Supporting Material, File S2 Text

Homeostatic Controllers Compensating for Growth and Perturbations

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Steady state of transporter-generated compound A without negative feedback

We start with Eq. 15 where transporter T pumps external A (A_{ext}) into a constantly growing cell ($\dot{V}$=constant)

$$\dot{A} = \frac{k_2 \cdot T}{V} - A\left(\frac{\dot{V}}{V}\right) \tag{S1}$$

We assume that the surface concentration of T is constant and that the pump rate is zero-order with respect to the external A concentration.

The steady state of A is given by setting Eq. S1 to zero, which gives

$$\dot{A} = \frac{k_2 \cdot T}{V} - A\left(\frac{\dot{V}}{V}\right) = 0 \quad \Rightarrow \quad A_{ss} = \frac{k_2 \cdot T}{\dot{V}} \tag{S2}$$

independent of the initial concentration of A.

In case there is a first-order removal of cellular A with respect to A the rate equation becomes

$$\dot{A} = \frac{k_2 \cdot T}{V} - k_3 \cdot A - A\left(\frac{\dot{V}}{V}\right) = 0 \tag{S3}$$

Setting Eq. S3 to zero leads to

$$A_{ss} = \frac{k_2 \cdot T}{k_3 V + \dot{V}} \;\rightarrow\; 0 \quad \text{as} \quad \text{V} \rightarrow \infty \tag{S4}$$

In case the removal of cellular A is zero-order with respect to A (for example by an enzyme removing A at maximum velocity V_{max}), then in this case the steady state condition

$$\dot{A} = \frac{k_2 \cdot T}{V} - V_{max} - A\left(\frac{\dot{V}}{V}\right) = 0 \tag{S5}$$

gives

$$A_{ss} = \frac{1}{\dot{V}} \left(k_2 \cdot T - V_{max} \cdot V\right) \tag{S6}$$

As the volume V grows there will be a critical volume V_{crit}=k_2T/V_{max} at which A_{ss} becomes zero.