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Emergence of tissue mechanics from cellular processes: shaping a fly wing MATTHIAS MERKEL, Max Planck Institute for the Physics of Complex Systems, Dresden (MPI-PKS), RAPHAEL ETOURNAY, Max Planck Institute of Molecular Biology and Genetics, Dresden (MPI-CBG), MARKO POPOVIC, AMITABHA NANDI, MPI-PKS, HOLGER BRANDL, MPI-CBG, GUILLAUME SALBREUX, Crick Institute, London, SUZANNE EATON, MPI-CBG, FRANK JLICHER, MPI-PKS — Nowadays, biologistsare able to image biological tissueswith up to 10,000 cells in vivowhere the behavior of each individual cell can be followed in detail.However, how precisely large-scale tissue deformation and stresses emerge from cellular behavior remains elusive. Here, we study this question in the developing wing of the fruit fly. To this end, we first establish a geometrical framework that exactly decomposes tissue deformation into contributions by different kinds of cellular processes. These processes comprise cell shape changes, cell neighbor exchanges, cell divisions, and cell extrusions. As the key idea, we introduce a tiling of the cellular network into triangles. This approach also reveals that tissue deformation can also be created by correlated cellular motion. Based on quantifications using these concepts, we developed a novel continuum mechanical model for the fly wing. In particular, our model includes active anisotropic stresses and a delay in the response of cell rearrangements to material stresses. A different approach to study the emergence of tissue mechanics from cellular behavior are cell-based models. We characterize the properties of a cell-based model for 3D tissues that is a hybrid between single particle models and the so-called vertex models.

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