- The electron transfer reaction between NADH and oxygen is a spontaneous reaction at 37 °C

$$NADH + \tfrac{1}{2}O_2 + H^+ \rightarrow NAD^+ + H_2O \qquad \Delta G = -220 \text{ kJ mol}^{-1}$$

When this reaction is carried out in solution in a test tube via direct mixing of NADH with dissolved oxygen, the reaction releases a significant amount of heat. However, when the reaction occurs in mitochondria during respiration, it produces very little heat. Explain why the heat evolved is much less in mitochondria.

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According to the First Law of Thermodynamics, energy can be transferred in the form of heat or work. The amount of energy the reaction releases is constant, so if the heat released in mitochondria is reduced it means more work must be done.

ΔG is the maximum amount of non-PV work obtainable from a system. The energy released by the oxidation of NADH in mitochondria is used to do non-PV work, *viz.* the pumping of H^+ ions across the inner mitochondrial membrane. By storing this energy in the form of an H^+ gradient, the amount of energy wasted as heat is reduced.