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Optimal architecture of differentiation cascades with asymmetric and symmetric stem cell division

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Abstract

The role of symmetric division in stem cell biology is ambiguous. It is necessary after injuries, but if symmetric divisions occur too often, the appearance of tumours is more likely. To explore the role of symmetric and asymmetric division in cell populations, we propose a mathematical model of competition of populations, in which the stem cell expansion is controlled by fully differentiated cells. We show that there is an optimal fraction of symmetric stem cell division, which maximises the long-term survival probability of the organism. Moreover, we show the optimal number of stem cells in a tissue, and we show that number has to be small enough to reduce the probability of the appearance of advantageous malignant cells, and large enough to assure that the population will not be suppressed by stochastic fluctuations.

Keywords: stem cells, (a)symmetric division, stochastic model, optimal architecture.

1. Introduction

Stem cells (SC) are the cells responsible for maintaining cellular homeostasis [1]. The potential for indefinite division is what gives the SC this ability, with a correct balance between the self-renewal and differentiation processes. If the two cells resulting from the division are identical, we refer to it as symmetric division. On the contrary, if both divided cells are different, it is an asymmetric division. Differentiation is the process by which the cells modify their morphology and genetic expression, to get the necessary qualities for the specific tissue

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