Talk 1: Onset of Epithelial-like cell shape formation in *Drosophila* embryogenesis

Talk 2: Morphogen gradients in *Drosophila* embryogenesis

#### Summary

Villi remodeling in embryogenesis



Mim in endocytosis and villi remodelling

Furrow formation and polygonal architecture initiation



Furrow length in onset of polygon shape

Hexagon dominated polygonal architecture



Furrow length in onset of hexagon dominance

### ACKNOWLEDGMENT

#### Lab members

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Mitochondria, ER, Peroxisome group....

Tamal Das, TIFR Hyderabacat

#### Collaborations

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#### Cell shape changes in embryogenesis



Paluch and Heisenberg 2009

https://www.sciencedirect.com/science/article/pii/S0960982209014511?via%3Dihub

#### Morphogen gradients in embryogenesis

A Gradients initiate tissue patterning



Briscoe and Small 2015

https://journals.biologists.com/dev/article/142/23/3996/47 124/Morphogen-rules-design-principles-of-gradient

#### Modular regulatory elements and transcriptional network



**B** Modular regulatory elements control target genes

C Transcriptional network dynamics generate pattern

Μ





Developmental time

Briscoe and Small 2015

https://journals.biologists.com/dev/article/142/23/3996/47 124/Morphogen-rules-design-principles-of-gradient

### Cell shape changes in embryogenesis



Paluch and Heisenberg 2009

https://www.sciencedirect.com/science/article/pii/S0960982209014511?via%3Dihub

#### Morphogen gradients operate in the syncytial embryo



### Morphogen gradients operate in the syncytial embryo

Bicoid

0

Dorsal/NFkB



Metazoan embryos as a model to study *de novo* polarity and packing of cells



Metazoan embryos as a model to study de novo polarity and packing of cells



(Adapted from Nance, 2014; Miller and McClay, 1997; Ohsugi et al., 1997, Krueger et al, 2018)

#### Morphogenesis: change in form in the early embryo

Gastrulation

It is not birth, marriage, or death, but gastrulation which is truly the most important time in your life

Lewis Wolpert

#### Germ layers in vertebrates and invertebrates



Are there different cellular properties that keep germ layers apart from each other?

# Endoderm and Ectoderm separate because of different adhesive properties



https://books.google.co.in/books?id=WbO6BwAAQBAJ&pg=PA361&lpg=PA361&dq=Morpho genesis:+change+in+form+in+the+early+embryo&source=bl&ots=9nKldrOONX&sig=hfWKur liAC2cYS4swRyZNC0lWKU&hl=en&sa=X&ved=0ahUKEwjsmbbRwJrLAhWSCY4KHe\_pDacQ6 AEIIDAB#v=onepage&q=Morphogenesis%3A%20change%20in%20form%20in%20the%20ea rly%20embryo&f=true Dissociation and mixing of amphibian embryo cells



Dissociation and mixing of amphibian embryo cells



#### Cell with increased adhesion are inside

Fig. 9.3 Sorting out of cells carrying different amounts of adhesion molecules on their surfaces. When two cell lines with different amounts of N-cadherin on their surface are mixed, they re-assort with the cells containing the most N-cadherin (green stained cells) ending up on the inside. Photographs courtesy of M. Steinberg, from Foty, R.A., and Steinberg, M.S.: The differential adhesion hypothesis: a direct evaluation. Developmental Biology 2005, 278: 255-263.



#### Adhesion and Contractility



Lecuit and Yap 2015

#### Cell shape changes in prospective mesodermal cells



Drosophila gastrulation

### Drosophila embryogenesis







#### Epithelial to mesenchymal transition in development



Acloque et al, J Cli Inv 2009

#### Gastrulation in Drosophila



#### Gastrulation in Drosophila



Signalling in gastrulation in Drosophila



Fig. 2. Maternal and zygotic gene activities directing the gastrulation events shown in Figure 1.

Leptin 1999



Apical

Constriction



https://www.sciencedirect.com/science/article/pii/S0012160614003790

## Pulsed contractions of an actin-myosin network drive apical constriction

Adam C. Martin<sup>1,2</sup>, Matthias Kaschube<sup>3,4</sup> & Eric F. Wieschaus<sup>1,2</sup>

Nature 2009





Membrane-GFP Spider-GFP

Martin et al Nature 2009

#### Pulsed constrictions in cells of the ventral furrow



Martin et al Nature 2009

#### Pulsed constrictions in cells of the ventral furrow



Myosin II accumulates at the center in constricting cells









Figure 2 | Constriction pulses are correlated with myosin coalescence. a, Merged images of Myosin–mCherry (Z-projection, 5 mm depth, green)

#### Myosin II coalescence and adherens junction bending







Figure 3 | Pulsed myosin coalescence and adherens junction bending require an actin– myosin network.



Apical

Constriction



https://www.sciencedirect.com/science/article/pii/S0012160614003790

#### Snail and Twist function in distinct phases of apical constriction





### Integration of contractile forces during tissue invagination

Adam C. Martin, Michael Gelbart, Rodrigo Fernandez-Gonzalez, Matthias Kaschube, and Eric F. Wieschaus

> JCB Volume 188(5):735-749 March 8, 2010



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# Polarized apical constriction possibly reflects tissue mechanics.



Adam C. Martin et al. J Cell Biol 2010;188:735-749



### AJs integrate global epithelial tension.







Adam C. Martin et al. J Cell Biol 2010;188:735-749







## Spot AJs integrate actomyosin fibers to form a supracellular meshwork.





#### Snail and Twist are required for epithelial tearing.





# Twist is required for myosin II stabilization and supracellular meshwork formation.





#### Causes and consequences of contractile force



