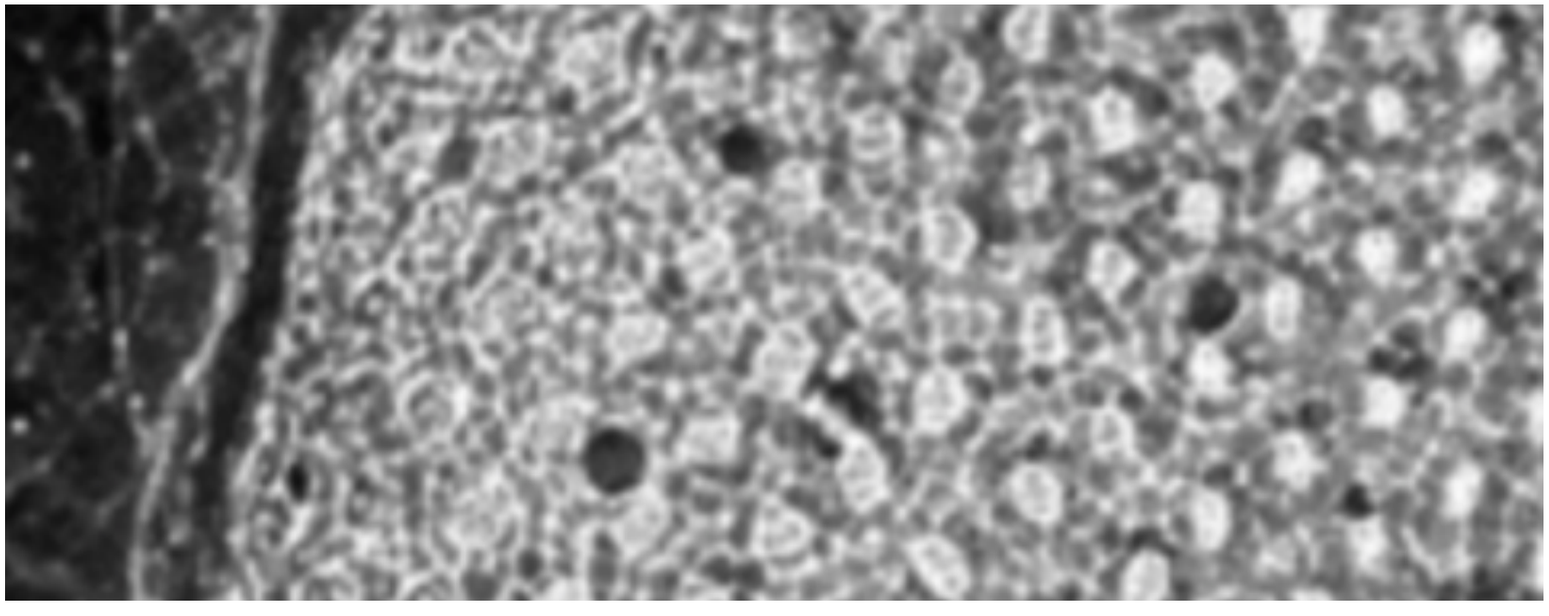
R8 Secretes Spitz to Activate EGFR and Trigger Differentiation

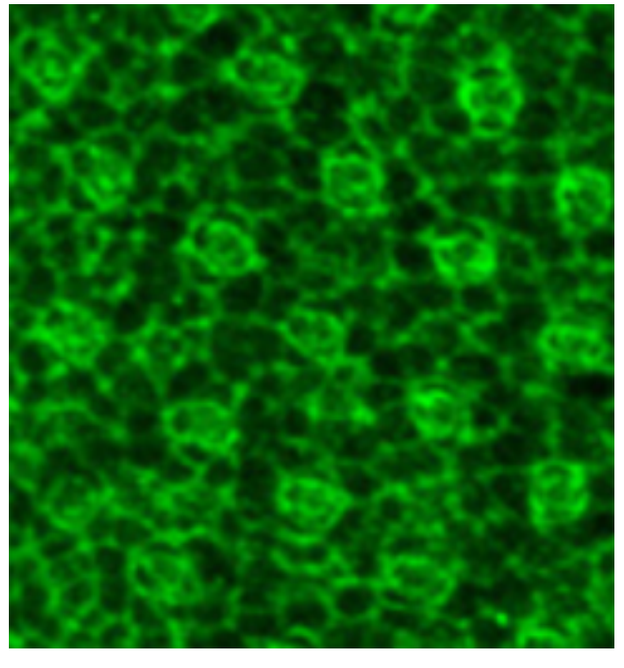








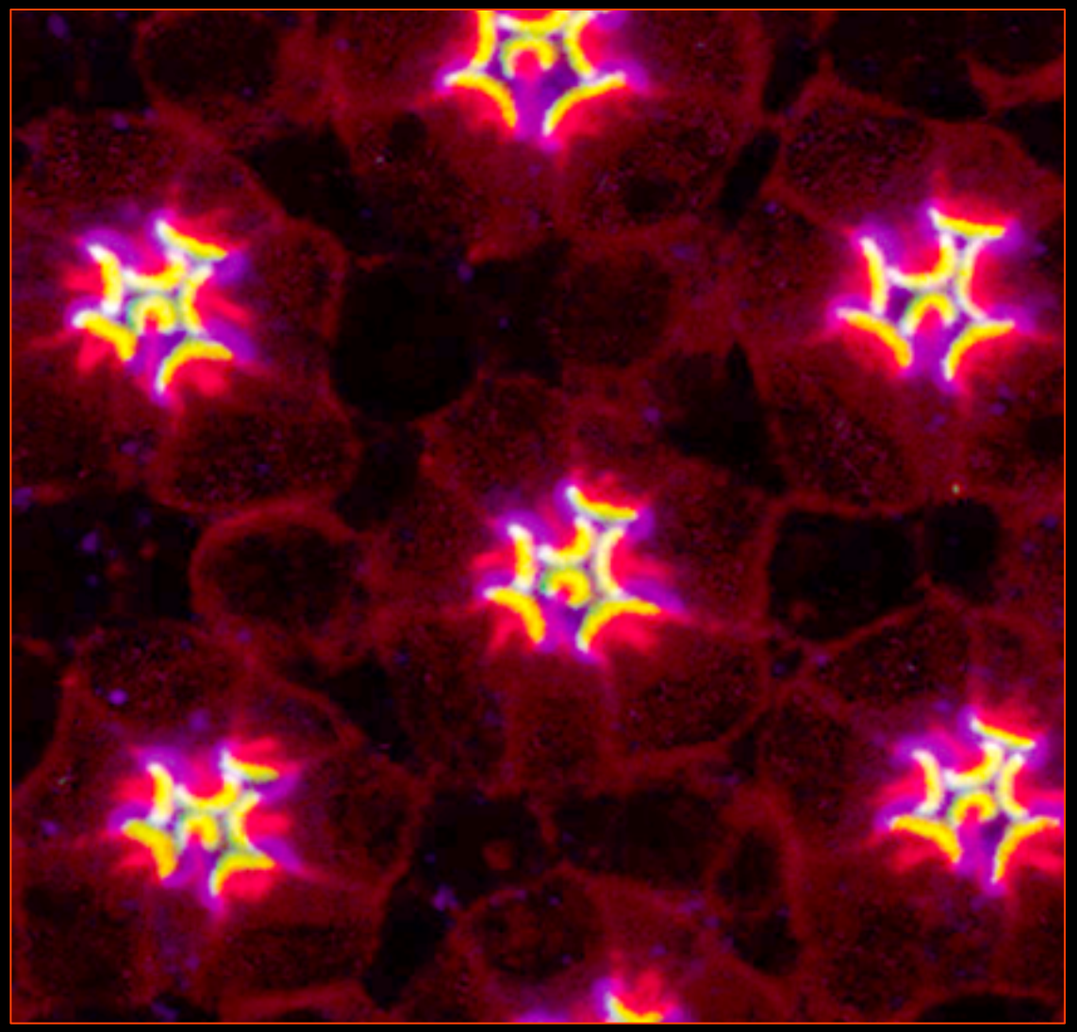




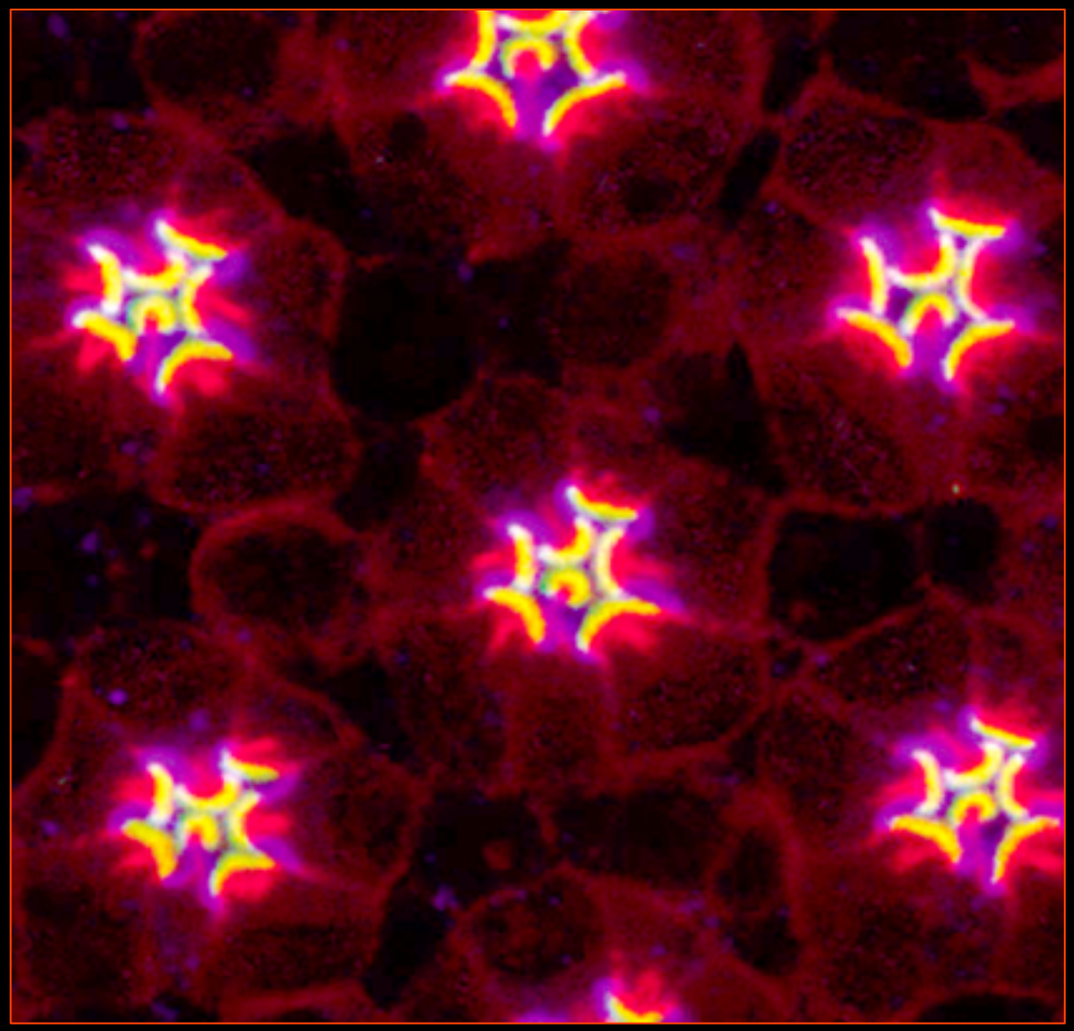
Escudero et al (2007)

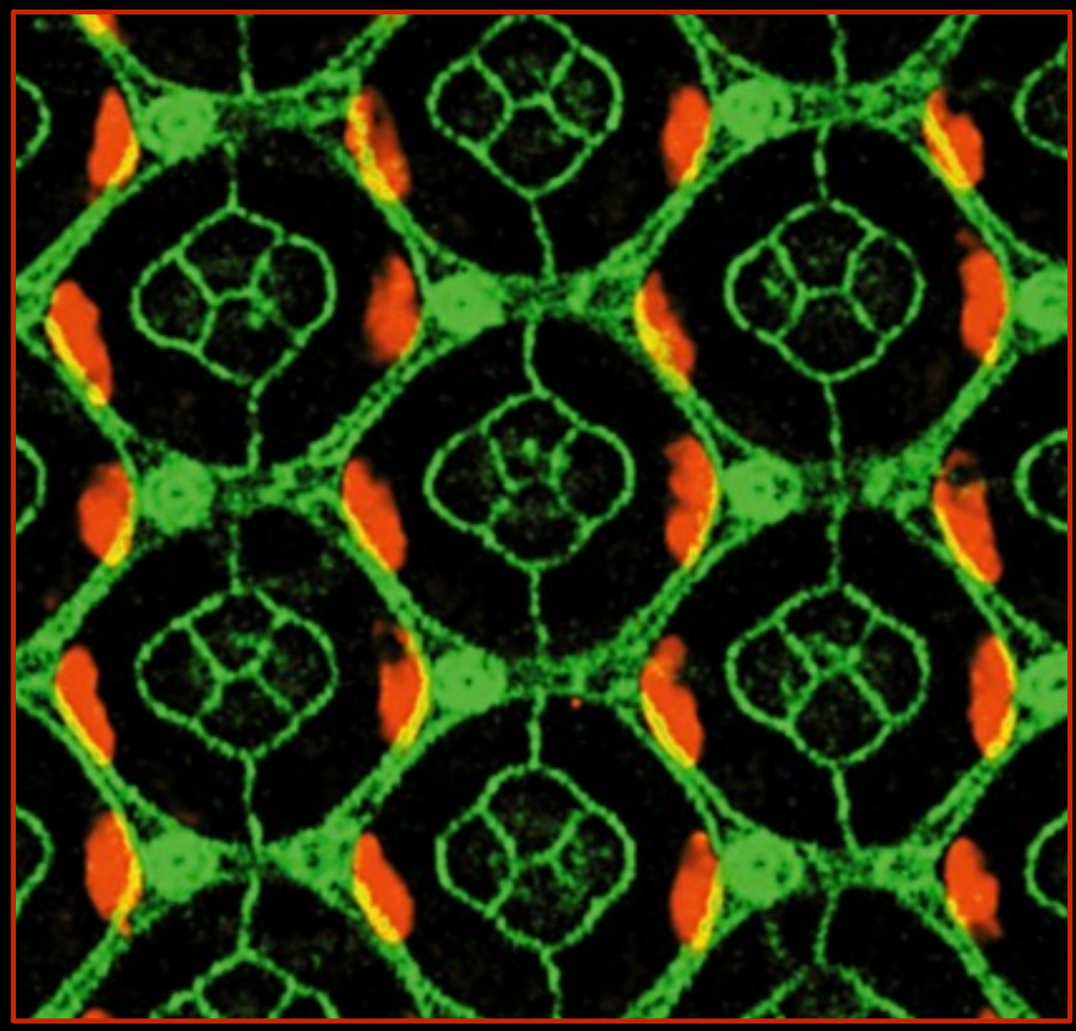
Two Days Later…..

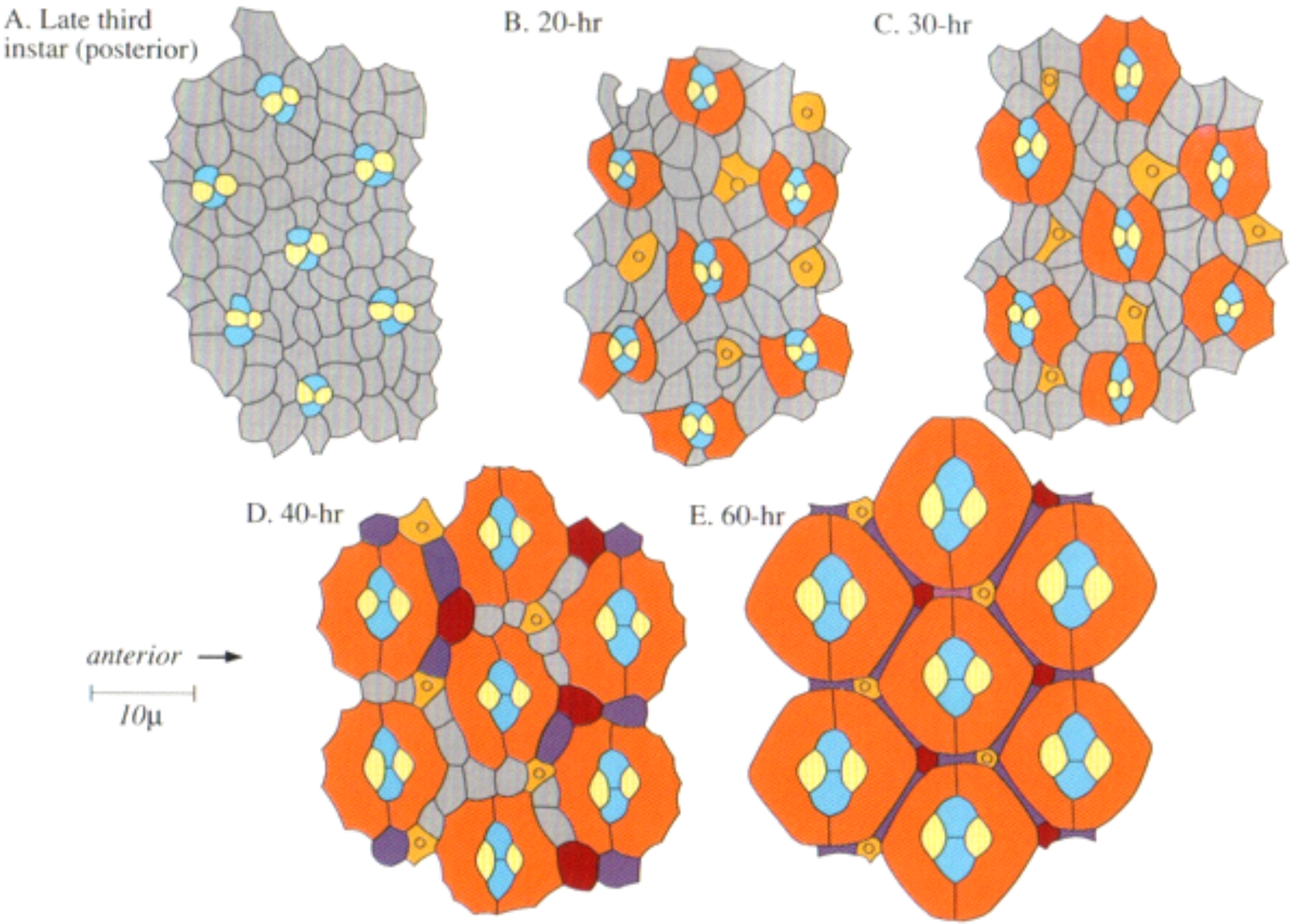
Two Days Later…..



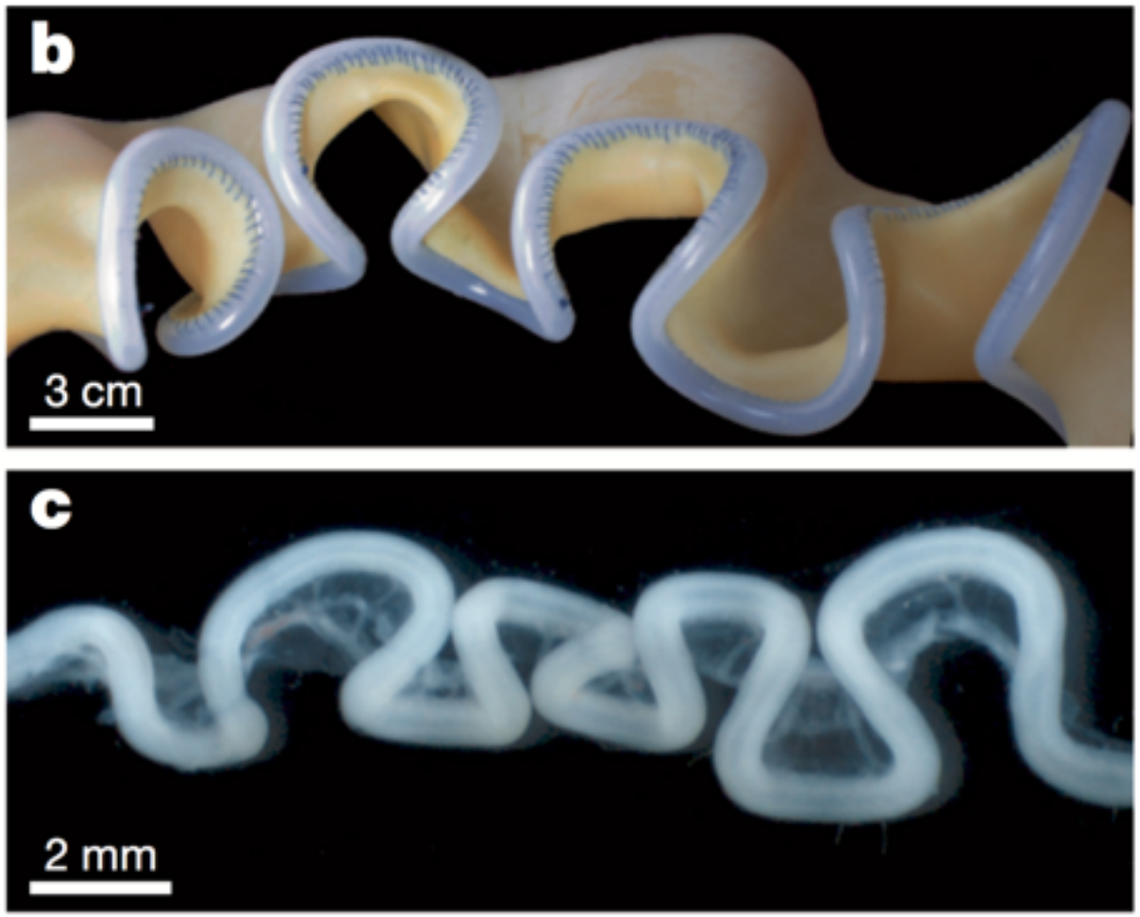
Two Days Later…..



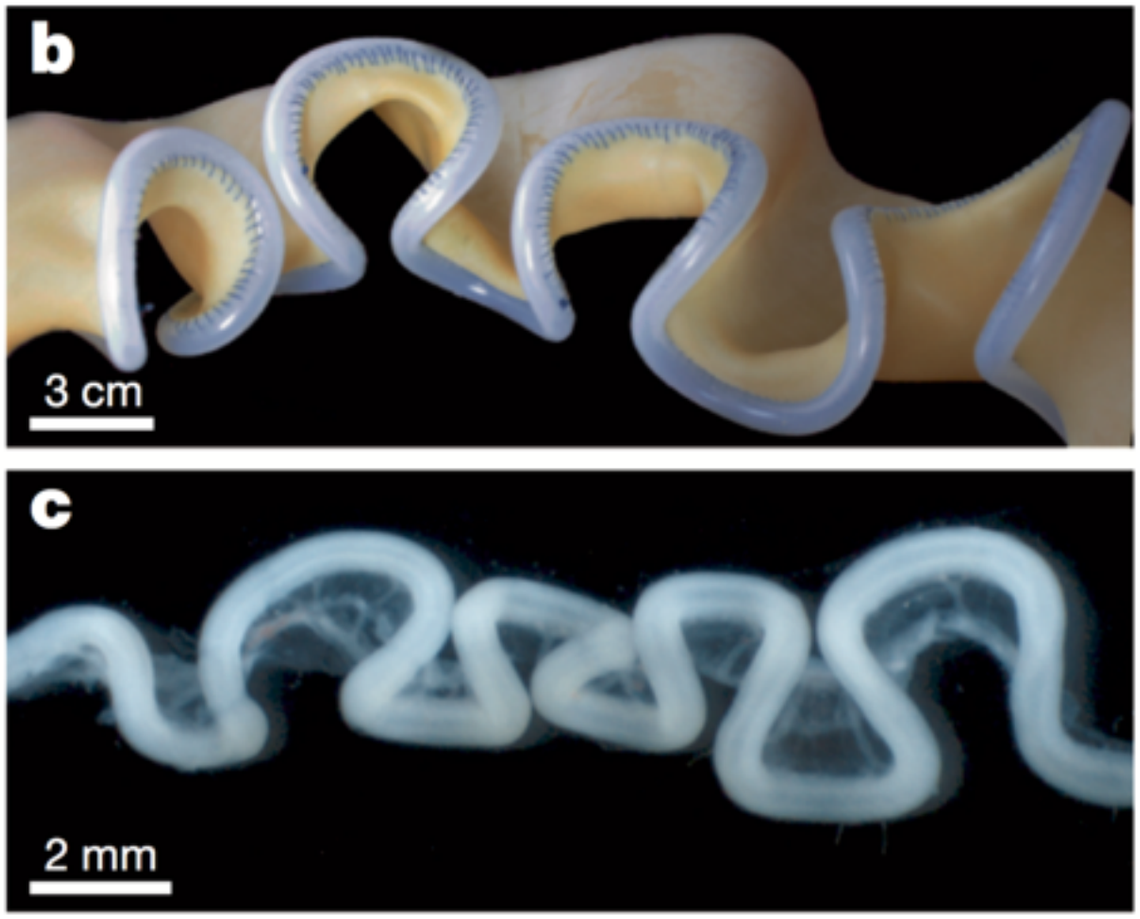




Wolff and Ready (1993)



Savin et al (2011) On Growth and Form of the Gut



Savin et al (2011) On Growth and Form of the Gut

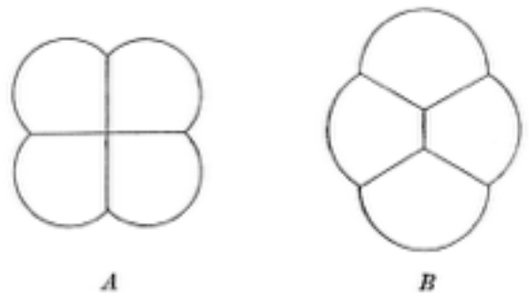


Fig. 172. A, an unstable arrangement of four cells or bubbles. B, the normal and stable configuration, showing the polar furrow.

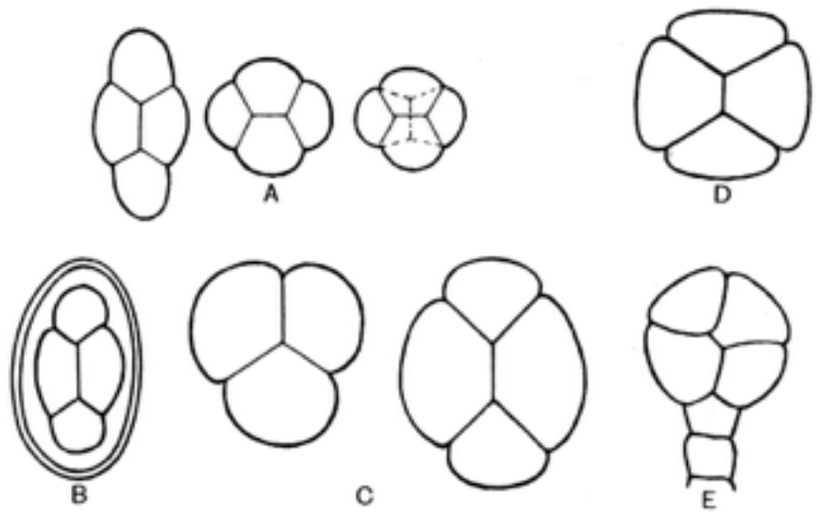


Fig. 173. Examples of the "polar furrow". A, Pollen-grains (tetrads) of *Neottia*. B, Egg of hookworm (*Ankylostoma*). C, First cells of a wasp's nest (*Polistes*). (From Packard, after Saussure.) D, Four-celled stage of Volvox: from Janet. E, Hair of Salvia, after Hanstein.

D. Thompson (1917) On Growth and Form

D. Thompson (1917) On Growth and Form

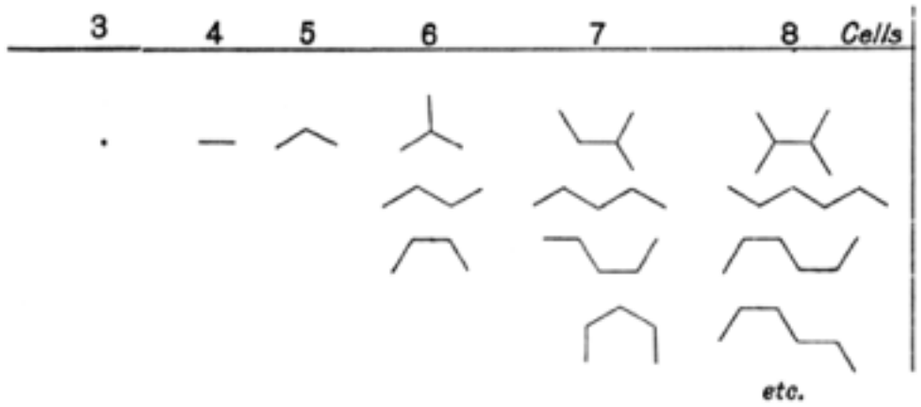


Fig. 245. Various possible arrangements of internal partition walls, in groups of 3, 4, 5, 6, 7, or 8 cells.

Fig. 246. Configurations for six cells.

D. Thompson (1917) On Growth and Form

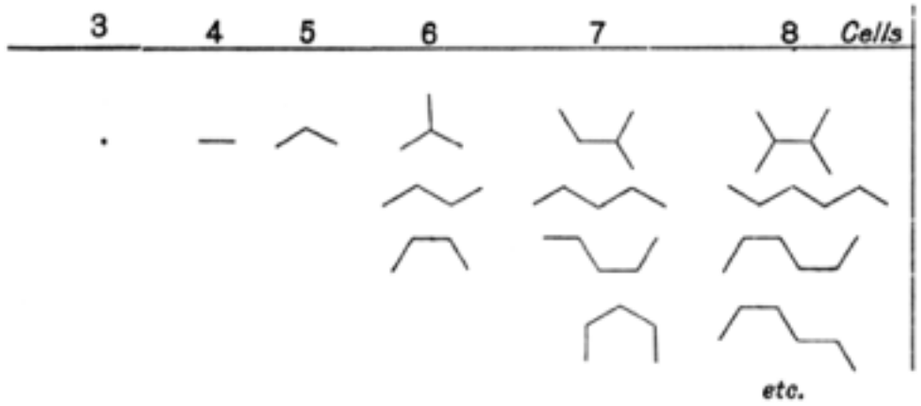
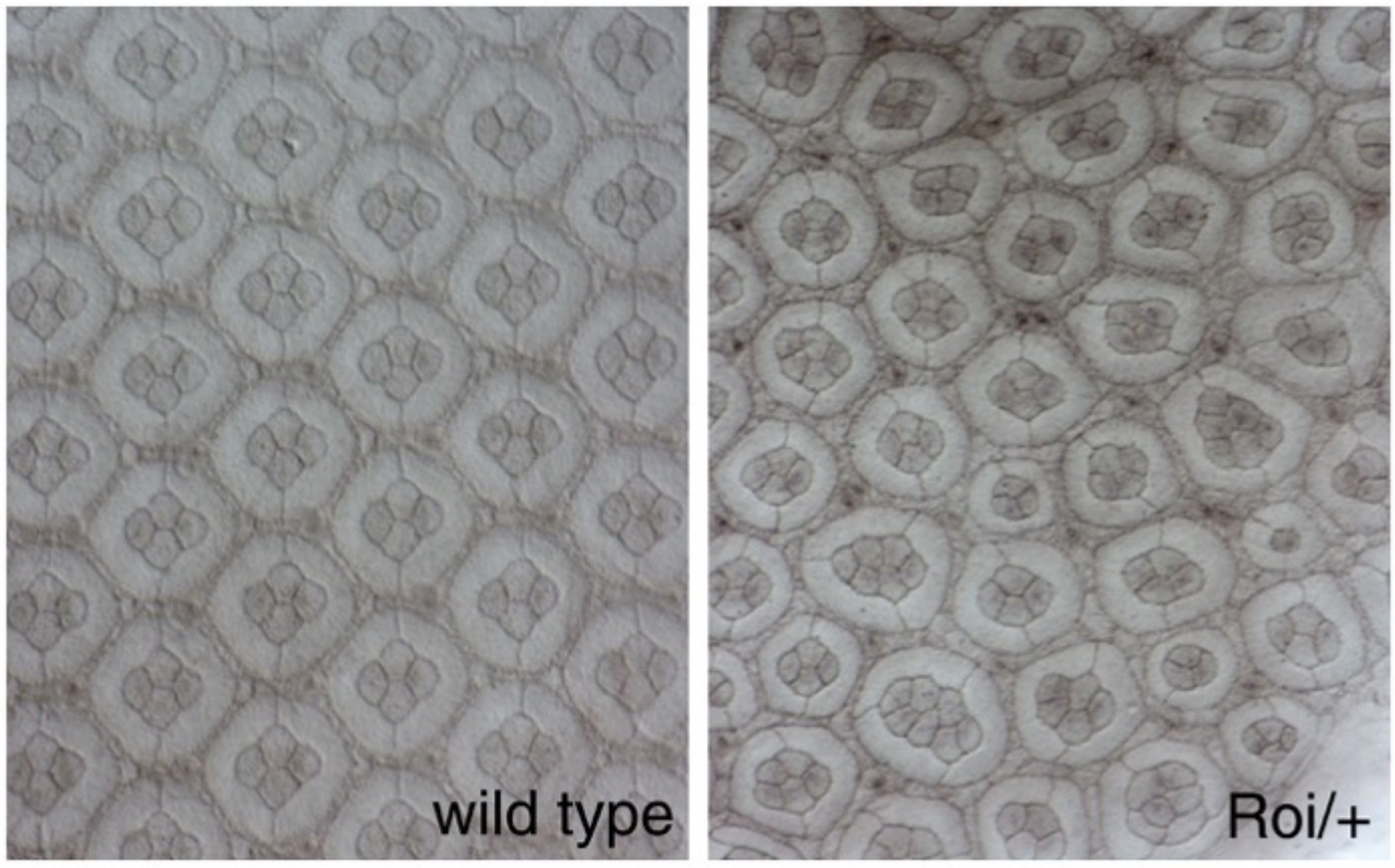
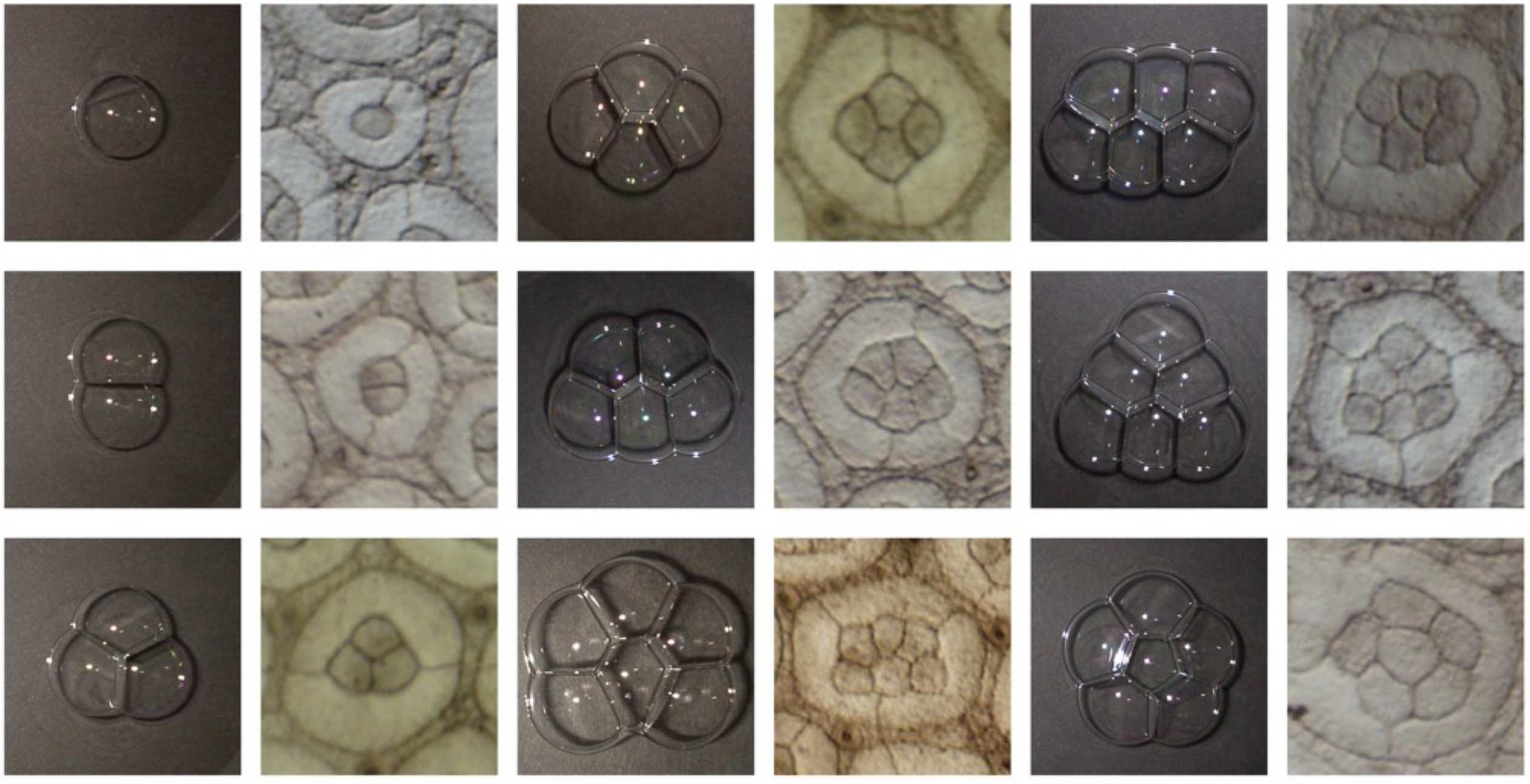


Fig. 245. Various possible arrangements of internal partition walls, in groups of 3, 4, 5, 6, 7, or 8 cells.

Fig. 246. Configurations for six cells.



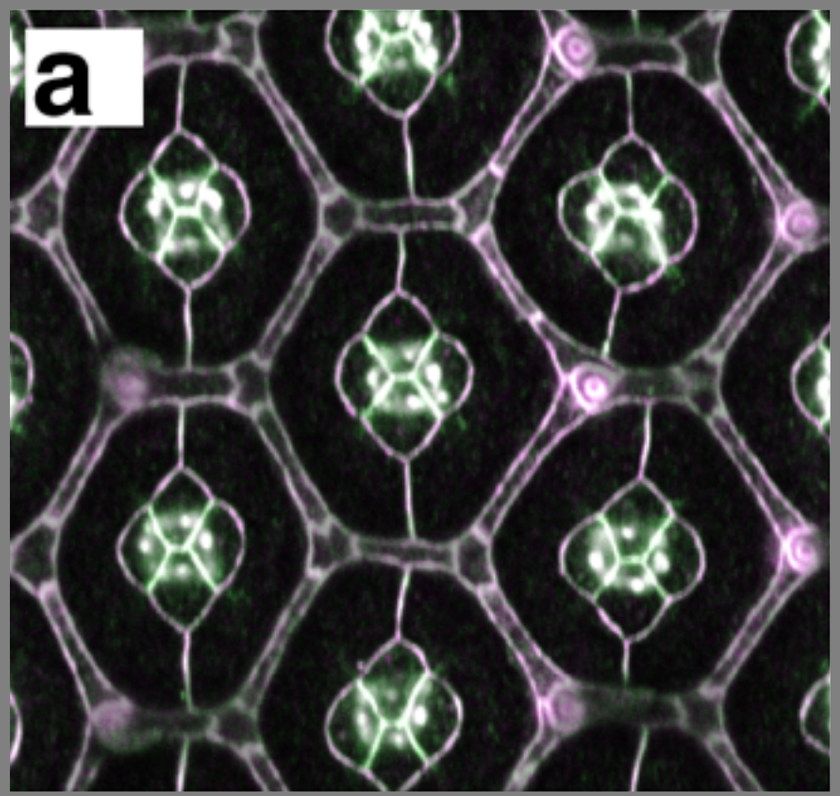
Hayashi and Carthew (2004)

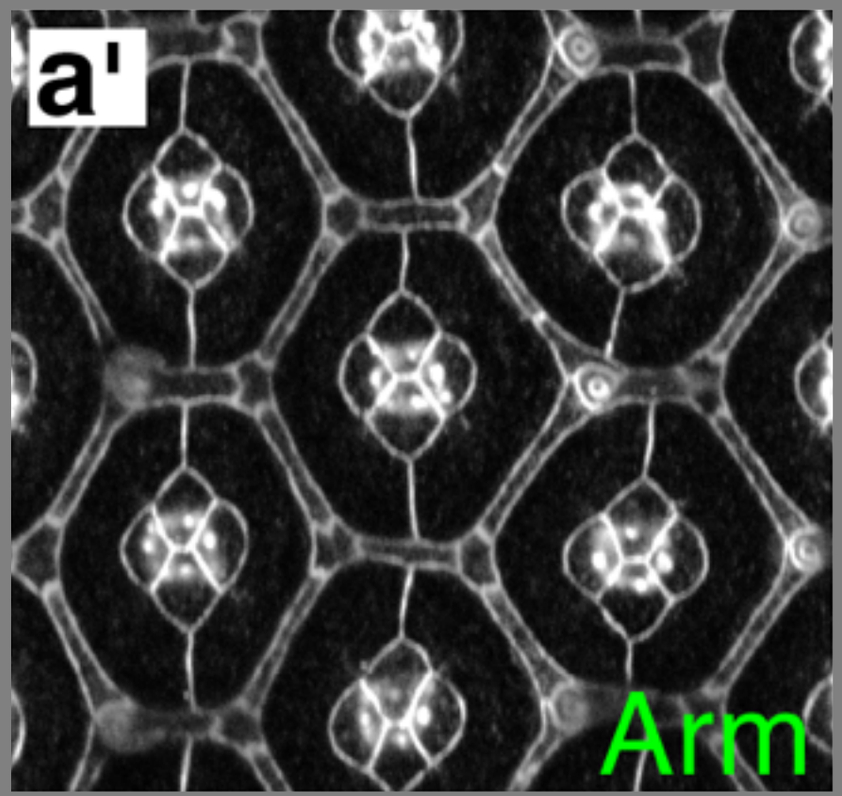


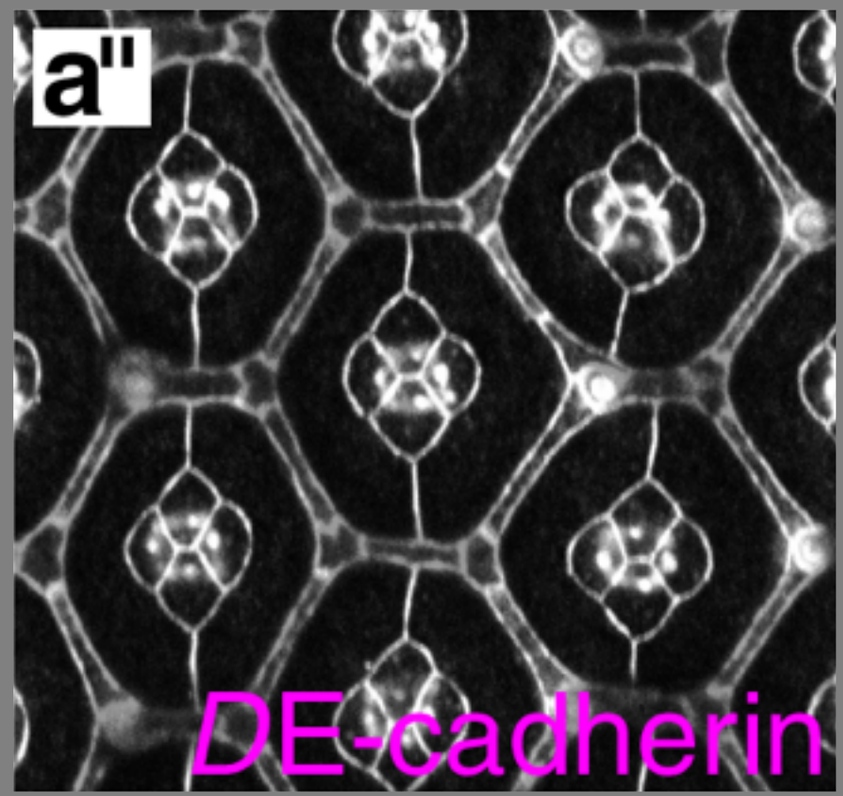
Configuration of cone cells and soap bubbles

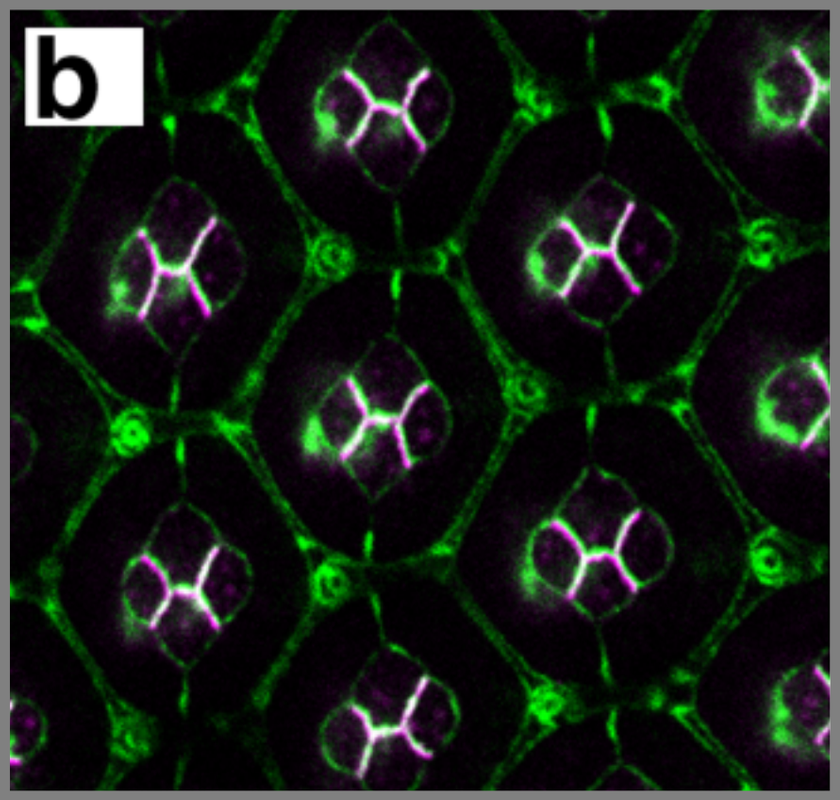
Hayashi and Carthew (2004)

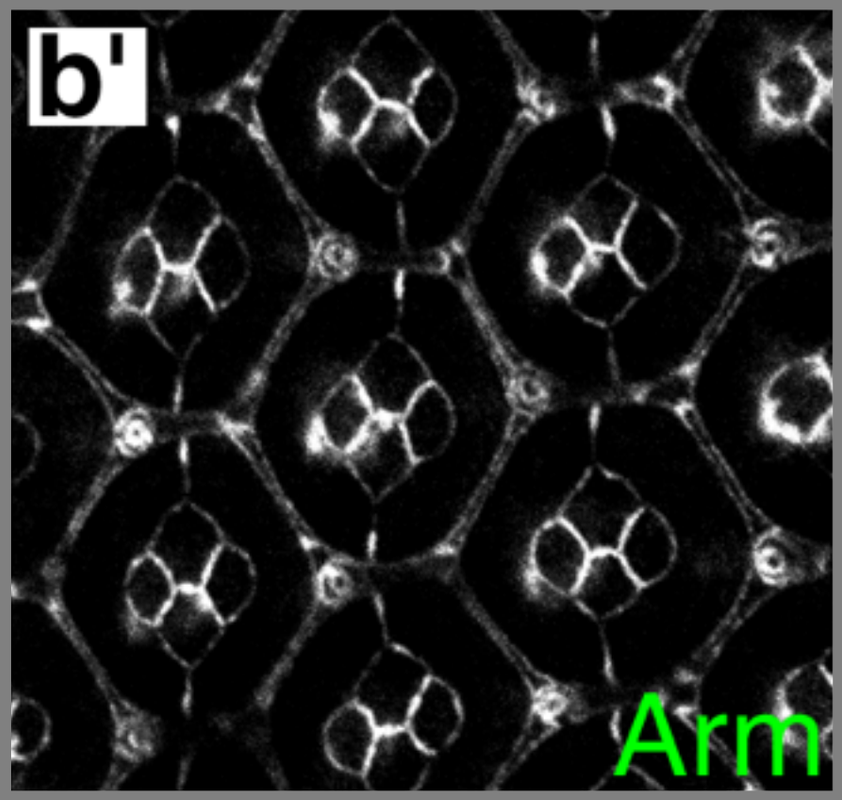
Two Cadherins are differentially expressed in the eye

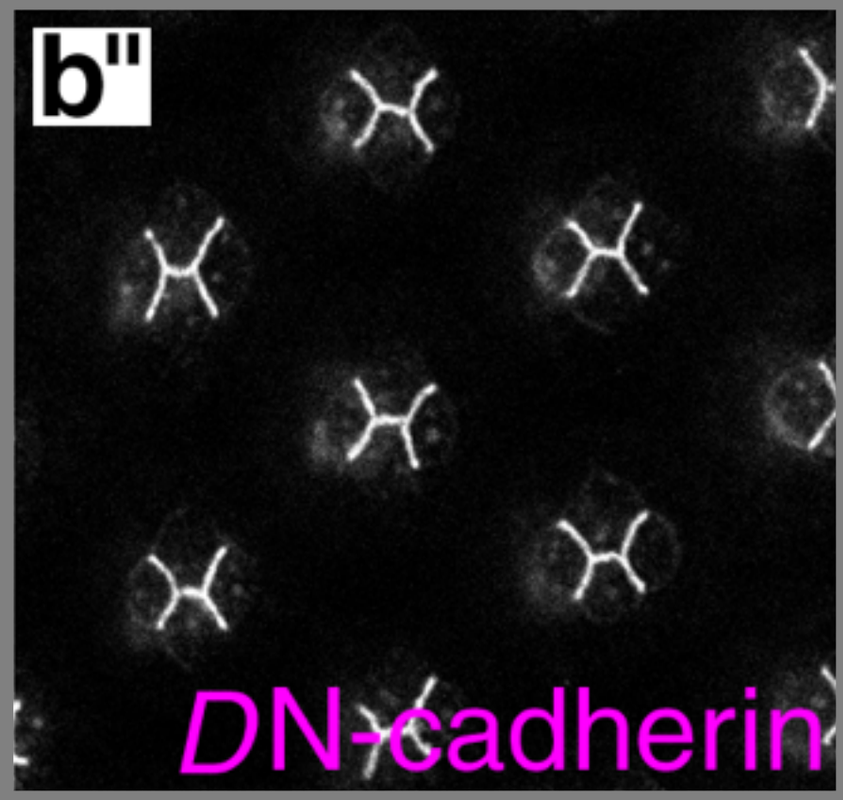


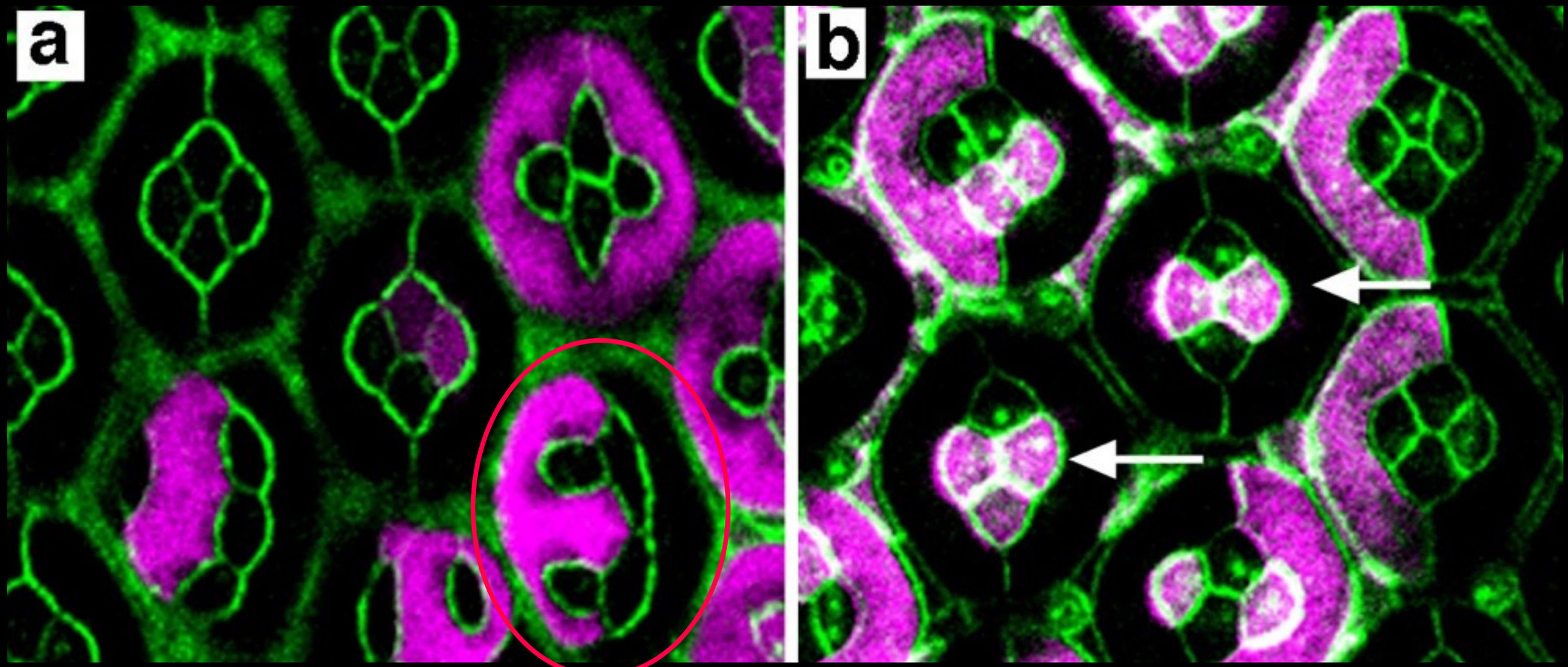












N-Cadherin+ Cells

E-Cadherin+ Cells

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