Models for Growth Kinetics of Yeast

With respect to the recent paper on the growth kinetics of yeast,[1] we would like to offer some corrections and suggestions. Our remarks pertain to the growth model

$$\mu = D_T \frac{s}{K_s + s} + as \tag{1}$$

given as eq. (7) by Mason and Millis.

First, a plot of this equation with μ as abscissa and s as ordinate would not have the asymptotic behavior as shown in their Figure 3(a). Rather, at high values of s ($s \gg K_s$) the asymptotic line is $s = (\mu - D_T)/a$ with a slope of $1/a$ and an intercept of D_T, see Figure 1.

At low values of s ($K_s \gg s$), the asymptotic line is

$$s = \frac{\mu}{D_T/K_s + a} \tag{2}$$

which has a slope of $(D_T/K_s + a)^{-1}$ and goes through the origin.

If eq. (1) is plotted in the Lineweaver–Burk manner (Fig. 2) the curve is quite different than that given in Figure 3(b) of ref. 1. As shown below when eq. (2) is plotted in reciprocal coordinates, one obtains an S-shaped curve. At high values of $1/s$, $K_s \gg s$, so that the asymptotic line to the curve becomes

$$\frac{1}{s} = \frac{1}{\mu}\left(\frac{D_T}{K_s} + a\right) \tag{3}$$

which goes through the origin with a slope of $(D_T/K_s + a)$.

At intermediate values of $1/s$, $s \gg K_s$,

$$\frac{1}{\mu} = \frac{1}{D_T/a + s} \cdot \frac{1}{a} \tag{4}$$

This equation does not give a straight line on $1/s$ vs. $1/\mu$ coordinates and therefore is not an asymptotic form.

At still lower values of $1/s$, $s \gg D_T/a$, another asymptotic equation is obtained

$$1/s = a/\mu \tag{5}$$

This line also goes through the origin with a slope of a. Therefore the Lineweaver–Burk plot has an inflection point since $(D_T/K_s + a)$ must be greater than a, as all the constants are positive.

Further, the authors give an enzyme kinetic mechanism for the form of eq. (1). However, it should be pointed out that carrier-mediated diffusion through membranes also obeys eq. (1) under some circumstances. One kinetic model for carrier-mediated transport is[2]

$$J = \frac{D_s}{L}(s_o - s_i) + \frac{D_c C}{L}\left(\frac{s_o}{K_s + s_o} - \frac{s_i}{K_s + s_i}\right) \tag{6}$$

where J is the flux across the membrane, D_s and D_c are the diffusivities of substrate and carrier complex in the membrane, L is the thickness of the membrane, s_o and s_i

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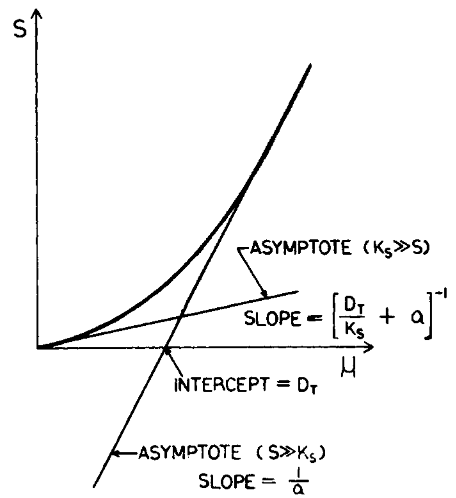

Fig. 1. Plot of growth model on rectangular coordinates with limiting asymptotic lines at high and low substrate concentrations.

are the substrate concentrations on each side of the membrane, K_s is the binding constant between substrate and carrier, and C is the carrier concentration in the membrane. If substrate transport across a membrane limits the growth rate, then the substrate concentration on the inside of the membrane, s_i, may approach zero so that the transport equation becomes

$$J = \frac{D_s}{L} s_o + \frac{D_c C}{L} \frac{s_o}{K_s + s_o} \tag{7}$$

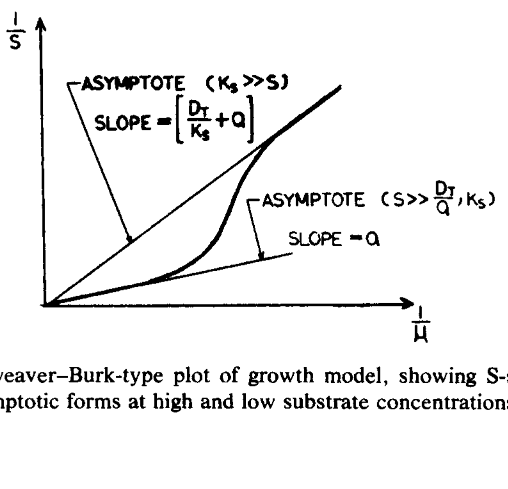

Fig. 2. Lineweaver–Burk-type plot of growth model, showing S-shaped curve and limiting asymptotic forms at high and low substrate concentrations.

This is the same form as the proposed growth model, eq. (1), with the constants related by $a = D_s/L$ and $D_T = D_c C/L$.

References

1. T. J. Mason and N. F. Millis, *Biotechnol. Bioeng.*, **18**, 1337 (1976).
2. J. S. Schultz, J. D. Goddard, and S. R. Suchdeo, *AIChE J.*, **20**, 417 (1974).

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