ATP by endogenous UV radiation
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Introduction

ATP by chemiosmosis (1) depends on enzymes in the inner membrane of mitochondria which transfer electrons from the oxidation of metabolism to molecular oxygen following the phosphorylation reaction:

ADP + phosphate → ATP

Hydrolysis of ATP to ADP and phosphate is highly favorable in aqueous solution producing an energy release of 30.5 kJ /mol ATP. In contrast, the molecular mechanism of oxidative phosphorylation in metabolic breakdown reactions is converted into phosphate bond energy through a 'high-energy intermediate', i.e., a chemical compound generated by an enzymatic oxidation-reduction reaction capable of transferring a phosphate group to ADP. But after decades of research, the 'high-energy intermediate' was never found.

Chemiosmosis does not require a 'high-energy intermediate'. Instead, respiration and phosphorylation is coupled by an electrochemical gradient of H+ ions across the mitochondrial membrane, i.e., the flow of electrons through the respiratory enzymes is linked to a net movement of H+ across the inner mitochondrial membrane that creates a transmembrane electrochemical potential comprising an osmotic pressure and an electric field component. The electrochemical potential powers the ATPase, an enzyme which is also located in the inner mitochondrial membrane that carries out the phosphorylation of ADP to ATP.

ATP by chemiosmosis with oxidation by the electron transfer chain OR oxidation by the molecular mechanism by 'high-energy intermediate' are both based on complex chemistry that is difficult to verify experimentally. In contrast, oxidation by UV radiation is simple and direct, but is only available as exogenous solar radiation outside the body – not endogenous UV as required in mitochondria of human cells. Nevertheless, the response (2) of mitochondria to exogenous UV was studied. The formation of the four electron reduction of oxygen in chemiosmosis was compared with the more likely one electron reduction of oxygen by exogenous UV as illustrated in Figure 1.

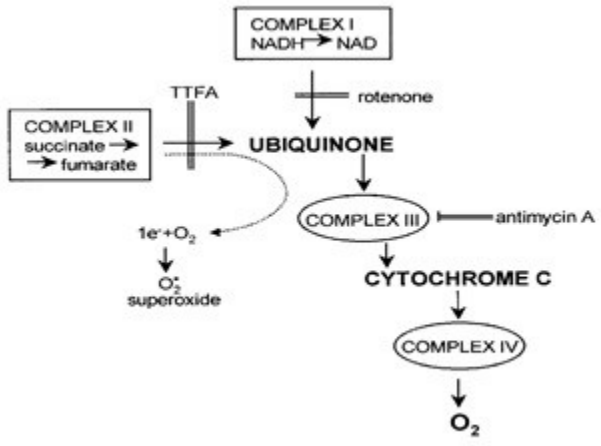

Figure 1. ATP produced by exogenous UV
In chemiosmosis, there is a four-electron reduction of O2 into two water molecules (solid arrows). However, after UV radiation, superoxide is produced because of one-electron reduction of O2 TTFA (curved pathway)

In Figure 1, the biological effects of exogenous UV in the mitochondria are DNA damage mediated by reactive oxygen species (ROS). The ROS intermediate was hydrogen peroxide synthesized from the superoxide anion and further metabolized into the highly reactive hydroxyl radical. UV-induced H2O2 accumulation in a keratinocyte cell line HaCaT showed carboxy-H2DCFDA is oxidized by hydrogen peroxide with the biological effects of exogenous UV such as DNA damage. However,

In the mitochondria, ATP production requires a source of endogenous UV.

Proposal

ATP is proposed produced by endogenous EM radiation within the mitochondria by simple QED. Simple QED differs (3) from the QED proposed by Feynman in that real and not virtual photons stand across the matrix between adjacent cristae surfaces of folds in 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 over distance d in the matrix between the fold formed between adjacent cristae is noted in Figure 2.

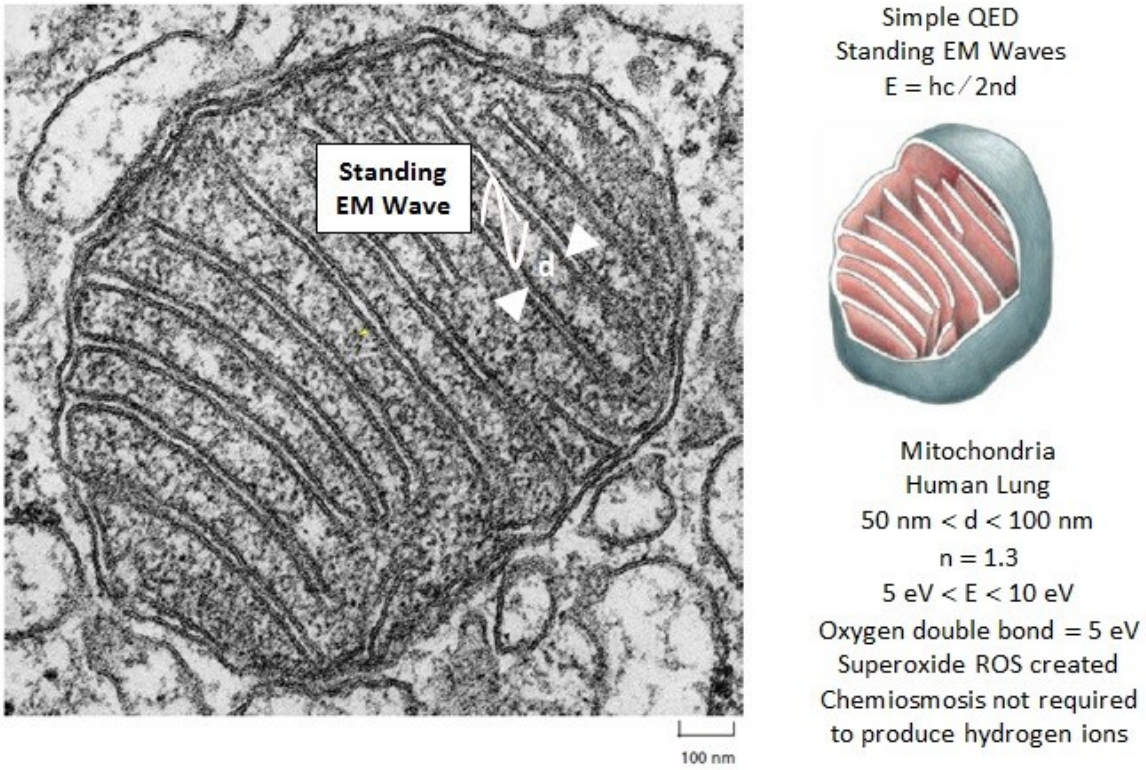

Figure 2. Simple QED in Mitochondria
Standing endogenous EM radiation in matrix between Cristae

Typically, the spacing d between adjacent cristae ($50 < d < 100$ nm). The Planck energy E of the standing EM waves based on a refractive index n ~ 1.3 is beyond the UV from 5 to 10 eV. Hence, the UV breaks the double bond of dissolved oxygen to create the superoxide oxygen anion that produces ATP by breaking down carbohydrate foods and converts ADP back to ATP. Simple QED alters ATP production by the addition of EM radiation, $E = h\nu$,

ADP + phosphate + $h\nu \rightarrow$ ATP

In the mitochondria, simple QED is both the source of ATP synthesis and ROS. Unlike chemiosmosis, simple QED does not depend on pH gradient across the inner membrane and anions are indeed created at UV levels. For over 50 years, chemiosmosis theory made the claim that the unlikely successive four-electron absorptions pumped hydrogen ions across the inner membrane, when in fact, simple QED produces the one-electron superoxide from the UV that actually produced the hydrogen ions that power mitochondria.

Not long after Mitchell presented chemiosmosis theory, the mitochondria were mechanically treated with ultrasound. Electron microscopy (4) revealed numerous submicron spherical vesicles of inner mitochondrial membrane. A typical micrograph is shown in Fig. 3.

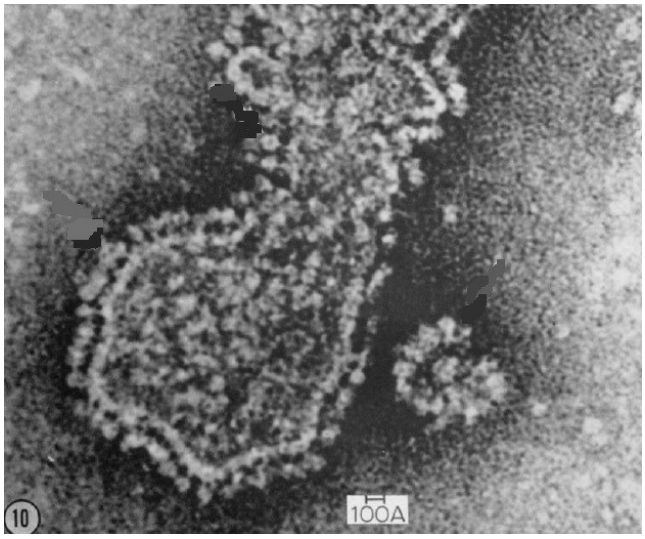

Figure 3. Submicron Spherical Vesicle
Ultrasonic treated Mitochondria

The particles, called submitochondrial particles (SMP), were spherical having diameters of 8–10 nm located on the surface of the cristae, but are also dispersed throughout the interposed matrix. Comparison with intact mitochondria for bovine heart muscle shows the SMP display an inside-out orientation compared with intact mitochondria, i.e., the globular SMP structures seen facing the matrix on the surface of cristae are found on the outer face of SMP outside the matrix as shown in Figure 4.

Regardless, simple QED explaining the production of ATP from endogenous UV produced in mitochondria as standing EM waves between adjacent cristae is also applicable to SMP. However, the Planck energy E in SMP is, $E > 100$ eV, which is in the EUV. Lower EM energy states in the UV are excited by EUV fluorescence.

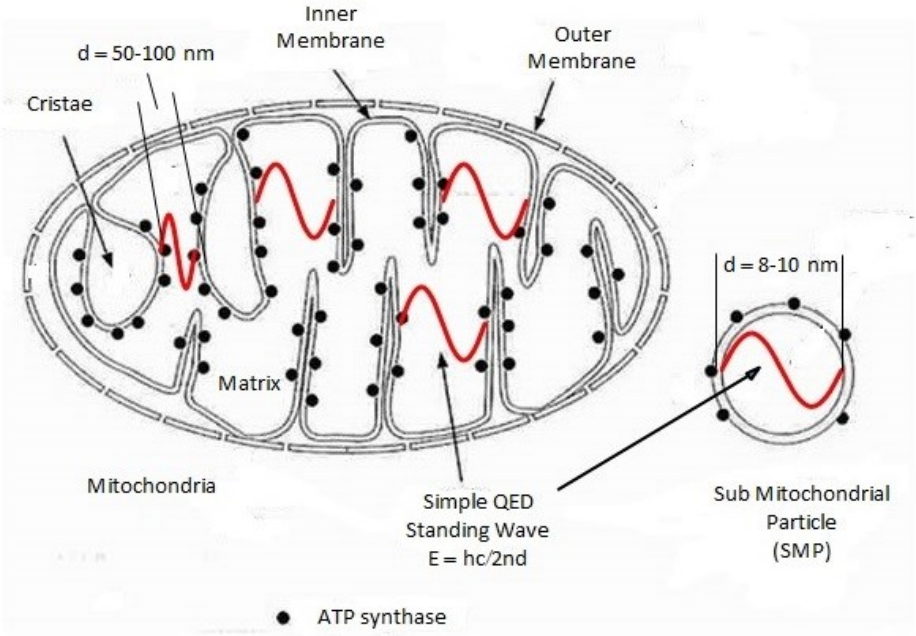

Figure 4. Simple QED standing EM waves in Mitochondria and SMP

Simple QED produces standing EM radiation in the UV and beyond as shown everywhere in the mitochondria and SMP depending on the ATP energy release regardless of which surface the ATP synthase is bound, i.e., the EM waves are conserved from ATP regardless of the binding surface. In the mitochondria, the spacing d between crista is, d = 50-100 nm producing EM radiation in the UV and beyond. However, the EM radiation in the spherical SMP having d = 8-10 nm far higher is in the EUV at about 125 eV, the lower quantum states in the UV excited by fluorescence.

In 1974, ultrasonic modification (5) produced particles from bovine heart mitochondria larger than SMP that yielded phospholipid vesicles with a diameter of about 100 nm, comparable to the spacing d in mitochondria in Figure 5. The vesicles formed ATP by oxidative phosphorylation that differed from ATP hydrolysis of the ATPase. The artificial vesicle system to reconstitute the respiratory chain enzyme, *cytochrome c oxidase*, together with the ATPase. When these vesicles were fed with *cytochrome c* (the electron donor for cytochrome oxidase) as well as oxygen, ATPase was synthesized.

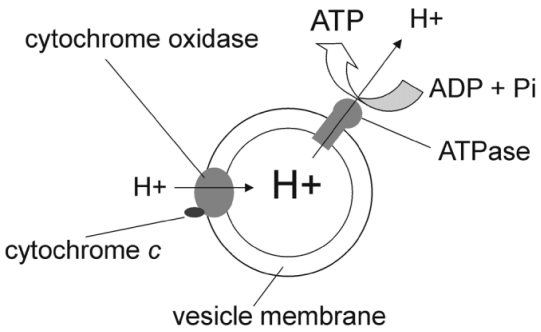

Figure 5. Respiratory enzymes and the ATP from artificial vesicles.
Cytochrome oxidase reduces *cytochrome c* and transfers the electrons received to molecular oxygen (not shown), the energy release used to build up the hydrogen ion H+ across the membrane

In 1974, the *Halobacterium halobium* was shown (6) to move protons by photosynthesis of light, the movement across the membrane correlated with increases in intracellular ATP levels, i.e., the bacterium allows ATP generation from light without the complex electron transport system found in green plants. What this means is chemiosmosis by bacteriorhodopsin as a light driven hydrogen ion pump can use a H+ gradient to synthesize ATP as shown in Figure 6.

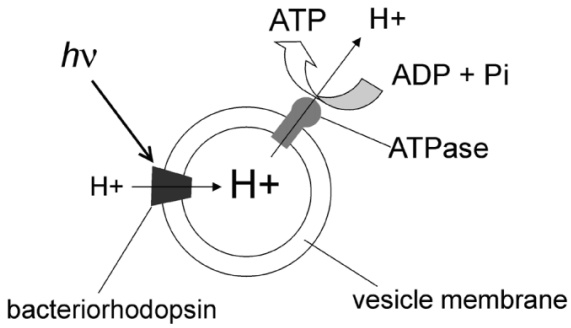

Figure 6. Light driven ATP in Vesicles
Bacteriorhodopsin and the ATPase in artificial vesicles. Bacteriorhodopsin uses light energy ($h\nu$) to pump protons across the membrane. The mitochondrial ATPase uses the H+ gradient to phosphorylate ADP

Indeed, bacteriorhodopsin did function as a light-driven proton pump, and if the purified ATPase can use a H+ gradient to synthesize ATP, Mitchell's chemiosmosis theory of oxidative and photophosphorylation was considered verified. However, chemiosmosis theory was not generally accepted in the 1970's as the major difficulty (3) was the lack of a mechanism to explain how a membrane H+ potential can drive the ATP synthesis.

In this regard, the question is whether simple QED providing a UV source to the productions of ATP offers a simple and direct alternative to chemiosmosis or the high energy intermediate. Although simple QED is only a recent theory that could be invoked in Weber 's extensive analysis (1) of the question whether chemiosmosis OR the high energy intermediate theory of ATP is correct, of which chemiosmosis was selected as correct, perhaps because the high energy intermediate was never found, when in fact neither theory is true. In retrospect, simple QED may be construed as the high energy intermediate, but not as a chemical entity, but rather as EM source in UV radiation.

Discussion

Metabolic Heat

Carbon dioxide and water are two of the most prevalent and energetically stable compounds found in nature. Under UV radiation, the heat of metabolic processes in the mitochondria is liberated when carbon and hydrogen atoms in complex food molecules are converted to CO2 and H2O. Heat is produced `during respiration of which a fraction is converted to ATP instead of being dissipated as heat. The six-carbon sugar glucose formed by the UV induced breakdown of complex carbohydrates is the most common fuel for respiration.

$C_6H_{12}O_6 + 6\ O_2 \rightarrow 6\ CO_2 + 6\ H_2O + 2800$ kJ

In glycolysis , respiration of one molecule of glucose releases 2800 kJ of which form ATP or is lost as heat is the source of UV in simple QED. Glucose is split into two molecules of pyruvic acid, each with three carbon atoms. Pyruvic acid then enters the mitochondria, where it is converted to the acetyl group (2-carbon) of acetyl coenzyme A which is then degraded to CO2 and water in the citric acid cycle. During the course of CO2 production, the electrons lose energy which is transferred to ATP that finally culminates in electrons and protons combining with molecular oxygen to form water.

ATP by Acid Base-Titration

ATP by UV radiation finds similarity to the ATP produced (7) in light induced acid-base titration of spinach chloroplasts. In 1967, ATP in the dark due was produced in the titration from an acidic to a basic environment . Considerable significance was attached to acid-base titration because of the proton gradient assumed in the chemiosmosis hypothesis as a possible explanation because of the proton gradient (1) in chemiosmosis. The conditions needed to induce ATP require the transition from acidic pH 4.0 to basic pH 8 medium as shown in Figure 7.

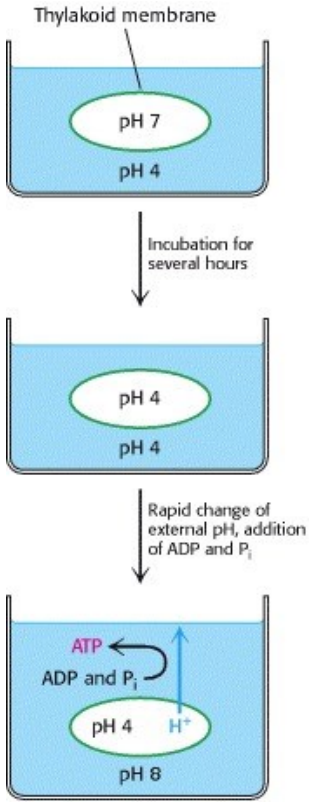

Figure 7. ATP from Titration of Acid to Base

The conditions needed to induce ATP hydrolysis in chloroplasts are very similar to those needed for ATP synthesis in mitochondria. The thylakoid membrane houses stacks of ~ 10 grana having ~ 3 nm lamina discs distributed throughout the chloroplasts. Initially, the thylakoid membrane separates the neutral grana pH 7 from the acidic bath pH 4. Incubation makes the grana acidic at pH 4. Rapid changing of the bath to basic pH 8 imposes a H+ gradient of (pH 4 - pH 8) across the membrane. The ATP produced was thought to be confirmation of Mitchell's chemiosmosis theory**.** However, titration of acids with bases produces heat, a typical example of adding NaOH to a weak acid is shown in Figure 8.

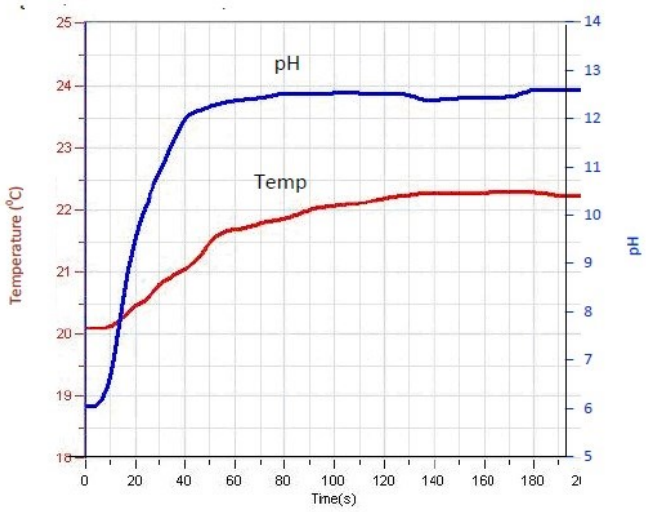

Figure 8. Titration of weak acid with NaOH from pH 6 to pH 12.5

Apparently, Mitchell did not consider the heat Q release indicated by the increase in bath temperature with increasing pH important in the production of ATP. However, in the confined space of the thylakoid the temperature does not increase because of the Planck law. Instead, the heat Q is conserved by producing EM radiation in the UV that drives the formation of ATP.

Oxidative Stress and Metabolism

Mitochondrial ROS and dysfunction are observed (8) in many pathological conditions. The initiation and progression of diseases from mitochondrial dysfunction are decreased by reducing ROS. However, ROS are also important in breaking down food molecules to produce ATP. But the literature is silent on the formation of ROS. By simple QED, the ROS are formed by endogenous UV radiation created in mitochondria from metabolic heat. Since UV is indiscriminant, mitochondria enhance ATP production, but also cause mitochondrial dysfunction. However, mitochondria are not the only source of ROS. Simple QED produces UV radiation in any submicron organelles < 100 nm, such as SMP and vesicles, the only proviso being the organelle produces metabolic heat or is heated by external heat. Simple QED produces ROS by oxidizing organelles.

In chemiosmosis, superoxide is formed by complex electron transfer in mitochondria by several metabolic pathways leading to the formation of peroxynitrite. In contrast, simple QED produces the UV that directly creates the superoxide. Indeed, all ROS reported in the literature are created from endogenous UV by simple QED. But UV produced in mitochondria that create ATP also damage DNA. Because of this, capacity of the mitochondria to detoxify ROS with antioxidant enzymes is critical (9) in preventing the reactions of ROS with cellular components including autophagy in removal of persistent DNA damage.

Vessel Formation

Since simple QED induced UV is essential in both mitochondrial ATP and ROS production, quality control is required (10) to continually clear oxidized, or otherwise damaged proteins and lipids, the selective removal of proteins to the lysosome is mediated by mitochondrial derived vesicles (MDVs). Of interest is the mechanism of pinching-off the outer membrane as shown in Figure 9.

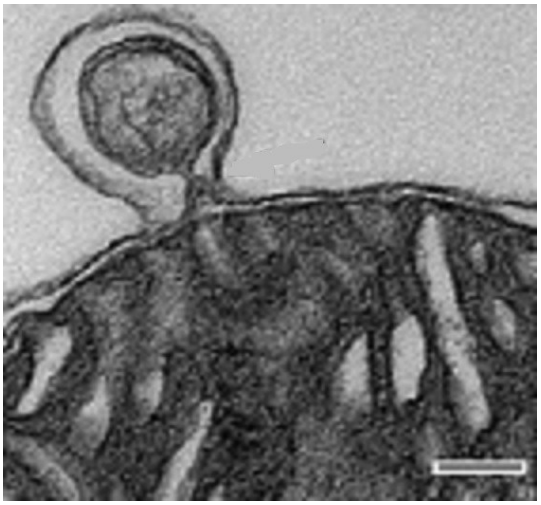

Figure 9. Spherical vesicle formed in Pinching-Off Mitochondrial membrane
(Scale bar 100 mm)

Vesicle formation requires the formation of spherical particles having diameter $d < 100$ nm. Moreover, the spherical particles have almost the same diameters as illustrated in Figure 10.

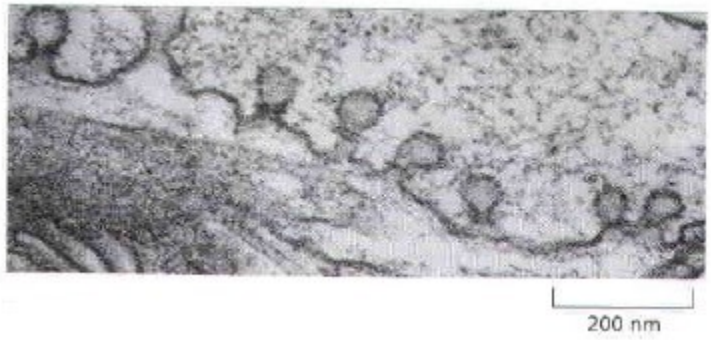

Figure 10. Constancy of Spherical Vesical size.

The formation of nearly identical spherical vesicles suggests the mechanism cannot be driven by internal pressure as shapes could not be controlled. What this means is a displacement controlled internal pressure force is at play. Simple QED in < 100 nm vesicles is proposed to produce EM radiation beyond the UV that removes electrons from cargo molecules leaving behind a highly repulsive positively charged state. Unlike pressure, the repulsive charged state is displacement limited, a condition that not only requires vesicles to be about the same size, but maintains a spherical shape. A spherical shape is important in forming a narrowing neck allowing the fusion of the membrane to close the vesicle.

Conclusions

Unlike human skin exposed to exogenous UV from solar radiation, endogenous UV is produced in submicron organelles within tissues of mammalian bodies. The only condition is that the organelle produces metabolic heat, or absorbs locally available heat.

The simple QED formation of endogenous UV radiation within the mitochondria offers a direct way of producing ATP compared to the complex electron transfer theory of chemiosmosis. However, the UV in mitochondria also damage the DNA, a condition that requires continual repair and autophagy of damaged mitochondria.

The search for the long-sought molecular mechanism alternative to chemiosmosis is over. The 'high-energy intermediate' is not a chemical, but rather endogenous UV produced in the mitochondria by simple QED.

References

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