Mathematical Modeling of Regulatory Mechanisms in Yeast Colony Development

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Summary: In the present study, yeast colony development serves as a model system to study growth of fungal populations with negligible nutrient- and signal transport within the mycelium. Mathematical simulations address the question whether colony development is governed by diffusional limitation of nutrients. A hybrid one-dimensional cellular automaton model was developed that describes growth of discrete cells based upon microscopic interaction rules in a continuous field of nutrient and messenger. The model is scaled for the geometry of the experimental setup, cell size, growth- and substrate uptake rates. Therefore, calculated cell density profiles and nutrient distributions can be compared to experimental results and the model assumptions can be verified. In the physiologically relevant parameter range, simulations show an exponentially declining cell density along the median axis of the colonies in case of a diffusion limited growth scenario. These results are in good agreement with cell density profiles obtained in cultivations of the yeast *Candida boidinii* with glucose as the limiting carbon source but stand in contrast to the constant cell density profile estimated for *Yarrowia lipolytica* grown under the same conditions. While from the comparison of experimental results and simulations a diffusion limited growth mechanism is proposed for glucose limited *C. boidinii* colonies, this hypothesis is rejected for the growth of *Y. lipolytica*. As an alternative, a quorum sensing model was developed that can explain the evolution of constant cell density profiles based on the effect of a not further characterized unstable or volatile messenger.