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A MECHANICAL AND NUMERICAL APPROACH APPLIED TO EPITHELIUM TOPOLOGY AND DEVELOPMENT

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Introduction

A key decisive in the understanding of morphogenesis processes concerns the description of the development of regular topology epithelial tissue as usually observed. The cell pattern is characterized by the average number of the cell neighbours (frequency distribution). Nevertheless, the mechanisms of packing geometry formation, such as the follicular tissue surrounding the *Ciona Intestinalis* egg, are poorly understood. In order to study further this epithelium development, we made a numerical model based on the mechanics of divided media. Here we propose two scenarios: one governed by cell accretion and the other managed by cell division. With the first one, we explore the influence of the growth rate and with the second one the incidence of mitosis.

Methods

Based on the physics of divided media [Voivret, 2009] the model is managed by contact and at-distance interactions for both the cytoplasm and the membrane. For each grain, the equation of dynamics is solved by using a 4th order Runge-Kutta scheme.

The two scenarios begin considering the same state: ten cells are randomly distributed at the surface of a sphere that represents a *Ciona* egg. Then, in the accretion scenario, the sphere and the cells grow while new small cells arrive. In the division scenario, the cells grow and afterwards divide and/or die. At the end of the simulation, when the surface is totally covered, the number of neighbours of each cell is counted (fig. 1) and their frequency is deduced.

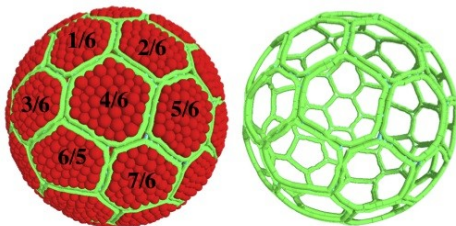


Figure 1: End of the simulation, inside the cell the index of the cell/ neighbour-number is noted.

Results

In the accretion simulations, the obtained numbers of neighbours appear close to the experimental results (fig. 2). The simulations 1 and 2 refer to calculations with a respectively low and high rate of growth.

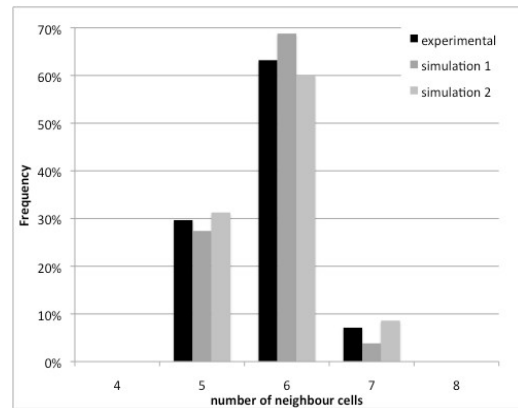


Figure 2: Average frequency of the neighbour cell number of epithelial cells.

The results issued from the division simulations are also in good agreement with observed distributions [Gibson, 2006].

Discussion

The fact that the experimental data are enclosed between the two simulation results shows the relevance of the numerical model with this set of parameters. We aim now testing those scenarios with different conditions for division, with two kind of cell with various division speeds or with different boundary conditions (e.g. cell culture boxes).

References

Gibson et al, Nature, Vol. 442, 31 August 2006.
Voivret et al, Phys. Rev. Lett. 102:e178001, 2009.