A mathematical modeling toolbox for ion channels and transporters across cell membranes

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The following supplementary material is from " A mathematical modeling toolbox for ion channels and transporters across cell membranes" manuscript. It contains an overview of all equations related to Ion channels, Pumps, Cotransporters, and Symporters, organized in a table form. The detailed transporters along with the descriptions of their equatuons can be found from here.

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4.3. Sodium Hydrogen Exchanger (NHE)

Sodium Hydrogen Exchanger (NHE)	Ref
Ammonium competitor $$\mathbf{J}^{\mathbf{NHE}}_{\mathbf{Na^+}} = E_t \frac{g^M_{ENa} Na^M (g^N_{EH} H^N + g^N_{ENH4} NH^N_4) - g^N_{ENa} Na^N (g^M_{EH} H^M + g^M_{ENH4} NH^M_4)}{R_M R_{NN} + R_N R_{MM}} \quad (149)$$ $$\mathbf{J}^{\mathbf{NHE}}_{\mathbf{H^+}} = E_t \frac{g^M_{EH} H^M (g^N_{ENa} Na^N + g^N_{ENH4} NH^N_4) - g^N_{EH} H^N (g^M_{ENa} Na^M + g^M_{ENH4} NH^M_4)}{R_M R_{NN} + R_N R_{MM}} \quad (150)$$ $$\mathbf{J}^{\mathbf{NHE}}_{\mathbf{NH_4^+}} = E_t \frac{g^M_{ENH4} NH^M_4 (g^N_{ENa} Na^N + g^N_{EH} H^N) - g^N_{ENH4} NH^N_4 (g^M_{ENa} Na^M + g^M_{EH} H^M)}{R_M R_{NN} + R_N R_{MM}} \quad (151)$$ where $[E]_t = [E]_M + [ENa]_M + [EH]_M + [ENH_4]_M + [E]_N + [ENa]_N + [EH]_N + [ENH_4]_N$ $Na^M = \frac{[Na]_M}{K^M_{Na}}, \quad H^M = \frac{[H]_M}{K^M_H}, \quad NH^M_4 = \frac{[NH_4]_M}{K^M_{NH_4}} \mid Na^N = \frac{[Na]_N}{K^N_{Na}}, \quad H^N = \frac{[H]_N}{K^N_H}, \quad NH^N_4 = \frac{[NH_4]_N}{K^N_{NH_4}}$ $R_M = 1 + Na^M + H^M + NH^M_4 \mid R_N = 1 + Na^N + H^N + NH^N_4$ $R_{MM} = g^M_{ENa} Na^M + g^M_{EH} H^M + g^M_{ENH_4} NH^M_4 \mid R_{NN} = g^N_{ENa} Na^N + g^N_{EH} H^N + g^N_{ENH_4} NH^N_4$	[34, 63]
No competitor $$\mathbf{J}^{\mathbf{NHE}}_{\mathbf{Na}} = E_t \frac{g^M_{ENa} g^N_{EH} (Na^M H^N) - g^N_{ENa} g^M_{EH} (Na^N H^M)}{R_M R_{NN} + R_N R_{MM}} \quad (152)$$ $$\mathbf{J}^{\mathbf{NHE}}_{\mathbf{H}} = E_t \frac{g^M_{EH} g^N_{ENa} (H^M Na^N) - g^N_{EH} g^M_{ENa} (H^N Na^M)}{R_M R_{NN} + R_N R_{MM}} \quad (153)$$	[64, 65]
$$J_{NHE} = P_{NHE} \frac{([Na]_{M(bl)}[H]_{N(c)} - [Na]_{N(c)}[H]_{M(bl)})}{K_{Na} K_H \left(\left(1 + \frac{[Na]_{M(bl)}}{K_{Na}} + \frac{[H]_{M(bl)}}{K_H}\right)\left(\frac{[Na]_{N(c)}}{K_{Na}} + \frac{[H]_{N(c)}}{K_H}\right) + \left(1 + \frac{[Na]_{N(c)}}{K_{Na}} + \frac{[H]_{N(c)}}{K_H}\right)\left(\frac{[Na]_{M(bl)}}{K_{Na}} + \frac{[H]_{M(bl)}}{K_H}\right) \right)} \quad (154)$$	[34, 38]

Table 29: The corresponding equations describing the flux and current transported via sodium hydrogen exchanger across the membrane