Broadband endogenous UV in Mitochondria

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Abstract

In the 1960's, the hallmark of molecular biology was Mitchell's discovery of ATP synthesis in mitochondria by chemiosmosis based on oxidative phosphorylation across the inner membrane through a chain of complex redox reactions with electron transfer from donors to acceptors assisted by enzymes. But consistent with Sagan's finding that mitochondria evolving on the early Earth under intense solar UV radiation, ATP synthesis more likely occurred by UV enhanced dehydration reactions of ADP and phosphate instead of redox reactions by hydrolysis. Under constant UV absorption over time, mitochondria naturally evolved nanoscale spaces between cristae tissue similar to the half-wavelengths of the absorbed solar UV radiation. Upon ozone forming in the atmosphere, solar UV was significantly reduced, and for survival mitochondria utilized the cristae spaces to produce their own endogenous UV source. But cristae spaces alone do not produce UV radiation. Recently, metabolic heat within mitochondria was proposed to produce UV standing between adjacent cristae by the process of simple QED, a nanoscale heat transfer process that conserves heat by creating EM radiation instead of increasing in temperature. To allow UV excitation of diverse molecules, the UV standing between adjacent cristae is extended to broadband UV comprising standing UV over a number of nearby cristae in *drosophila* and human lung species. However, the specific UV wavelength which optimizes UV enhanced ATP synthesis of mitochondria species must be determined by experiment.

I. INTRODUCTION

In the 1960's, the origin of life captivated biological research. Mitchell proposed [1] ATP synthesis in mitochondria followed hydrolysis given by chemiosmosis and driven by the flow of H+ ions across the inner membrane. Chemiosmosis occurs by chain of complex redox reactions with electron transfer from donors to acceptors assisted by conveniently available enzymes. In contrast, Sagan et al. [2] proposed life on the early Earth began by a dehydration reaction under intense UV radiation and showed experimentally ATP was formed from ADP + Phosphate under UV. Nevertheless, ATP by hydrolysis and not UV dehydration was chosen the hallmark of modern molecular biology.

However, recent abiotic synthesis of nucleotides using UV radiation and phosphate to purify intermediates [3] supports polymerization of nucleotides into RNA, but requires high energy of which only UV radiation was available on the early Earth. Nevertheless, the argument [4] is made that ionizing UV inherently destroys as much RNA as it creates and if UV was the primordial source of energy, why does no life today undergo ATP synthesis by UV radiation, thereby favoring chemiosmosis as an early bioenergetic process taking place alkaline hydrothermal vents.

Contrary to chemiosmosis, life on the early Earth recently was proposed [5] to have evolved from intense solar UV enhanced ATP synthesis by dehydration reactions as envisioned [2] by Sagan on the early Earth. Mitochondria likely evolved endogenous UV to replace solar UV upon ozone forming in the atmosphere. Today, the exogenous UV takes the form of EM waves standing between adjacent cristae as noted in Figure 1.

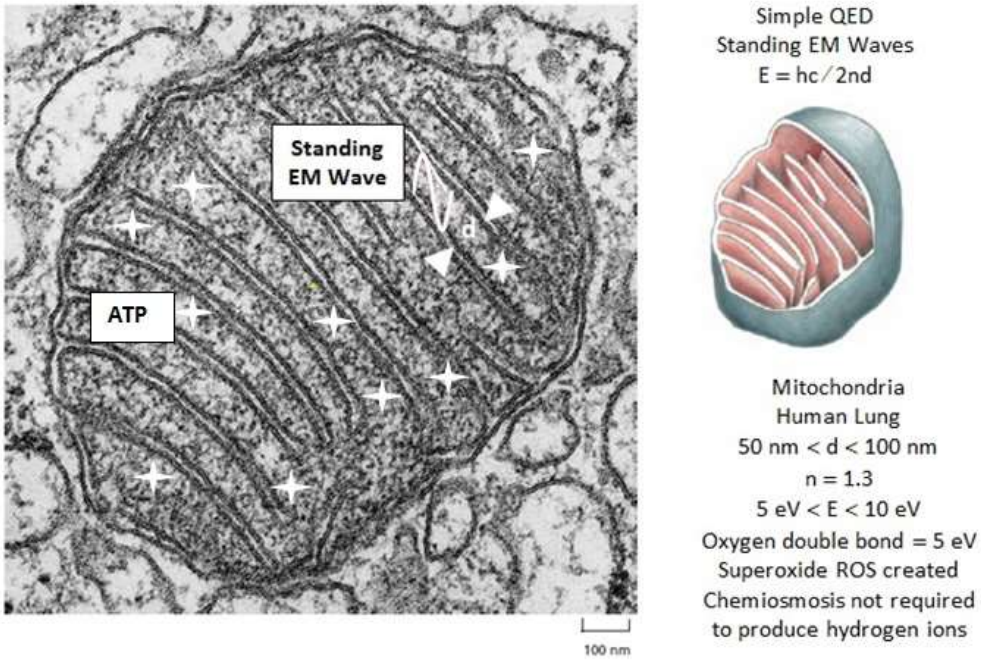

Figure 1. Human Lung Mitochondria
Showing ATP protecting DNA while providing heat source to EM standing wave

The EM wave standing in the mitochondria matrix [5] with a spacing d between adjacent cristae is defined by ($50 < d < 100$ nm). ATP molecules – white stars – are shown dispersed throughout the matrix. ATP binding is the likely heat source for simple QED to produce EM radiation. 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. The standing EM waves [3] are only shown between adjacent cristae with ATP synthase bound to lateral cristae surfaces in Figure 2.

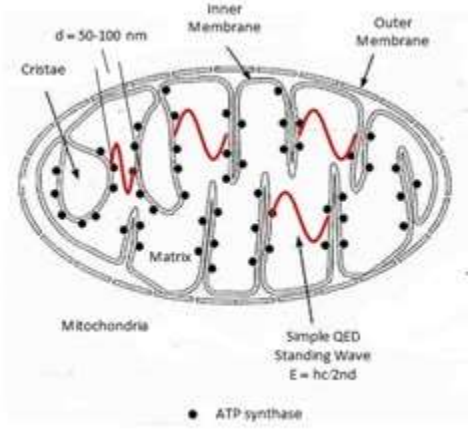

Figure 2 Standing EM waves between Cristae

Unlike exogenous UV from solar radiation, the UV radiation is endogenous to the mitochondria following the nanoscale heat transfer process of simple QED that converts [6] metabolic heat to EM radiation instead of temperature. Simple QED is based on the Planck law of quantum mechanics that denes atoms in nanostructures the heat capacity to conserve heat by a change in temperature. Hence, metabolic heat in human lung mitochondria having nanoscopic spaces < 100 nm between adjacent cristae create EM radiation > 5 eV that produce ATP by the dehydration reaction,

$$ADP + Pi + UV \rightarrow ATP + H_2O$$

where, Pi is a phosphate group. However, Nature most likely did not choose chemiosmosis as the mechanism for ATP synthesis as a more direct path is UV enhanced dehydration, thereby avoiding complex sequential electron chain reactions that require specific enzymes to be instantly available at each step to create electrons that passed from one electron carrier to another. Alternatively, ATP synthesis is simply more direct by UV assisted dehydration reaction

Although dehydration reaction by UV is simpler than chemiosmosis, the difficulty is UV damages DNA directly, and indirectly by creating reactive oxygen species (ROS). In this regard, chemiosmosis also creates ROS by errant interaction with oxygen along the electron chain of reactions. But ROS is not a problem as mitochondria release ATP to protect against UV damage, i.e., the ability of ATP to protect mitochondria [7] allows both chemiosmosis and dehydration reactions to proceed during UV radiation. Regardless, Nature took advantage of the simplicity of UV induced ATP synthesis over chemiosmosis to sustain life at the expense of expending some ATP in protecting the mitochondria.

In mitochondria, ATP synthesis of human lung was based on simple QED induced [5] endogenous UVC radiation between adjacent cristae having spacings 50-100 nm as noted in Figure 1. But mitochondria of fruit fly *Drosophila* have [8] far smaller cristae spacings of the matrix at 13 nm with cristae width of 17 mn as shown in Figure 3.

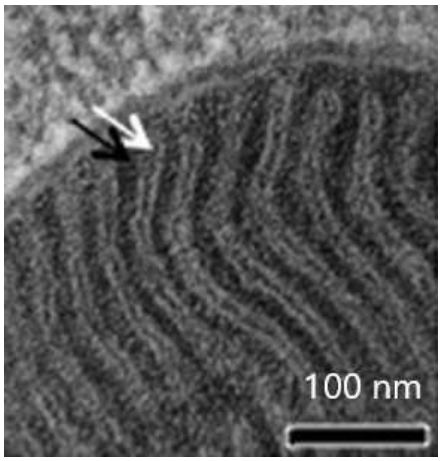

Figure 3. Mitochondria *Drosophila* Cristae
White arrow, cristae 17 nm; black arrow, matrix 13 nm

The problem is *Drosophila* having adjacent cristae spacings of 13 nm induce standing simple QED induced EM radiation in the EUV >> UVC and can only enhance ATP synthesis by fluorescing down to UVC levels. However, fluorescence is inefficient. It is therefore desirable to have the EM waves stand over longer spacings to produce broadband UV to not only enhance ATP synthesis with UVC, but also process the synthesis of ~1500 proteins necessary in maintaining diverse cell functions.

II. PURPOSE

The purpose of this paper is to extend ATP synthesis by UVC radiation standing between adjacent cristae to multiple nearby cristae in producing broadband UV spectrum.

III. ANALYSIS

The molecular arrangement of ATP synthase dimers on cristae from bovine heart, potato, and three types of fungi [9,10] comprising long rows of ATP synthase dimers on tightly curved cristae tips were found conserved in all species studied. Proton pumps of chemiosmosis theory [1] were arranged on flat cristae surfaces as illustrated with attendant protons in Figure 4.

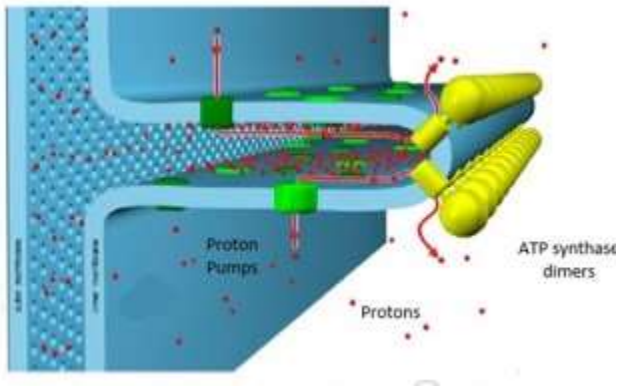

Figure 4. ATP synthase dimers on Cristae tips

By chemiosmosis, the ATP synthase forms yellow dimer rows at the cristae tips, the green proton pumps of the electron transfer chain pump red protons into the cristae space that flow back into the matrix through the ATP synthase rotor to produce ATP. But UV enhanced ATP synthesis differs as red EM radiation stands in the matrix between adjacent dimers shown in Figure 5.

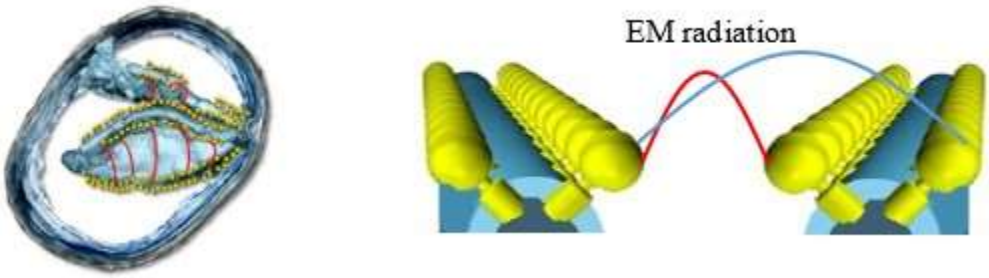

Figure 5. Standing EM radiation in Matrix between dimers of adjacent Cristae

In chemiosmosis, dimers arranged along tip of cristae serves no purpose as the dimers and proton pumps could just as well be located on the flat cristae surfaces. Figure 5 depicts the importance of the dimers in UV enhanced ATP synthesis in that the dimer heads on adjacent cristae closest each other uniquely define the nodes of red standing EM radiation across the matrix instead of the geometrically unlikely blue standing EM waves.

But in mitochondria, the broadband UV process takes advantage of EM waves standing over a number N of cristae spaces separated by a matrix of dimension Δ shown in Figure 6.

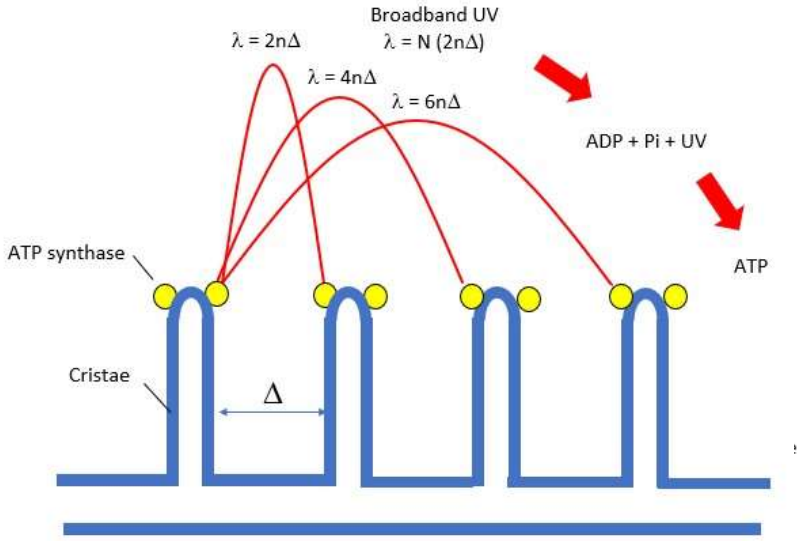

Figure 6. Broadband UV radiation in Mitochondria

The broadband UV consists of the sum of EM radiation E between dimer ATP synthase,

$$UV = n\Delta \sum_{1}^{N} K = n\Delta \frac{N}{2}(N+1)$$

where, n is the refractive index of the matrix and N is the number of cristae in the mitochondria. Taking the refractive index n = 1.3 for water, the wavelengths λ of each standing wave is given in Table 1

Table 1. Broadband UV near UVC = 254 nm

Mitochondria Species	λ = 2nΔ·K ~ nm K								
	1	2	3	4	5	6	7	8	9
Drosophila Δ = 13 nm	33.8	67.6	91.3	121.6	169.1	202.8	236.7	270.5	304.2
Human Lung Δ = 50 nm	130	260	390						

Taking UVC = 254 nm, Table 1 is marked in blue arrows showing the K value at which UVC occurs for *Drosophila* and the human lung. Both mitochondria require fluorescence down to 254 nm for ATP synthesis. For *Drosophila* from K = 8 at 270.5 nm, and for human lung K = 2 at 260 nm. The advantage of broadband UV is the efficiency of fluorescence is enhanced.

IV. CONCLUSIONS

Broadband UV enhances ATP synthesis by dehydration by increasing the efficiency of fluorescence.

The UV level for mitochondria species may not be UVC. Experiments are required to determine the optimum UV wavelength to enhance ATP synthesis by dehydration.

References

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