Chemiosmosis or Simple QED?

Thomas Prevenslik

Introduction

Chemiosmosis is diffusion of ions through a partially permeable membrane. In the generation of ATP during respiration, chemiosmosis is the flow of hydrogen ions across the inner membrane of mitochondria providing power for producing work at the cellular level. The chemistry is complex, but may be simplified to the oxidation of NADH,

$$\mathrm{NADH} + \tfrac{1}{2}\mathrm{O_2} + \mathrm{H^+} \rightleftharpoons \mathrm{H_2O} + \mathrm{NAD^+}$$
$$\Delta G^{\circ\prime} = -52.6\ \mathrm{kcal\ mol^{-1}}\ (-220.1\ \mathrm{kJ\ mol^{-1}})$$

It was first suggested that electron transfer leads to the formation of a covalent high-energy intermediate that serves as a high phosphoryl transfer which then drives ATP synthesis, but decades of research failed to identify the chemical source, the consequence of which prompted Mitchell (1) in 1961 to propose the chemiosmosis theory that did not rely on the intermediate. Instead, the build-up of hydrogen ions on one side of the inner membrane of the mitochondrion would be the source of potential energy needed to power the formation of ATP from ADP and Pi,

$$\mathrm{ADP} + \mathrm{P_i} + \mathrm{H^+} \rightleftharpoons \mathrm{ATP} + \mathrm{H_2O}$$
$$\Delta G^{\circ\prime} = +7.3\ \mathrm{kcal\ mol^{-1}}\ (+30.5\ \mathrm{kJ\ mol^{-1}})$$

In effect, the inner mitochondrial membrane was therefore the ATP energy-transducing membrane. Mitchell postulated that the energy released from the transfer of electrons along the electron transport chain moved hydrogen ions from the matrix to the intermembrane space, the force of this flow driving the formation of ATP.

Initially, the chemiosmosis theory was not accepted because the notion of a high-energy intermediate was more appealing. Amidst this controversy, Mitchell was awarded the 1978 Nobel Prize in chemistry for chemiosmosis, but today the chemistry still remains controversial. One problem was dependence of the gradient of hydrogen ions on the pH of the intermembrane space, but a rapid fall in pH produced (2) by adding dissolved oxygen in the intermembrane space did not produce the oxidation predicted by chemiosmosis. Also, anions not predicted by chemiosmosis theory were found. What this means is high-energy chemical (3) intermediates to chemiosmosis are not required as an intermediates would not resolve the problems of pH and anions.

In this regard, the torsional theory (4) was proposed (2) wherein translocation of both protons and anions produce ATP synthesis. However, the chemistry explanations of torsional theory only complicate the complexity of chemiosmosis. A totally different conceptual approach to ATP synthesis based on physics is suggested.

Proposal

ATP synthesis in mitochondria is proposed to occur by simple QED that does not depend on electron induced pumping of hydrogen ions across the inner membrane to produce ATP. Simple QED differs (5) from the QED proposed by Feynman in that real and not virtual photons stand across the matrix between adjacent cristae surfaces of folds of the inner membrane, the EM energy at UV levels breaking oxygen double bonds to power ATP production. The human lung mitochondria showing the EM wave standing in the matrix between the fold formed between adjacent cristae is noted in Figure 1.

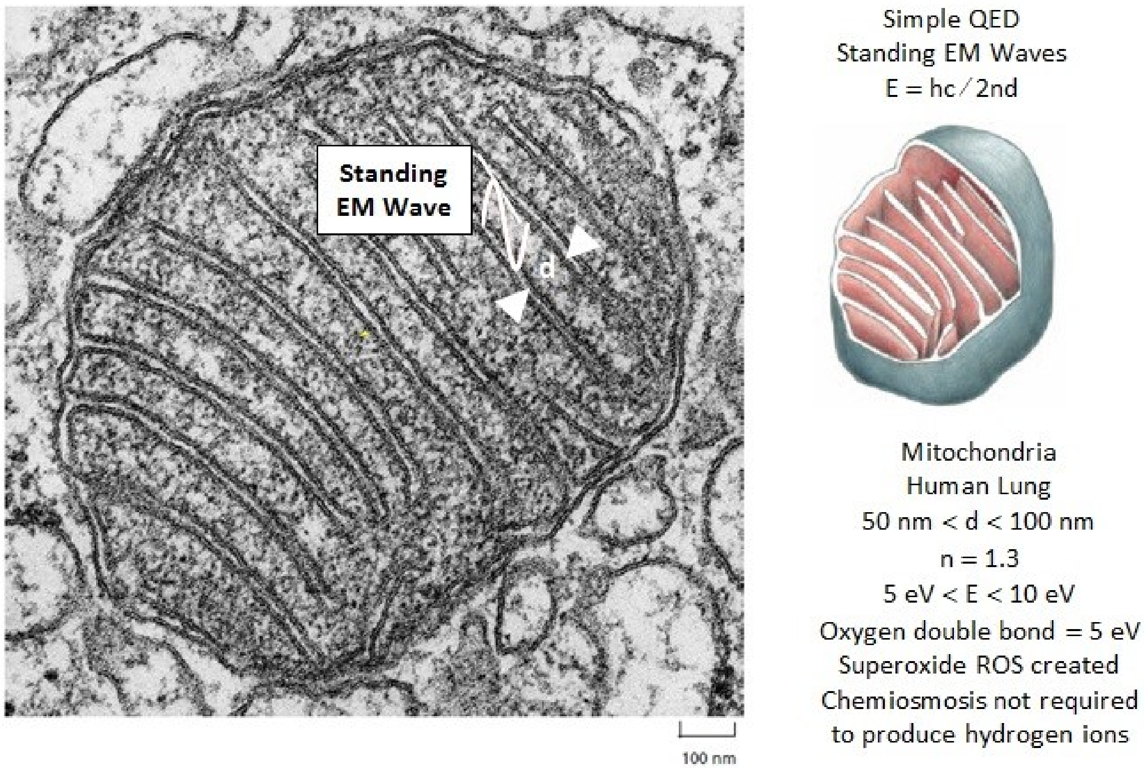

Figure 1 Simple QED in Mitochondria
Standing EM radiation in Matrix between Cristae

In the matrix with a spacing d between adjacent cristae ($50 < d < 100$ nm), the Planck energy E of the standing EM waves based on a refractive index $n \sim 1.3$ is beyond the UV at 5 to 10 eV. Hence, the UV produces the oxygen anion superoxide by breaking the double bond of dissolved oxygen in the matrix that creates ATP from breaking down carbohydrate foods and converts ADP back to ATP, but also forms reactive oxygen species (ROS). In the mitochondria, simple QED is both the source of ATP synthase and ROS. Simple QED does not depend on pH of the intermembrane space and anions are indeed created at UV levels. For over 50 years, chemiosmosis theory made the unintentional, but false claim that the unlikely successive electron absorptions pumped hydrogen ions across the inner membrane, when in fact simple QED in the UV and beyond actually produced the hydrogen ions that power mitochondria.

Discussion

Hydrogen Ion Production

Taking 5 eV as a lower bound EM energy, the simple QED photon provides the matrix with about 500 kJ/mol ATP to create hydrogen ions by breaking O-H and H-H bonds at 459 and 432 kJ/mol of O-H and H-H reactants, respectively. What this means is simple QED produces hydrogen ions in mitochondria from UV radiation thereby avoiding the unlikely successive electron absorptions in chemiosmosis. In contrast, the release of 30.5 kJ/mol of ATP is free energy and not due to the breaking of oxygen and hydrogen bonds, but rather because the bonds formed after hydrolysis are lower in energy than the bonds present before hydrolysis.

Anions in Mitochondria

In mitochondria, the finding of anions shows chemiosmosis based on hydrogen ions alone cannot explain the activation of ATP release. UV energy at 5 eV is available to break the oxygen double bond at about 500 kJ/mol ATP to produce the superoxide anion ROS. After all, mitochondria DNA in mammals, although $<$ 1 % of total cellular DNA, is known to be damaged by ROS at UV levels.

UV Energy Source

Simple QED produces UV between adjacent cristae by conserving the ATP energy released in the matrix because the Planck law of quantum mechanics at nanoscale spacings $d < 100$ nm denies the atom heat capacity (5) to increase in temperature that otherwise occurs at the macroscale. In mitochondria, the energy release of 30.5 kJ/mol ATP is conserved in the matrix by non-thermal conversion to EM radiation at UV levels, a process that always continues providing oxygen is available.

Conclusion

In chemiosmosis, simple QED providing the mitochondrial matrix with a source of UV radiation to produce hydrogen ions is the physics alternative to the unsuccessful long-sought high energy chemistry intermediate producing hydrogen ions across the inner membrane.

References

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