Role of intercellular adhesion in cell migration : A cellular potts model perspective

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Germ cell transepithelial migration



- Post gastrulation the germ cells (pole cells) find themselves in the primordial midgut, which is an epithelial sack
- Germ cells exit the midgut as single cells and is a crucial step in their journey towards the gonad
- Not all germ cells make it !

Germ cells in migration in Drosophila melanogaster [source : Kim et al, Cell Reports 2021]



Germ cells exiting the midgut



Germ cell transepithelial migration



a) Schematic showing germ cells exiting the midgut ; b) E-cadherin junctions formed between the germ cell and the epithelial cells

2D toy model of the midgut - epithelial ring



2D epithelial ring with a germ cell in the lumen

The cyan cell representing the lumen and all the springs prevent the ring from collapsing.



2D epithelial ring with all the internal support structures displayed



Adhesion between germ cell and epithelial cells determines the fate of transepithelial migration



 J_{EG} = 5.0



 J_{EG} = 20.0

Border cell migration



Ontogenic series : Drosophila ovariole showing egg chambers at different stages of development [source : Cai et al, Cell 2014]

- Egg chamber is composed of 15 nurse cells and one oocyte encased within ~850 follicle cells
- The oocyte secretes chemoattractants that the border cells sense.
- Border cell cluster around 2 special cells called the Polar cells

• Border cells are 6 to 10 follicle cells that migrate ~150 µm over 3 to 6 hours within ovarian egg chamber

Border cell migration between the nurse cells



Ex-vivo live imaging of the border cell migration in the egg chamber. [Source : Dai et al Science 2020]



Hierarchy of E-cadherin expression

- Unlike in the case of EMT, the border cells up regulate E-cadherin expression as they start the migration
- Polar cell express the highest level of Ecadherin
- Border cells express less
- Nurse cells express the least amount of Ecadherin

Cai et al, Cell 2014



Changing the expression of E-cadherin

- Decrease in nurse cell E-cadherin expression increases the failure rate in migration
- Increase in nurse cell E-cadherin expression slows down the migration but migration success rate is unaffected
- Decrease in border cell E-cadherin expression adversely affects the migration
- Increase in border cell E-cadherin expression has no effect

Cai et al, Cell 2014



The J matrix elements that represents the adhesion affinity between the different cell types

2D toy model of the border cell migration $J_{PN} = J_{BN} = J_{NN} = 10$ 300 -250 200 -> 150 100 -50 -0 -200 400 800 600 1000

300 -

250

200

100

50

0 –

0

> 150



$$J_{PP} = 0; J_{PB} = 5; J_{BB} = 5$$

$$J_{PN} = J_{BN} = J_{NN} = 40$$



200

Х







Optimal adhesion affinity hypothesis



- a) Slippery surface with no traction
- b) Carpeted surface
- c) Carpeted floor with melted American processed cheese

Drawn by Anastasia Repouliou

Cell compartments - Filopodia?





100

T = 10

200

Х

300



Thank you for listening

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https://compucell3d.org/



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Questions please