1920s

1913 Sucrose $\xrightarrow{?}$ Glc + Fru

Invertase — Enzyme

Michaelis – Menten

① $E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES$

② $ES \xrightarrow{k_2} P + E$

$t=0$

$[E]_0 = [E] + [ES]$

$[S]_0 = [S] + [ES] + [P]$

$[S]_0 \gg [E]_0 > [ES]$

$$\frac{d[ES]}{dt} = k_1[E][S] - (k_{-1}+k_2)[ES] \approx 0 \quad \text{at SS}$$

$$v = \frac{d[P]}{dt} = k_2[ES]$$

$$= k_2$$

$$0 = k_1([E]_0 - [ES])([S]_0 - [ES] - [P]) - (k_{-1}+k_2)[ES]$$

$[S] \gg [ES]$

$v_t \to 0$

$$\approx k_1([E]_0 - [ES])[S]_0 - (k_{-1}+k_2)[ES]$$

$$= k_1[E]_0[S]_0 - (k_1[S]_0 + k_{-1} + k_2)[ES]$$

$$\boxed{[ES]_{SS} = \frac{k_1[E]_0[S]_0}{k_1[S]_0 + k_{-1} + k_2}}$$

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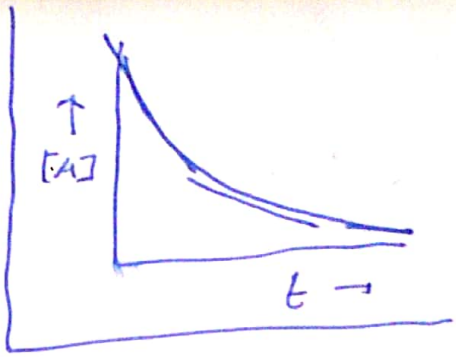
$$v_0 = \left.\frac{d[P]}{dt}\right|_{t\to 0} = k_2 [ES]_{ss}$$

$$= k_2 \times \frac{k_1 [E]_0 [S]_0}{k_1 [S]_0 + k_{-1} + k_2}$$

$$= \frac{k_2 [E]_0}{1 + \frac{k_{-1}+k_2}{k_1}\frac{1}{[S]_0}} \qquad v_{max}$$

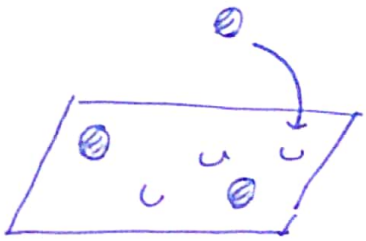
$$\downarrow \quad K_M$$

$$v_0 = \frac{v_{max}}{1 + \frac{K_M}{[S]_0}}$$

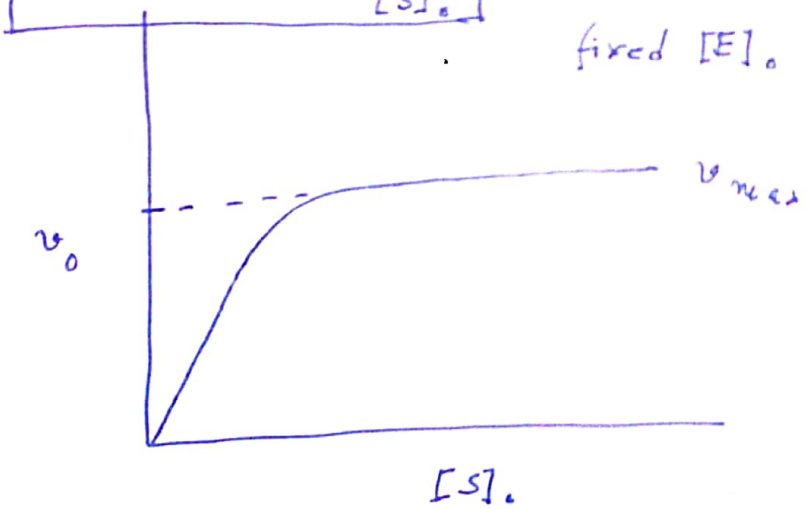


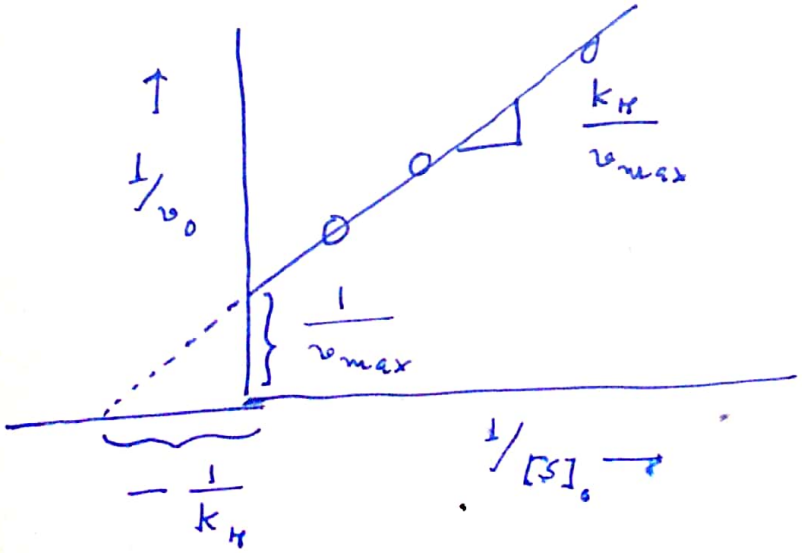
$v_0 \propto [S]_0 \quad [S]_0 \to 0$

$v_0 = k_2[E]_0 \quad [S]_0 \to \infty$



fixed $[E]_0$





$$v_0 = \frac{v_{max}}{1 + \frac{K_M}{[S]_0}}$$

$$\frac{1}{v_0} = \frac{1}{v_{max}} + \frac{K_M}{v_{max}}\frac{1}{[S]_0}$$

Lineweaver – Burk plot

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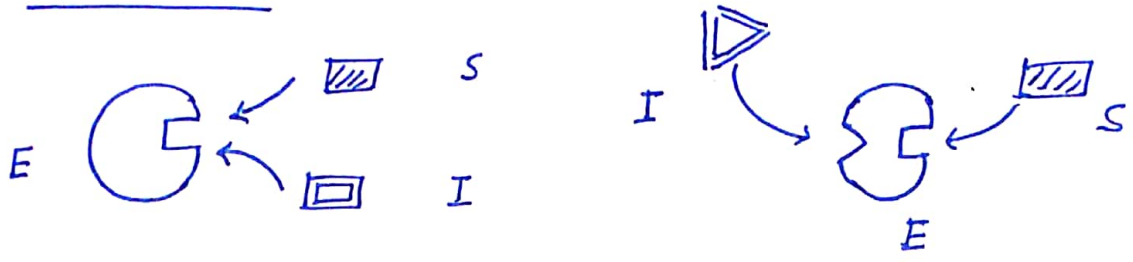
$[S]_o = [S] + [ES] + [P]$

Inhibition



Competitive inhibition Non-competitive inhibition

A) Competitive :

① $E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES$

② $ES \xrightarrow{k_2} P + E$

③ $E + I \rightleftharpoons EI$ $\quad K_I = \dfrac{[E][I]}{[EI]}$

$[E]_o = [E] + [ES] + [EI]$

$= [E] + [ES] + \dfrac{[E][I]}{K_I}$

$= [ES] + \left(1 + \dfrac{[I]}{K_I}\right)[E]$

$[E] = \dfrac{[E]_o - [ES]}{\left(1 + \dfrac{[I]}{K_I}\right)}$

$\left.\dfrac{d[ES]}{dt}\right|_{ss} \approx 0 = k_1 [E][S] - (k_{-1} + k_2)[ES]$

$= k_1 \left\{\dfrac{[E]_o - [ES]}{(\quad)}\right\}[S]_o - (k_{-1} + k_2)[ES]$

$= \dfrac{k_1 [E]_o [S]_o}{(\quad)} - \left\{\dfrac{k_1 [E]_o}{(\quad)} + k_{-1} + k_2\right\}[ES]$

$v_o = k_2 [ES]_{ss} = k_2 \dfrac{k_1 [E]_o [S]_o / \left(1 + [I]/K_I\right)}{\dfrac{k_1 [S]_o}{\left(1 + \frac{[I]}{K_I}\right)} + k_{-1} + k_2}$

$= \dfrac{k_2 [E]_o}{1 + \dfrac{k_{-1} + k_2}{k_1} \dfrac{1}{[S]_o}\left(1 + \dfrac{[I]}{K_I}\right)}$

$$\boxed{v_o = \frac{v_{max}}{1 + \dfrac{K_M}{[S]_o}\left(1 + \dfrac{[I]}{K_I}\right)}}$$

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B) Non-competitive

① $E + S \underset{k_{-1}}{\overset{k_1}{\rightleftharpoons}} ES$

② $ES \xrightarrow{k_2} P + E$

③ $E + I \rightleftharpoons EI \qquad k_I = \dfrac{[E][I]}{[EI]}$

④ $ES + I \rightleftharpoons ESI \qquad k_I = \dfrac{[ES][I]}{[ESI]}$

$$[E]_0 = [E] + [ES] + [EI] + [ESI]$$

$$= [E] + [ES] + \frac{[E][I]}{k_I} + \frac{[ES][I]}{k_I}$$

$$= [E]\left(1 + \frac{[I]}{k_I}\right) + [ES]\left(1 + \frac{[I]}{k_I}\right)$$

$$= \left([E] + [ES]\right)\left(1 + \frac{[I]}{k_I}\right)$$

$$[E] = \frac{[E]_0}{1 + \frac{[I]}{k_I}} - [ES]$$

$$\left.\frac{d[ES]}{dt}\right|_{SS} \approx 0 = k_1[E][S] - (k_{-1} + k_2)[ES]$$

$$= k_1\left\{\frac{[E]_0}{1 + \frac{[I]}{k_I}} - [ES]\right\}[S] - (k_{-1} + k_2)[ES]$$

$$[ES] = k_1\left(\frac{[E]_0}{1 + [I]/k_I}\right)$$

$$v_0 = k_2[ES]_{SS} = k_2 \frac{k_1[E]_0[S]_0 / (1 + [I]/k_I)}{k_1[S]_0 + (k_{-1} + k_2)}$$

$$\boxed{v_0 = \frac{v_{max}}{\left(1 + \frac{k_M}{[S]_0}\right)\left(1 + \frac{[I]}{k_I}\right)}}$$

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$$v_0 = \frac{v_{max}}{1 + \frac{k_M}{[S]_0}}$$

No inhibition

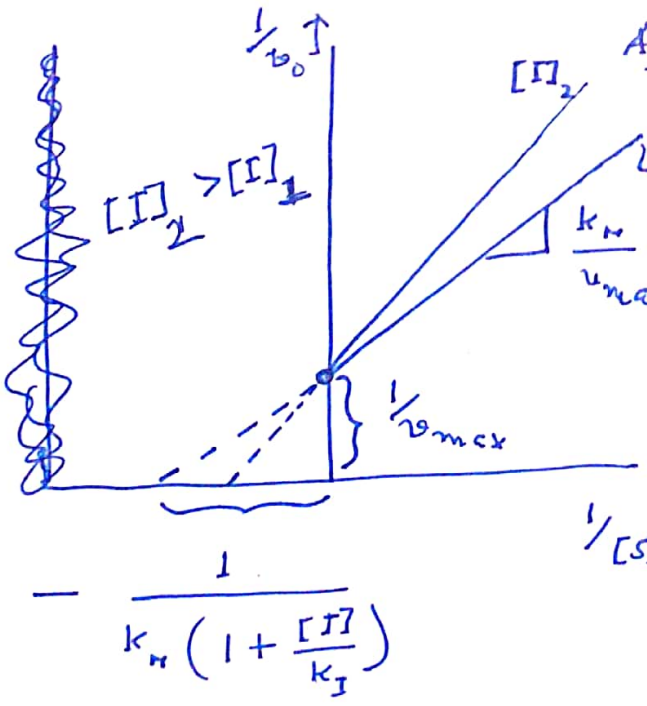
$$v_0 = \frac{v_{max}}{1 + \frac{k_M}{[S]_0}\left(1 + \frac{[I]}{k_I}\right)} \quad A$$

$$v_0 = \frac{v_{max}}{\left(1 + \frac{k_M}{[S]_0}\right)\left(1 + \frac{[I]}{k_I}\right)} \quad B$$

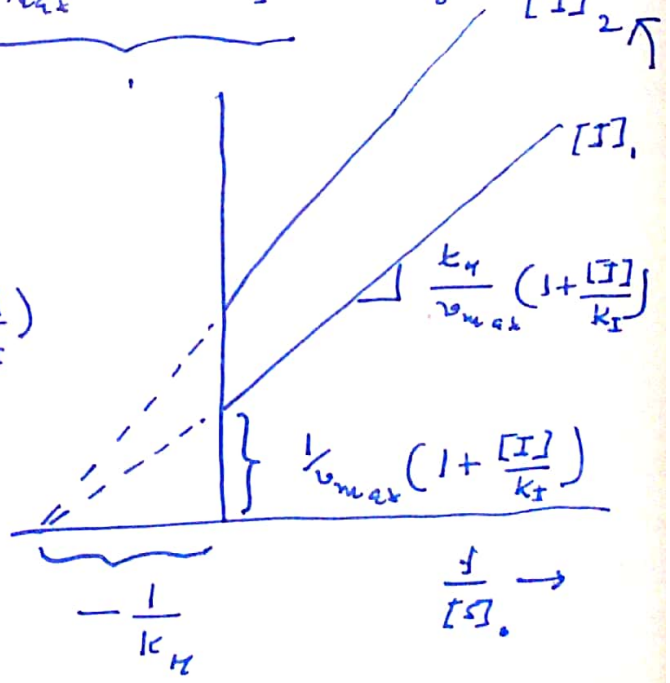
Lineweaver-Burk plots

A) $\frac{1}{v_0} = \underbrace{\frac{1}{v_{max}}}_{} + \underbrace{\frac{k_M}{v_{max}}\left(1 + \frac{[I]}{k_I}\right)}_{} \frac{1}{[S]_0}$ Competitive

B) $\frac{1}{v_0} = \underbrace{\frac{1}{v_{max}}\left(1 + \frac{[I]}{k_I}\right)}_{} + \underbrace{\frac{k_M}{v_{max}}\left(1 + \frac{[I]}{k_I}\right)}_{} \frac{1}{[S]_0}$ Non-competitive



Competitive



Non-competitive

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