# -Biochemistry Homework 4

Q1) Malate dehydrogenase catalyzes the conversion of malate to oxaloacetate in the citric acid cycle, which takes place in the mitochondrion, and also plays a key role in the transport of reducing equivalents across the inner mitochondrial membrane via the malate-aspartate shuttle . This shuttle requires the presence of malate dehydrogenase in the cytosol and the mitochondrial matrix.

Q2)

Electrons flow into the system at Complex I from the NAD_-linked reactions and at Complex II from succinate and fatty acyl–CoA through FAD
Antimycin A inhibits electron flow (through Q) from *all* these sources, whereas rotenone inhibits flow only through Complex I. Thus, antimycin A is a more potent poison.

**Q3)**
**(a)** Cyanide inhibits cytochrome oxidase ($a$ _ $a_3$); all carriers become reduced.
**(b)** In the absence of $O_2$, no terminal electron acceptor is present; all carriers become reduced.
**(c)** In the absence of NADH, no carrier can be reduced; all carriers become oxidized.
**(d)** These are the usual conditions for an aerobic, actively metabolizing cell; the early carriers (e.g., Q) are somewhat reduced, while the late ones (e.g., cytochrome *c*) are oxidized.

Q4)

**Answer**

**(a)** Using the equation pH = $-\log [H^+]$, we can calculate external $[H^+] = 10^{-7.4} = 4.0 \times 10^{-8}$ M; and internal $[H^+] = 10^{-7.7} = 2.0 \times 10^{-8}$ M.

**(b)** From **(a),** the ratio is 2:1. We can calculate the free energy inherent in this *concentration* difference across the membrane. Assuming a temperature of 25 °C:

$$\begin{aligned}\Delta G &= RT \ln (C_2/C_1)\\ &= (2.48 \text{ kJ/mol}) \ln 2\\ &= -1.7 \text{ kJ/mol}\end{aligned}$$

**(c)** Given that the volume of the mitochondrion = $\frac{4}{3}\pi(0.75 \times 10^{-3} \text{ mm})^3$ and $[H^+] = 2.0 \times 10^{-8}$ M, the number of protons is

$$\frac{(1.33)(3.14)(0.75 \times 10^{-3} \text{ mm})^3(2.0 \times 10^{-8} \text{ mol/L})(6.02 \times 10^{23} \text{ protons/mol})}{(10^6 \text{ mm}^3\text{/L})} = 21 \text{ protons}$$

**(d)** No; the energy available from the $H^+$ concentration gradient, $2.3\Delta\text{pH}\,RT = 2.3(0.3)$ (2.48 kJ/mol) = 1.7 kJ/mol, is insufficient to synthesize 1 mol of ATP.

**(e)** The total energy inherent in the pH gradient is the sum of the energy due to the concentration gradient and the energy due to the charge separation. The overall transmembrane electrical potential is the main factor in producing a sufficiently large $\Delta G_t$ (see Eqns 19–8 and 19–9).