Chapter 7

Quantitative Aside 7.1—Phosphate-to-Oxygen Ratio (P/O ratio)

The theoretical calculation of the P/O ratio for mitochondria is even more complex than detailed in the text. We know that 10 H^+ are transported for each NADH oxidized, and 6 H^+ per molecule of $FADH_2$. The remaining question is the number of protons used per ATP synthesized. We can actually deduce this from structural information that is emerging for the enzyme itself. The enzyme acts as a rotary motor, with one subunit that binds to ATP and another than binds protons. We know that the catalytic subunit has 3 ADP/P_i-binding sites, with one rotation thus yielding 3 ATP. What is not clear is the number of protons bound by the motor, and if the enzymes in different species bind the same number of protons per rotation.
The yeast enzyme has been studied in detail, and it binds 10 protons per rotation. This would yield a coupling ratio of 10/3 for protons/ATP, which would actually produce the "old value" of 3 ATP per NADH (with 10 H^+ transported/NADH). But, this is further complicated by the fact that for each ATP exported to the cytoplasm versus ADP/P_i imported, another proton is transported to the matrix to balance charge (a 13/3 proton/ATP ratio). This yields a P/O ratio of $(10/13) \times 3 = 2.3$ for NADH, and $(6/13) \times 3 = 1.4$ for $FADH_2$.