Models and molecular mechanisms for trade-offs in the context of metabolism

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Abstract

Accumulating evidence for trade-offs involving metabolic traits has demonstrated their importance in evolution of organisms. Metabolic models with different level of complexity have already been considered when investigating mechanisms that explain various metabolic trade-offs. Here we provide a systematic review of modelling approaches that have been used to study and explain trade-offs between: (i) kinetic properties of individual enzymes, (ii) rates of metabolic reactions, (iii) rate and yield of metabolic pathways and networks, (iv) different metabolic objectives in single organisms and in metabolic communities, and (v) metabolic concentrations. In providing insights into mechanisms underlying these five types of metabolic trade-offs obtained from constraint-based metabolic modelling, we emphasize the relation of metabolic trade-offs to the classical black box Y-model that provides conceptual explanation for resource acquisition-allocation trade-offs. In addition, we identify several pressing concerns and offer a perspective for future research in the identification and manipulation of metabolic trade-offs by relying on the toolbox provided by constraint-based metabolic modelling for single organisms and microbial communities.

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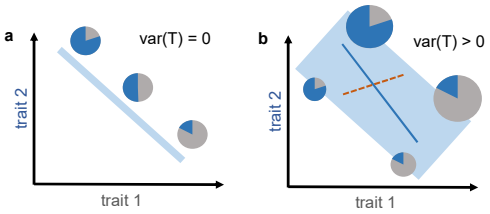

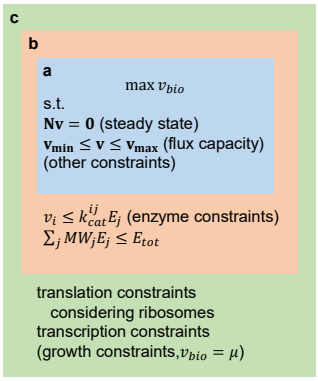

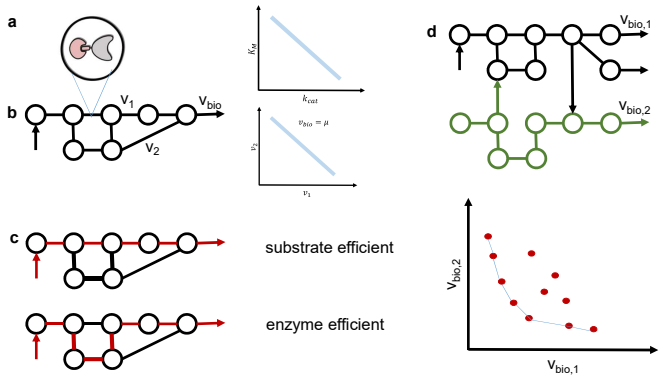

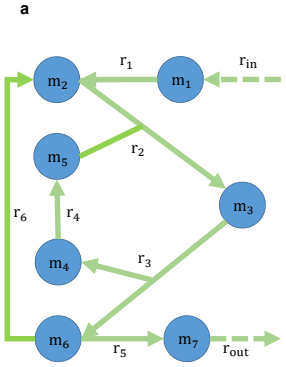

b

$$v_1 + v_6 = v_2$$
$$\frac{dc_2}{dt} = v_1 + v_6 - v_2$$

$$v_5 + v_6 = v_3$$
$$\frac{dc_6}{dt} = v_3 - v_5 - v_6$$

c

$$c_3 + c_4 + c_5 = const.$$

$$\frac{dc_3}{dt} = v_2 - v_3$$
$$\frac{dc_4}{dt} = v_3 - v_4$$
$$\frac{dc_5}{dt} = v_4 - v_2$$
$$\frac{dc_3}{dt} + \frac{dc_4}{dt} + \frac{dc_5}{dt} = 0$$