

Phase transition in the collective migration of tissue cells: Experiment and model

(Szabó Model)

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- 1 Introdução
- 2 Experimento
- 3 Modelo
- 4 Resultados

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Movimento coletivo

- Cardumes de peixes
- Hordas de quadrúpedes
- Grupos de pássaros
- Colônias de bactérias (Fractais)
- Agregados de amoeba (Vórtex)
- Células de esperma (Vórtex)

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Descrição

- 1 Keratocytes (Goldfish scale tissue cell);
- 2 Estudo da migração das células;
- 3 Variando densidade ρ ;

Resultado: Observam uma transição brusca de uma mobilidade desordenada para migração coletiva ordenada de alguns grupos à medida que ρ aumenta.

Experimento

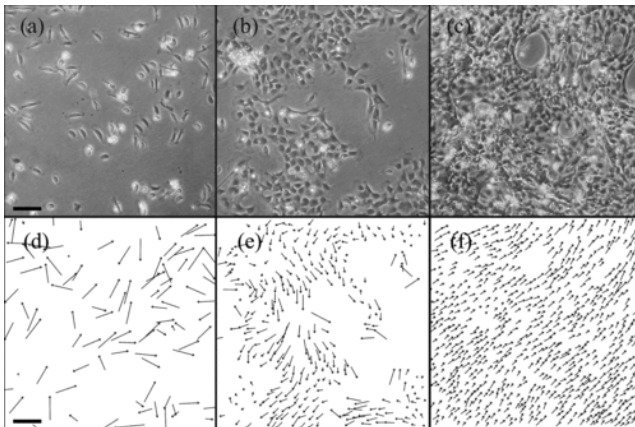


Figura: Phase contrast images showing the typical behavior of cells for three different densities. (a) 1.8, (b) 5.3, (c) 14.7 cells/100x100μm². We observed that as cell density increases cell motility undergoes collective ordering. The speed of single cells is higher than that of cells moving in coherent groups. Scale bar 200μm. (d)–(f) Velocity of cells. Scale bar 50μmmin. Reference 17 contains corresponding videos.

- N : Número de células;
- \vec{v}_i : Velocidade da célula;

$$\bar{V} = \left\langle \frac{1}{N} \sum_{i=1}^N \frac{v_i(\vec{t}_k)}{|\vec{v}_i(\vec{t}_k)|} \right\rangle_{t_k} \quad (1)$$

Resultados experimentais

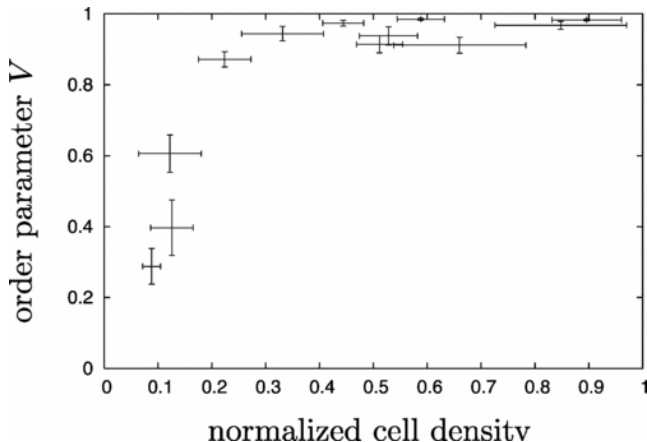


Figura: Order parameter is shown as a function of normalized cell density. Cell density was normalized with the maximal observed density of $2.5 \times 10^3 \text{ cells}/\mu\text{m}^2$ and error bars indicate the standard error of the density and order parameter..

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Descrição

- ① Self-Propelled Particles (SPP's);
 - ② Se movem adiante com velocidade bem definida;
 - ③ Direção sofre ruído;
- "collective motion must emerge solely as a result of direct cell to cell interactions (forces)."
 - "we consider self-propelled particles model cells that attempt to adjust their direction of motion toward the direction of the net-force acting on them."

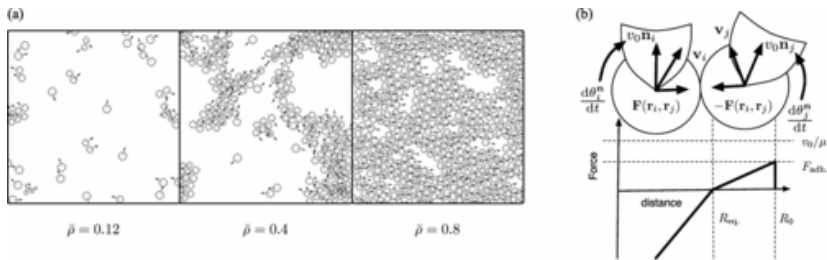


Figura: Computer simulations were performed of the system described in the text for different densities. These simulations showed a transition to the ordered phase similar to that seen in experiments. (a) Typical behavior of cells is shown for three different values of the normalized number density $\bar{\rho} = \rho/\rho_{max}$, with $\rho_{max} = 2$, which is approximately the density where gaps disappear, and the cells reach tight packing in simulations.

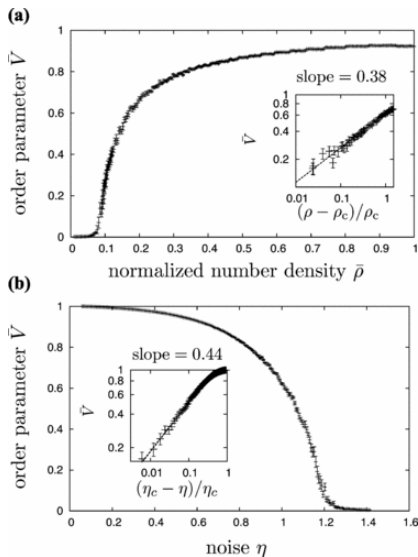
- v_0 : self-propelling velocity magnitude;
- $\vec{n}_i(t)$: Vetor unitário de direção;
- $\vec{F}(\vec{r}_i, \vec{r}_j)$: Força entre células;
- μ : mobilidade;

$$\frac{d\vec{r}_i(t)}{dt} = v_0 \vec{n}_i(t) + \sum_{j=1}^N \vec{F}(\vec{r}_i, \vec{r}_j)$$

- e_z : vetor ortogonal ao plano de movimento;
- τ : relaxation time;
- ξ : Gaussian white noise;

$$\frac{d\theta^{\vec{n}_i}(t)}{dt} = \frac{1}{\tau} \arcsin \left[\left(\vec{n}_i(t) \frac{\vec{v}_i(t_k)}{|\vec{v}_i(t_k)|} \right) \cdot \mathbf{e}_z \right] + \xi$$

Resultados



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Block 2

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Shuntaro Takahashi, Hiroyuki Furusawa, Takuya Ueda, and Yoshio Okahata.

Translation enhancer improves the ribosome liberation from translation initiation.

Journal of the American Chemical Society, 135(35):13096–13106, 2013.

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