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GLOBAL DYNAMICS OF TWO COMPARTMENT MODELS FOR CELL PRODUCTION SYSTEMS WITH REGULATORY MECHANISMS

We analyze two-compartment models of a hierarchical cell production system under three different mechanisms of regulation by the level of mature cells. In the first model the stem cell's division rate is regulated whereas in the second model the stem cell's fraction of self-renewal is regulated. For these two models we prove that respective reproduction numbers exceed one if and only if a positive equilibrium exists and that it is globally asymptotically stable. This shows that the regulation mechanisms control the cell production system properly and that homeostatic conditions of stem and mature cells are reached. For the mathematical proof we employ a method of Lyapunov function exploiting nonlinearity of the model. We show that the amount of stem cell population that keep the balance of mature cell population influences on the dynamical behavior of cell populations and compare the amount of stem and mature cells at equilibrium. Additionally, we formulate a third model, in which the stem cell's fraction of differentiation is regulated. We prove that a positive equilibrium, if it exists, is unstable and the numbers of stem and mature cells always tend to infinity if the reproduction number exceeds one.