Supplementary Material: Cell sorting by active forces in a phase-field model of cell monolayers

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February 15, 2024

1 Supplementary Figures

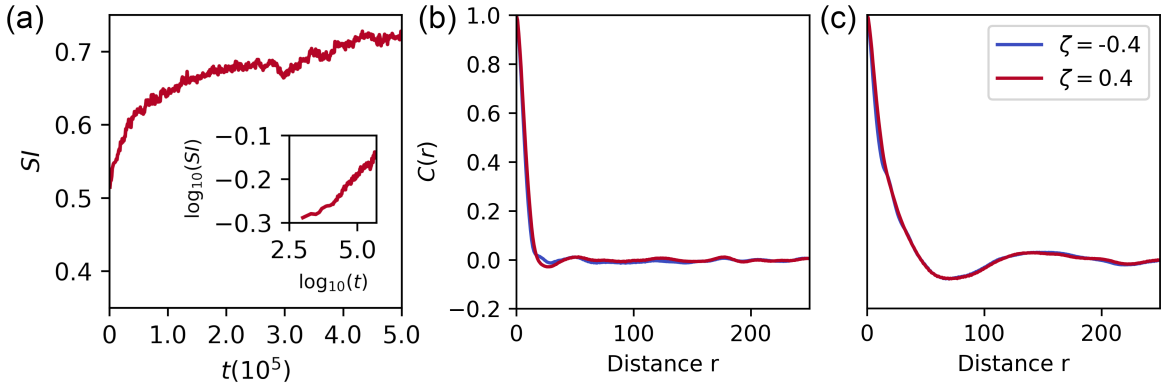

Fig. SI1: Segregation in a 1:1 mixture of extensile and contractile cells. (a) Segregation index SI versus time. The onset of segregation is fast, and the SI increases past ~ 0.7 on the timescale of the simulation. The inset showing SI on log-log axes indicates the system coarsens steadily. (b) Density autocorrelation function $C(r)$ at time (b) $t = 1 \times 10^3$ (c) $t = 5 \times 10^5$.

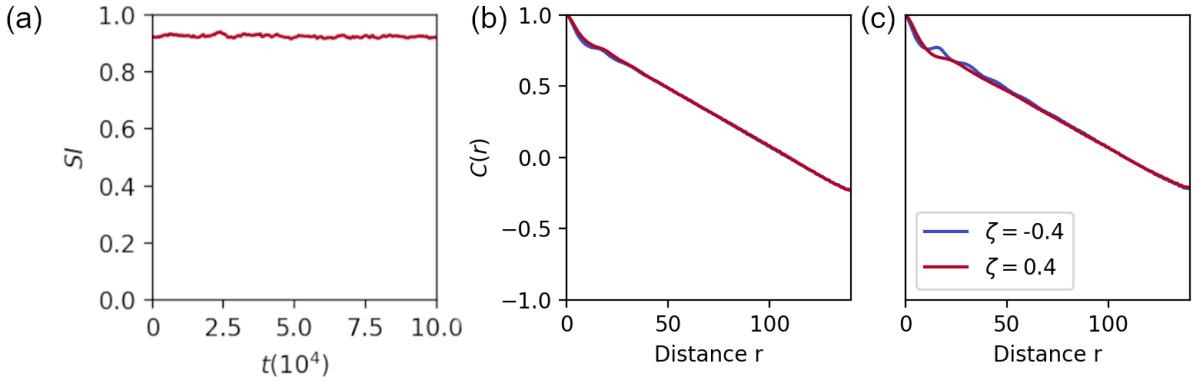

Fig. SI2: Ordering in system prepared in a $1:1$ macrophase-separated initial condition, with $\zeta_{\text{inter}} = \pm 0.4$, illustrated in main text Fig. 1 (c) and (d). (a) Segregation index SI. Aside from small fluctuations, the SI remains high because almost all cells are entirely surrounded by neighbours of the same type. (b) Density autocorrelation function $C(r)$ at time (b) $t = 5 \times 10^2$ (c) $t = 1 \times 10^5$.

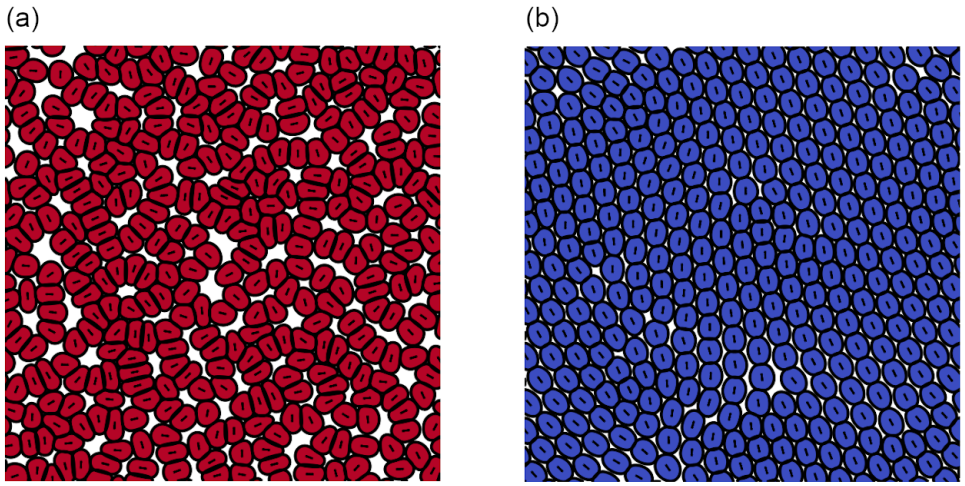

Fig. SI3: Snapshots of monolayers of $n = 336$ (a) extensile ($\zeta_{\text{inter}} = +0.4$) and (b) contractile ($\zeta_{\text{inter}} = -0.4$) cells. The extensile system is unjammed and has free space, while the contractile system is close to jammed.

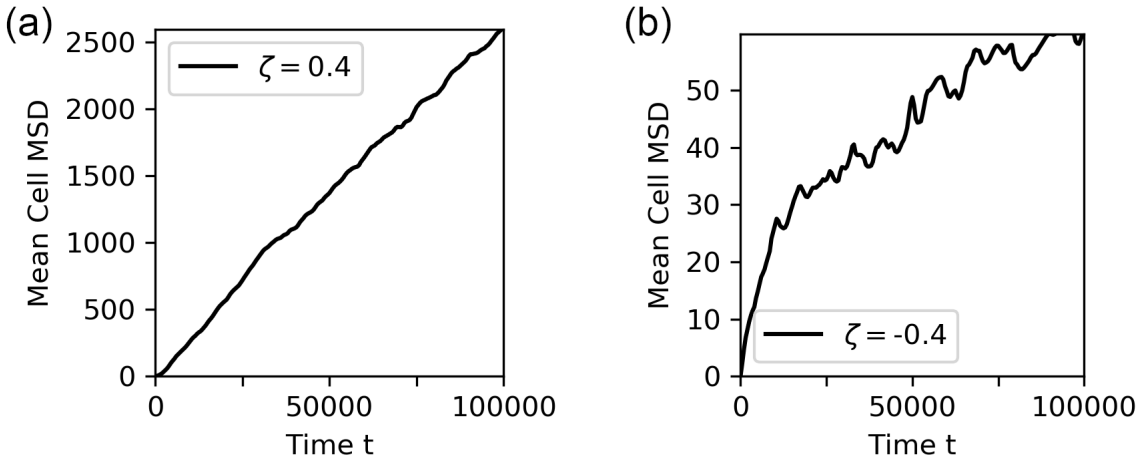

Fig. SI4: Mean-square displacement of (a) extensile cells with $\zeta_{\text{inter}} = +0.4$ and (b) contractile cells with $\zeta_{\text{inter}} = -0.4$. The extensile cells are fluidised while the contractile cells are almost jammed.

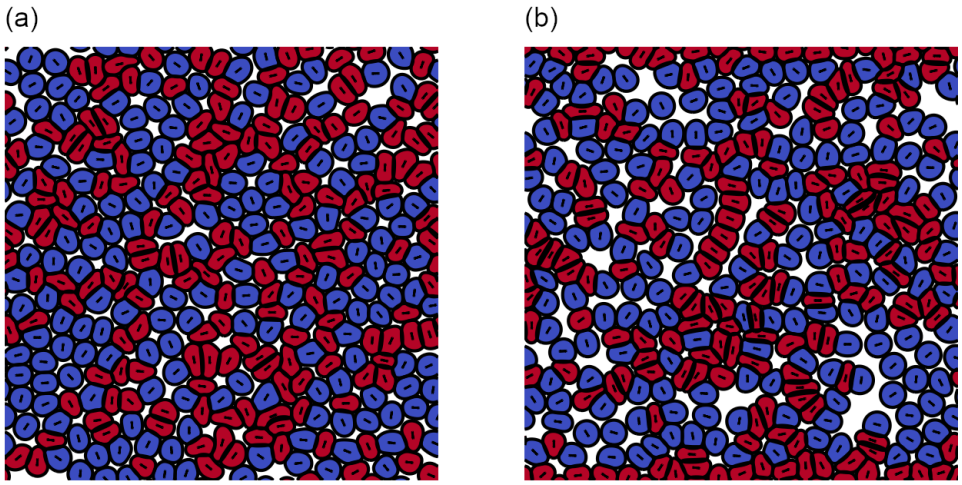

Fig. SI5: Snapshots of the evolution of a $1:1$ mixture of extensile (red, $\zeta_{\text{inter}} = +0.8$) and passive (blue, $\zeta_{\text{inter}} = 0.0$) cells. In this simulation, the difference in ζ_{inter} between the constituents of the mixture is the same as in the main text, which concerns $\zeta_{\text{inter}} = +0.4, -0.4$. System visualised at (a) $t = 5 \times 10^2$, (b) $t = 1 \times 10^5$ for a fully mixed initial condition showing no microphase separation. The system remains mixed for the duration of the simulation, although some transient structures of order one cell width do emerge.

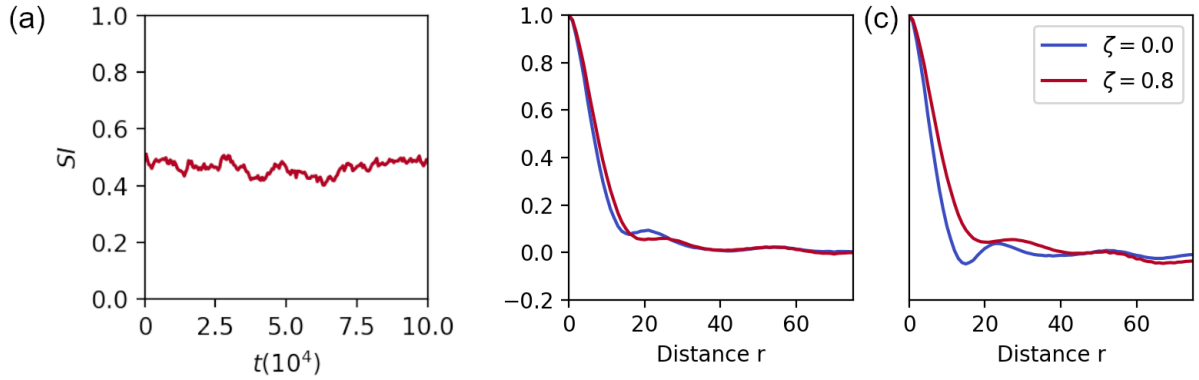

Fig. SI6: Failure to order in a $1:1$ mixture of extensile ($\zeta_{\text{inter}} = +0.8$) and passive ($\zeta_{\text{inter}} = 0.0$) cells. (a) Segregation index SI. Over time, the SI fluctuates around a value close to $1/2$. (b) Density autocorrelation $C(r)$ at time (b) $t = 5 \times 10^2$ and (c) $t = 1 \times 10^5$. Over the course of the simulation, the locations of the minima do not change although they do get more pronounced. These metrics do not resolve transient chains of extensile and contractile cells that form and re-form during the simulation.

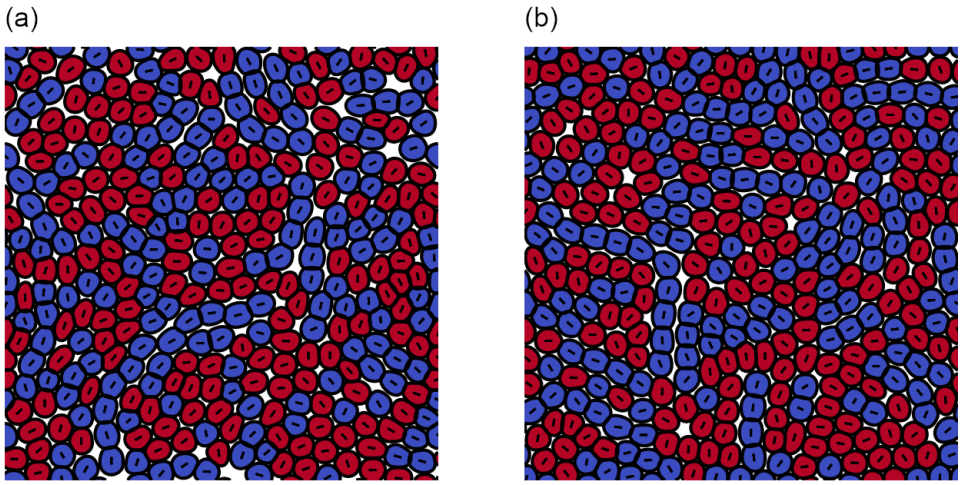

Fig. SI7: Snapshots of the evolution of a $1:1$ mixture of passive (red, $\zeta_{\text{inter}} = 0.0$) and contractile (blue, $\zeta_{\text{inter}} = -0.8$) cells. In this simulation, the difference in ζ_{inter} between the constituents of the mixture is the same as in the main text, which concerns $\zeta_{\text{inter}} = +0.4, -0.4$. System visualised at (a) $t = 5 \times 10^2$, (b) $t = 1 \times 10^5$ for a fully mixed initial condition showing no microphase separation. The system remains mixed for the duration of the simulation.

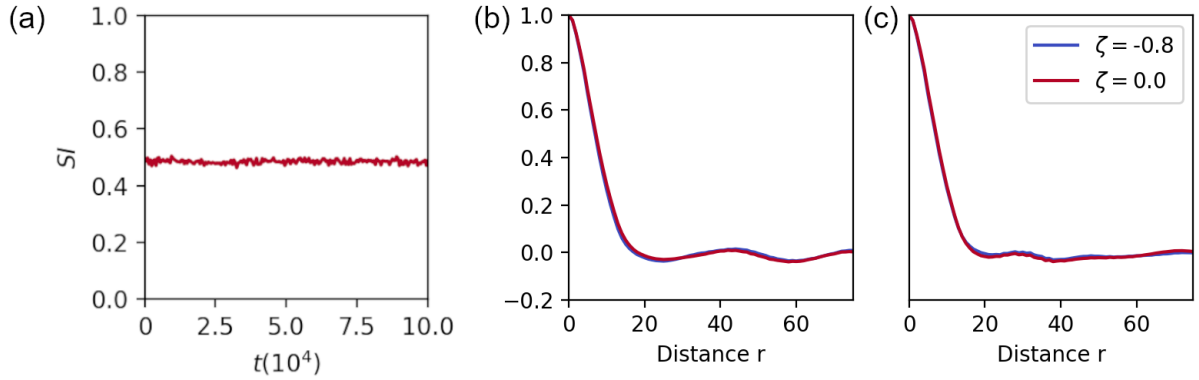

Fig. SI8: Failure to order in a $1:1$ mixture of passive ($\zeta_{\text{inter}} = 0.0$) and contractile ($\zeta_{\text{inter}} = -0.8$) cells. (a) Segregation index SI. Over time, the SI fluctuates around a value close to $1/2$. Density autocorrelation $C(r)$ at time (b) $t = 5 \times 10^2$ and (c) $t = 1 \times 10^5$. The length scale of the system in fact *shrinks* slightly: the disordered initial condition evolved into a packing that is close to ordered, although the system does not demix.

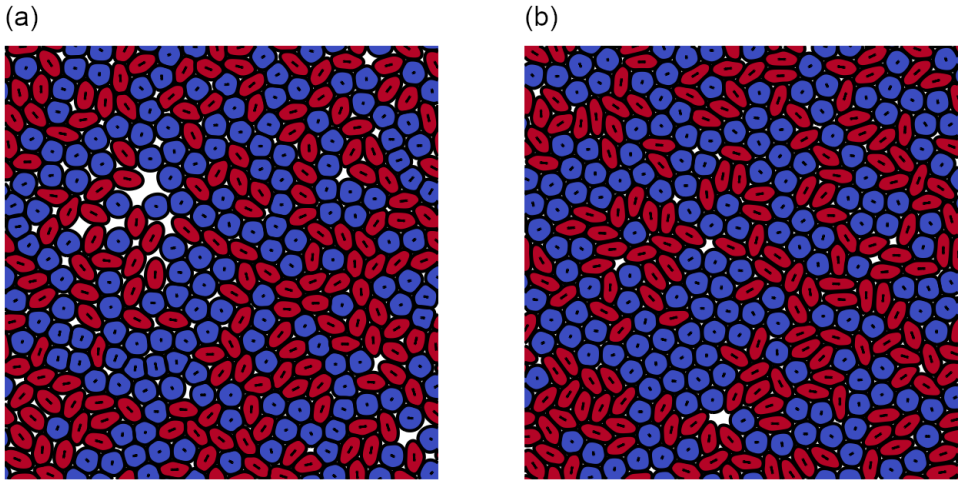

Fig. SI9: Snapshots of the evolution of a $1:1$ mixture of extensile (red, $\zeta_{\text{inter}} = \zeta_{\text{self}} = 0.4$) and contractile (blue, $\zeta_{\text{inter}} = \zeta_{\text{self}} = -0.4$) cells at (a) $t = 5 \times 10^2$ and (b) $t = 1 \times 10^5$. Contractile cells are closer to isotropic, while extensile cells again arrange themselves in a 'capped-line' fashion. The start and end states are correlated because the dynamics are slow.

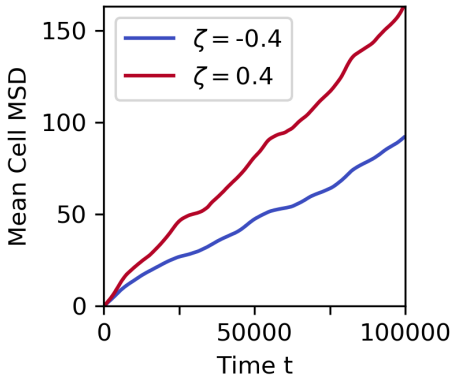

Fig. SI10: Mean-square displacement in a $1:1$ mixture of extensile and contractile cells, with $\zeta_{\text{self}} = \zeta_{\text{inter}}$ for both species. The diffusion of the phase-field cells is much slower than when $\zeta_{\text{self}} = 0$.

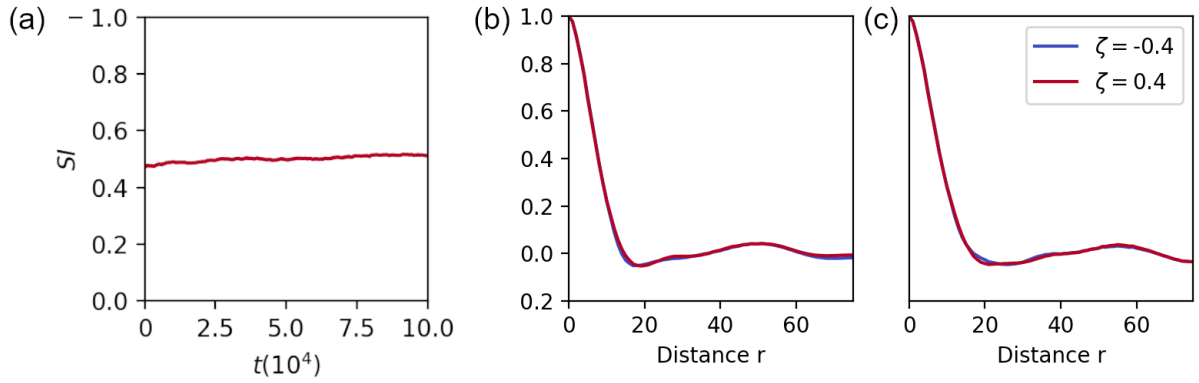

Fig. SI11: Slowed-down ordering in a $1:1$ mixture of extensile and contractile cells, with $\zeta_{\text{self}} = \zeta_{\text{inter}}$ for both species. (a) The segregation index SI grows very slowly. The density autocorrelation $C(r)$ at time (b) $t = 5 \times 10^2$ and (c) $t = 1 \times 10^5$ shows a first minimum at slightly larger r at $t = 10^5$. Commensurate with the slow diffusion in Figure SI10 any signatures of phase separation develop more slowly than in the system with $\zeta_{\text{inter}} = \pm 0.4, \zeta_{\text{self}} = 0$. Microphase separation may emerge on much longer timescales.