In a developmental process, a monolayer sheet of epithelial cells move collectively to achieve morphogenesis of epithelial tissues. A driving mechanism of such collective cell movement is junctional remodeling, as found in the clockwise rotation of genitalia in the morphogenesis of the *Drosophila* male terminalia. Since cells undergo elastic deformations, the influence of junctional remodeling may mechanically propagate among cells, leading to spontaneously establishment of spatiotemporal patterns. Here, using the numerical cellular vertex model, we find that junctional remodeling in collective cell movement exhibits a spatiotemporal self-organization without specific spatial patterns of signal activities. Junctional remodeling exhibits a propagation wave in a specific direction with speed much faster than that of the cell movement. Such a propagation occurs both in the absence and presence of the pulsatile contraction of cell boundaries.

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**PS1.55**

**Twist and skew: Spatial T1-transitions during cellularization in *Drosophila* explained by curvature-induced anisotropic stresses**

Jean-Francois Rupprecht, Jacques Prost, Timothy Saunders

Abstracts

Organ and tissue formation are complex three-dimensional processes involving cell growth and rearrangements, which all occur within curved boundaries. However, most theoretical studies focused on relatively flat epithelial tissues, i.e. with no significant curvature difference between the apical and basal sides of the tissue. Here, we focus on the modelling of the cellularization process in *Drosophila*, during which growth results in an increasingly curved basal surface. We aim at describing the following two experimental results concerning the cell morphology, as observed through state-of-the-art 3D microscopy in vivo: (i) cells can undergo neighbor exchange along the apical-basal axis (which we call apico-basal T1-transitions) with an increased occurrence within the curved embryo pole compared to the flat trunk region; and (ii) cells within the anterior pole skew toward the trunk along their long axis relative to the embryo surface, with maximum skew on the ventral side. Based on theoretical arguments, we find that the interplay between the tissue growth and the embryo curvature results in an anisotropic mechanical stresses that is maximal in the region of occurrence of apico-basal T1-transitions. In addition, we propose a vertex model for cells in a curved environment that quantitatively describe the observed cellular skew. We finally discuss why we expect the cell deformation and rearrangements to play important roles on the packing of cells confined in the highly curved three-dimensional environment of the *Drosophila* embryo. In line with D’Arcy Thompson approach, our study illustrates that the increasingly complex processes observed during morphogenesis can still be explained from mechanical arguments.

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**PS1.56**

**Wave propagation of junctional remodeling in collective cell movement of epithelial tissue**

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Abstracts

Collective cell migration has been studied as a self organization in life activities. Recently, rotational phenomena of collective cell migrations observed in morphogenesis are focused. For example, they are observed in the elongation process of somite in Zebrafish (unpublished data by H. Takeda (The University of Tokyo) et al.) and the fruiting body formation of Dictyostelium discoideum. Thus, because rotational phenomena can be observed in distinct cell species, we conjecture that they are generated by a universal mechanism for cells. Our goal is to extract vital mechanisms of collective cell migrations in morphogenesis from the viewpoint of mathematics. As a typical mathematical approach, several self-propelled particle models based on the Vicsek model have often studied. In this study, we propose a self-propelled particle model focusing on cell polarity and cell-cell adhesive force, and explore mechanisms of which each migration mode occurs robustly for the parameters and the initial conditions. In this presentation, as a numerical result, we will show a phase diagram for the parameters of a driving force by the cell polarity and the cell-cell adhesive force. This phase diagram can be separated to four regions indicating the following migration modes, respectively: (i) Rigid rotational migration, (ii) Non-rigid rotational migration, (iii) Reversal rotational migration, and (iv) Cancer cell-like migration. In fact, the three modes (i), (ii), and (iv) are observed in several cells. On the other hand, The mode (iii) has not been known as a typical migration mode. However, it is shown in a recent experiment using cancer cells by H. Haga (Hokkaido University) et al. that (iii) appears as a migration mode by the cancer cells with high cell-cell adhesive force. This implies that an actual cell migration is suggested from our mathematical model.

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**PS1.57**

**A mathematical model of cell polarity and cell migration**

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Collective cell migration has been studied as a self organization in life activities. Recently, rotational phenomena of collective cell migrations observed in morphogenesis are focused. For example, they are observed in the elongation process of somite in Zebrafish (unpublished data by H. Takeda (The University of Tokyo) et al.) and the fruiting body formation of Dictyostelium discoideum. Thus, because rotational phenomena can be observed in distinct cell species, we conjecture that they are generated by a universal mechanism for cells. Our goal is to extract vital mechanisms of collective cell migrations in morphogenesis from the viewpoint of mathematics. As a typical mathematical approach, several self-propelled particle models based on the Vicsek model have often studied. In this study, we propose a self-propelled particle model focusing on cell polarity and cell-cell adhesive force, and explore mechanisms of which each migration mode occurs robustly for the parameters and the initial conditions. In this presentation, as a numerical result, we will show a phase diagram for the parameters of a driving force by the cell polarity and the cell-cell adhesive force. This phase diagram can be separated to four regions indicating the following migration modes, respectively: (i) Rigid rotational migration, (ii) Non-rigid rotational migration, (iii) Reversal rotational migration, and (iv) Cancer cell-like migration. In fact, the three modes (i), (ii), and (iv) are observed in several cells. On the other hand, The mode (iii) has not been known as a typical migration mode. However, it is shown in a recent experiment using cancer cells by H. Haga (Hokkaido University) et al. that (iii) appears as a migration mode by the cancer cells with high cell-cell adhesive force. This implies that an actual cell migration is suggested from our mathematical model.

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