Text S1

Mathematical modeling

Our mathematical model consists of a system of coupled ordinary differential equations (ODEs) which describe the dynamic concentrations of the phosphotransfer proteins throughout the \( R. \text{sphaeroides} \) cell. We applied the law of mass action to the phosphotransfer reactions in Table 1 and obtained the following system of non-linear ODEs.

\[
\begin{align*}
\frac{dA_2}{dt} &= -k_1 A_2 + k_3 A_{2p} Y_3 - k_{-3} A_4 Y_3p + k_4 A_{2p} Y_4 - k_{-4} A_4 Y_4p + k_5 A_{2p} Y_6 - k_{-5} A_2 Y_6p \\
&\quad + k_6 A_{2p} B_1 - k_{-6} A_2 B_{1p} + k_7 A_{2p} B_2 - k_{-7} A_2 B_{2p} \\
\frac{dA_{2p}}{dt} &= k_1 A_2 - k_3 A_{2p} Y_3 + k_{-3} A_4 Y_3p - k_4 A_{2p} Y_4 + k_{-4} A_4 Y_4p - k_5 A_{2p} Y_6 + k_{-5} A_2 Y_6p \\
&\quad - k_6 A_{2p} B_1 + k_{-6} A_2 B_{1p} - k_7 A_{2p} B_2 + k_{-7} A_2 B_{2p} \\
\frac{dA_3}{dt} &= -k_2 A_3 + k_8 A_{3p} Y_6 - k_{-8} A_4 Y_6p + k_9 A_{3p} B_2 - k_{-9} A_3 B_{2p} \\
\frac{dA_{3p}}{dt} &= k_2 A_3 - k_8 A_{3p} Y_6 + k_{-8} A_4 Y_6p - k_9 A_{3p} B_2 + k_{-9} A_3 B_{2p} \\
\frac{dY_3}{dt} &= -k_3 A_{2p} Y_3 + k_{-3} A_4 Y_3p + k_{10} Y_3p \\
\frac{dY_{3p}}{dt} &= k_3 A_{2p} Y_3 - k_{-3} A_4 Y_3p - k_{10} Y_3p \\
\frac{dY_4}{dt} &= -k_4 A_{2p} Y_4 + k_{-4} A_4 Y_4p + k_{11} Y_4p \\
\frac{dY_{4p}}{dt} &= k_4 A_{2p} Y_4 - k_{-4} A_4 Y_4p - k_{11} Y_4p \\
\frac{dY_6}{dt} &= -k_5 A_{2p} Y_6 + k_{-5} A_4 Y_6p - k_8 A_{3p} Y_6 - k_{-8} A_4 Y_6p + k_{12} Y_{6p} + +k_{15a} Y_{6p} A_3 + k_{15b} Y_{6p} A_{3p} \\
\frac{dY_{6p}}{dt} &= k_5 A_{2p} Y_6 - k_{-5} A_4 Y_6p + k_8 A_{3p} Y_6 - k_{-8} A_4 Y_6p - k_{12} Y_{6p} - k_{15a} Y_{6p} A_3 - k_{15b} Y_{6p} A_{3p} \\
\frac{dB_1}{dt} &= -k_6 A_{2p} B_1 + k_{-6} A_2 B_{1p} + k_{13} B_{1p} \\
\frac{dB_{1p}}{dt} &= k_6 A_{2p} B_1 - k_{-6} A_2 B_{1p} - k_{13} B_{1p} \\
\frac{dB_2}{dt} &= -k_7 A_{2p} B_2 + k_{-7} A_2 B_{2p} - k_9 A_{3p} B_2 + k_{-9} A_3 B_{2p} + k_{14} B_{2p} \\
\frac{dB_{2p}}{dt} &= k_7 A_{2p} B_2 - k_{-7} A_2 B_{2p} + k_9 A_{3p} B_2 - k_{-9} A_3 B_{2p} - k_{14} B_{2p}
\end{align*}
\]
Here $A_i = [\text{Che}A_i], \quad A_{ip} = [\text{Che}A_{ip}], \quad Y_j = [\text{Che}Y_j], \quad Y_{jp} = [\text{Che}Y_{jp}], \quad B_k = [\text{Che}B_k]$ and $Y_{kP} = [\text{Che}Y_{kP}]$

where $i = [2,3], \quad j = [3,4,6]$ and $k = [1,2]$ with the reaction rates as given in Table S2.

In order to close the system of equations we defined a set of initial conditions:

$$
\begin{align*}
A_i (x,0) &= A_{i0}, \quad A_{ip} (x,0) = 0, \quad Y_j (x,0) &= Y_{j0}, \quad Y_{jp} (x,0) = 0, \\
B_k (x,0) &= B_{k0} \quad \text{and} \quad B_{kP} (x,0) = 0 \\
\end{align*}
$$

(15)

Here $A_{i0}$ is the initial concentration of $\text{Che}A_i$, $Y_{j0}$ the initial concentration of $\text{Che}Y_j$ and $B_{k0}$ the initial concentration of $\text{Che}B_k$. The model was populated with the experimental data in Table S2 and equations (1)-(14), along with the respective initial conditions in equation (15), were solved using an adaptive time stepping ODE solver in Matlab (ode15s) due to the stiffness of the problem.