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chemistry

$$A \xrightarrow{k_{cis}} A^*$$

$$A + A^* \underset{k_r^A}{\overset{k_f^A}{\rightleftharpoons}} [AA^*] \xrightarrow{k_{cat}^A} 2A^*$$

$$PPase + A^* \underset{k_r^P}{\overset{k_f^P}{\rightleftharpoons}} [PPaseA^*] \xrightarrow{k_{cat}^P} PPase + A$$

$$N + A^? \underset{k_r^N}{\overset{k_f^N}{\rightleftharpoons}} \left[NA^?\right], \quad ? \in \{, *\}$$

$$[AN] + A^* \underset{k^-}{\overset{k^+}{\rightleftharpoons}} [ANA^*] \xrightarrow{k_*^-} [A^*N] + A^*$$

$$[A^*N] + A \underset{k^-}{\overset{k^+}{\rightleftharpoons}} [ANA^*]$$

model

$$\begin{aligned}(\partial_t - D\Delta)\, A = &-k_{cis}A - k_f^A A^* A - k^+ [NA^*]\, A \\ &+ k_r^A [AA^*] + k_{cat}^P [PPaseA^*] - k_f^N NA + k_r^N [NA] + k^- [ANA^*]\end{aligned}$$

$$\begin{aligned}(\partial_t - D\Delta)\, A^* = &\, k_{cis}A - k_f^A AA^* + k_r^A [AA^*] + 2k_{cat}^A [AA*] - k_f^P PPaseA^* + k_r^P [PPaseA*] - k_f^N NA^* + k_r^N [NA^*] \\ &- k^+ [NA]A^* + (k^- + k_*^-)[ANA^*]\end{aligned}$$

$$(\partial_t - D\Delta)[AA^*] = k_f^A AA^* - (k_r^A + k_{cat}^A)[AA^*] \quad ? \approx 0?$$

$$(\partial_t - D\Delta)PPase = (k_r^P + k_{cat}^P)[PPaseA^*] - k_f^P PPaseA^* \approx 0$$

$$(\partial_t - D\Delta)[PPaseA^*] = k_f^P PPaseA^* - (k_r^P + k_{cat}^P)[PPaseA^*] \approx 0$$

$$\partial_t N = -k_f^N N(A + A^*) + k_r^N([NA] + [NA^*])$$

$$\partial_t [NA] = k_f^N NA - (k_r^N + k^+ A^*)[NA] + k^-[ANA^*]$$

$$\partial_t[NA^*] = k_f^N NA^* - \left(k_r^N + k^+ A\right)[NA^*] + \left(k^- + k_*^-\right)[ANA^*]$$

$$\partial_t[ANA^*] = -(2k^- + k_*^-)[ANA^*] + k^+\left([NA]A^* + [NA^*]A\right)$$

$$N + [NA] + [NA^*] + [ANA^*] = N_0 \tag{1}$$

preobrazovaniya

(??) $\Rightarrow$

$$\begin{aligned}(\partial_t - D\Delta)A = &-k_{cis}A - k_f^A AA^* - k^+[NA^*]A + k_r^A[AA^*] + k_{cat}^P[PPaseA^*] - k_f^N A(N_0 - [NA^*] - [ANA^*]) \\ &+ (k_r^N + k_f^N A)[NA] + k^-[ANA^*]\end{aligned}$$

$$\begin{aligned}(\partial_t - D\Delta)A^* = &\, k_{cis}A - k_f^A AA^* + k_r^A[AA^*] + 2k_{cat}^A[AA^*] - k_f^P PPaseA^* + k_r^P[PPaseA^*] \\ &- k_f^N N_0 A^* + (k_r^N + k_f^N A^*)[NA^*] + (k_f^N - k^+)[NA]A^* + (k^- + k_*^- + k_f^N A^*)[ANA^*]\end{aligned}$$

$$(\partial_t - D\Delta)[AA^*] = k_f^A AA^* - (k_r^A + k_{cat}^A)[AA^*]$$

$$(\partial_t - D\Delta)PPase = (k_r^P + k_{cat}^P)[PPaseA^*] - k_f^P PPaseA^* \approx 0$$

$$(\partial_t - D\Delta)[PPaseA^*] = k_f^P PPaseA^* - (k_r^P + k_{cat}^P)[PPaseA^*] \approx 0$$

$$\partial_t[NA] = k_f^N A(N_0 - [NA^*]) - (k_r^N + k^+ A^* + k_f^N A)[NA] + (k^- - k_f^N A)[ANA^*]$$

$$\partial_t[NA^*] = k_f^N A^*(N_0 - [NA]) - (k_r^N + k_f^N A^* + k^+ A)[NA^*] + (k^- + k_*^- - k_f^N A)[ANA^*]$$

$$\partial_t[ANA^*] = -(2k^- + k^+)[ANA^*] + k^+\left([NA]A^* + [NA^*]A\right)$$

measureless

$$A^? = A_0 a^?; \quad PPase = \Pi_0 p; \quad N = \nu_0 n; \quad \tau = 1/k_{cis}$$

$$?[AA^*] = A_0[aa^*]? \quad ?[PPaseA^*] = A_0[pa^*]? \quad ?[NA^?] = A_0[na^?]?$$

$$\Delta \to \frac{\Delta}{L^2}; \quad \partial_t \to \frac{\partial_t}{\tau}$$

$$\begin{aligned}(\partial_t - \frac{\tau D\Delta}{L^2})a = &-a - \tau k_f^A A_0 aa^* - \tau k^+ A_0[na^*]a + \tau k_r^A[aa^*] + \tau k_{cat}^P[pa^*] \\ &- \tau k_f^N \nu_0 a(n_0 - \frac{A_0}{\nu_0}[na^*] - \frac{A_0}{\nu_0}[ana^*]) + \tau(k_r^N + k_f^N A_0 a)[na] + \tau k^-[ana^*]\end{aligned}$$

$$\begin{aligned}(\partial_t - \frac{\tau D\Delta}{L^2})a^* = &\, a - \tau k_f^A A_0 aa^* + \tau k_r^A[aa^*] + 2\tau k_{cat}^A[aa^*] - \tau k_f^P \Pi_0 pa^* + \tau k_r^P[pa^*] \\ &- \tau k_f^N \nu_0 n_0 a^* + \tau(k_r^N + k_f^N A_0 a^*)[na^*] + \tau(k_f^N - k^+)[na]A_0 a^* + \tau(k^- + k_*^- + k_f^N A_0 a^*)[ana^*]\end{aligned}$$

$$(\partial_t - \frac{\tau D\Delta}{L^2})[aa^*] = \tau k_f^A A_0 a a^* - \tau(k_r^A + k_{cat}^A)[aa^*]$$

$$(\partial_t - \frac{\tau D\Delta}{L^2})p = \frac{\tau}{\Pi_0}(k_r^P + k_{cat}^P)A_0[pa^*] - \tau k_f^P p A_0 a^* \approx 0$$

$$(\partial_t - \frac{\tau D\Delta}{L^2})[pa^*] = \tau k_f^P \Pi_0 p a^* - \tau(k_r^P + k_{cat}^P)[pa^*] \approx 0$$

$$\partial_t[na] = \tau k_f^N \nu_0 a(n_0 - \frac{A_0}{\nu_0}[NA^*]) - \tau(k_r^N + k^+ A_0 a^* + k_f^N A_0 a)[na] + \tau(k^- - k_f^N A_0 a)[ana^*]$$

$$\partial_t[na^*] = \tau k_f^N \nu_0 a^*(n_0 - \frac{A_0}{\nu_0}[na]) - \tau(k_r^N + k_f^N A_0 a^* + k^+ A_0 a)[na^*] + \tau(k^- + k_*^- - k_f^N A_0 a)[ana^*]$$

$$\partial_t[ana^*] = -\tau(2k^- + k^+)[ana^*] + \tau k^+ A_0\,([na]a^* + [na^*]a)$$

further

$$d = \frac{\tau D}{L^2}$$

$$\kappa_f^a = \tau k_f^A A_0; \quad \kappa^+ = \tau k^+ A_0$$

$$\kappa_f^p = \tau k_f^P \Pi_0 ...$$

$$\kappa_f^n = \tau k_f^N \nu_0 ...$$

$$\kappa_r^? = \tau k_r^?; \quad \kappa^- = \tau k^-; \quad \kappa_{cat}^? = \tau k_{cat}^?$$

$$\alpha_0 = \frac{A_0}{\nu_0}; \quad \beta_0 = \frac{A_0}{\Pi_0}$$

$$\begin{aligned}(\partial_t - d)a = &-a - \kappa_f^a a a^* - \kappa^+[na^*]a + \kappa_r^a[aa^*] + \kappa_{cat}^p[pa^*] \\ &- \kappa_f^n a(n_0 - \alpha_0([na] + [na^*] + [ana^*])) + \kappa_r^n[na] + \kappa^-[ana^*]\end{aligned}$$

$$\begin{aligned}(\partial_t - d)a^* = &\, a - \kappa_f^a a a^* + \kappa_r^a[aa^*] + 2\kappa_{cat}^a[aa^*] - \kappa_f^p p a^* + \kappa_r^p[pa^*] \\ &- \kappa_f^n n_0 a^* + (\kappa_r^n + \kappa_f^n \alpha_0 a^*)[na^*] + (\alpha_0 \kappa_f^n - \kappa^+)[na]a^* + (\kappa^- + \kappa_*^- + \kappa_f^n a^*)[ana^*]\end{aligned}$$

$$(\partial_t - d)[aa^*] = \kappa_f^a a a^* - (\kappa_r^a + \kappa_{cat}^a)[aa^*]$$

$$(\partial_t - d)p = \beta_0(\kappa_r^p + \kappa_{cat}^p)[pa^*] - \beta_0 \kappa_f^p p a^* \approx 0$$

$$(\partial_t - d)[pa^*] = \kappa_f^p p a^* - (\kappa_r^p + \kappa_{cat}^p)[pa^*] \approx 0$$

$$\partial_t[na] = \kappa_f^n a(n_0 - \alpha_0[na^*]) - (\kappa_r^n + \kappa^+ a^* + \kappa_f^n \alpha_0 a)[na] + (\kappa^- - \kappa_f^n \alpha_0 a)[ana^*]$$

$$\partial_t[na^*] = \kappa_f^n a^*(n_0 - \alpha_0[na]) - (\kappa_r^n + \kappa_f^n \alpha_0 a^* + \kappa^+ a)[na^*] + (\kappa^- + \kappa_*^- - \kappa_f^n \alpha_0 a)[ana^*]$$

$$\partial_t[ana^*] = -(2\kappa^- + \kappa^+)[ana^*] + \kappa^+\left([na]a^* + [na^*]a\right)$$

finally

$$p \approx 1$$

$$[pa^*] \approx \frac{\kappa_f^p}{\kappa_r^p + \kappa_{cat}^p} a^* = \kappa_M a^*$$

$$\begin{aligned}(\partial_t - d)a = &-a - \kappa_f^a a a^* - \kappa^+[na^*]a + \kappa_r^a[aa^*] + \kappa_{cat}^p \kappa_M a^* \\ &- \kappa_f^n a(n_0 - \alpha_0([na] + [na^*] + [ana^*])) + \kappa_r^n[na] + \kappa^-[ana^*]\end{aligned}$$

$$\begin{aligned}(\partial_t - d)a^* = &\, a - \kappa_f^a a a^* + \kappa_r^a[aa^*] + 2\kappa_{cat}^a[aa^*] + (\kappa_M \kappa_r^p - \kappa_f^p)a^* \\ &- \kappa_f^n n_0 a^* + (\kappa_r^n + \kappa_f^n \alpha_0 a^*)[na^*] + (\alpha_0 \kappa_f^n - \kappa^+)[na]a^* + (\kappa^- + \kappa_*^- + \kappa_f^n \alpha_0 a^*)[ana^*]\end{aligned}$$

$$(\partial_t - d)[aa^*] = \kappa_f^a a a^* - (\kappa_r^a + \kappa_{cat}^a)[aa^*]$$

$$\partial_t[na] = \kappa_f^n a(n_0 - \alpha_0[na^*]) - (\kappa_r^n + \kappa^+ a^* + \kappa_f^n \alpha_0 a)[na] + (\kappa^- - \kappa_f^n \alpha_0 a)[ana^*]$$

$$\partial_t[na^*] = \kappa_f^n a^*(n_0 - \alpha_0[na]) - (\kappa_r^n + \kappa_f^n \alpha_0 a^* + \kappa^+ a)[na^*] + (\kappa^- + \kappa_*^- - \kappa_f^n \alpha_0 a)[ana^*]$$

$$\partial_t[ana^*] = -(2\kappa^- + \kappa^+)[ana^*] + \kappa^+\left([na]a^* + [na^*]a\right)$$

и всё бы ничего, но

$$?[ANA^*] = [A^*NA]?$$

$$[AN] + A^* \rightleftharpoons [ANA^*] \to [A^*N] + A^*$$

$$[A^*N] + A \rightleftharpoons [A^*NA] \to [A^*N] + A^*$$