In vivo morphology and cell dynamics: laser microscopy and patterns of "criticality" in oncological transformations

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Statistically based model of the DNA ensemble evolution allowed the formulation of mechanobiological approach linking the open complex dynamics and different scenario of gene expression related to normal and cancerous cell behaviour. It was shown the correspondence of open complex dynamics to specific type of criticality in mesodefects ensemble (the structural-scaling transition) in the presence of the mesoscopic potential associated with the epigenetic landscape. The role of open complexes is similar to the mesoscopic defects and provides the cell plasticity or the cell fragility depending on the structural susceptibility of the cytoskeleton structure and the types of collective modes of defects (open complexes). These modes are responsible for the DNA transformation leading to the natural cycle of gene expression and the cell division or spontaneous cell fragmentation with anomalous proliferation as the cancer precursor. A special type of critical phenomena (structural-scaling transitions) has been established, linking the nonlinear dynamics of the order parameter with the conditions of "thermalization" - "effective temperature", reflecting the interaction of open complexes, and the role of the latter in various scenarios of gene expression. The collective modes of "open states" are of the nature of self-similar solutions and can be considered as a mechanism associated with the dynamics of gene expression, transcription, and cell division. A variety of structural-scaling transitions and types of potential metastability (nonequilibrium free energy) due to "open states" allow us to offer an explanation for the landscapes of Waddington during cell evolution. It has been shown that the dynamics of "open states" as defects can be associated with the "ductile" states of normal cells and the "quasi-fragile" states of cancer cells with the corresponding dynamics of expression. The established patterns of "criticality" in the behavior of "open states" are used to interpret the original experimental data on in vivo cell dynamics obtained by laser (interference) microscopy. The analysis of fluctuations of "phase thicknesses" made it possible to establish the existence of multifractal spectra for normal (plastic) cells and monofractal for "embrittled" cancer cells. Study of the influence of external forces on cell dynamics made it possible to propose an explanation for the change in phenotypes under microgravity conditions. The results of the analysis of intravital cell dynamics are compared with the data on the processing of temperature field fluctuations, which established signs of multifractality for healthy tissue and monofractality for tissue with oncological pathologies.

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