Cancer: UVC in the Nanoparticle Treatment and Metastasis

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Abstract

Classical physics allows the atom to have heat capacity at the nanoscale, the conservation of heat proceeding by an increase in temperature. However, simple QED based on the Planck law of quantum mechanics (QM) denies the atoms in nanoparticles (NPs) the heat capacity to conserve heat by a change in temperature, the consequence of which is embodied in the proposed Cancer NP Treatment: ~ 80 nm NPs injected intravenously in cancer patients convert body heat to UVC radiation allowing DNA damage to accumulate in cancer cells to initiate apoptosis. Collateral DNA damage to normal cells does occur, but is corrected by DNA repair systems. CDC tests to determine safe NP dosage levels in the NP treatment are required to confirm the expectation that UVC levels will not compromise normal cells based on the argument that survival of organisms required evolution of DNA repair systems to continuously correct for DNA damage from the far more intense solar UVC on the primitive Earth. Simple QED not only emits UVC from NPs to treat cancer, but is the source of cancer metastasis as UVC emitted from ~100 nm filopodial protrusions at the leading edge of cancer cells damages DNA in distal normal cells.

Keywords: Covid-19, Quantum Mechanics, Planck law, Nanoparticles.

1. Introduction

The Covid-19 pandemic has recently highlighted the importance of the rapid development and testing of preventive vaccines for world-wide infectious diseases that require the discovery of antigens of inactivated viruses or RNA fragments to elicit an immune response. Because the discovery and verification of the Covid-19 antigen in a short time is not apparent, the NP Treatment was proposed [1] for patients tested positive and known to have the virus. A single intravenous injection of ~80 nm lipid NPs selected to emit UVC radiation to inactivate at least a few virions in the patient that then act as antigens to elicit the immune system to inactivate the remaining virions in the patient as well as future Covid-19 infections. No chemicals or lasers are required. In this way, the NP Treatment acts as an *in vivo* preventive vaccination using UVC to inactivate Covid-19 virions as antigens to elicit immunity

In Photodynamic Therapy (PDT), an IR laser irradiating gold and silver NPs attached to cancer cells is thought [2] to kill the cancer by an increase in temperature of surrounding tissue, but the Planck law denies the NPs the heat capacity to increase in temperature. What this means is cancer necrosis is likely caused by UV radiation produced by the heated NPs, the latter leading to the instant notion [1] of UV disinfection of the Covid-19 by NPs.

Unlike Covid-19, cancer cells growing faster than normal cells are not recognized by the immune system to elicit the necessary response to inactivate the cancer. Cancer vaccines therefore focus on recognizing fragments of a specific cancer similar to a specific vaccine for Covid-19 instead of a vaccine for all virus. Alternatively, cancer vaccines [3] allow the immune system to recognize tumour-associated-antigens (TAAs). But the problem with developing cancer vaccines is the TAAs are also present in normal cells, and therefore the immune system does not respond.

What this means is an antigen for a cancer not present in normal cells needs to be discovered. The huge task in considering the wide range of cancers: breast, prostate, liver, kidney, pancreas, and lung, melanoma, and leukaemia is unlikely.

2. Purpose

Cancer is too complex to expect a preventive vaccine be developed in the long-term, let alone the near term. Indeed, the long-standing CDC paradigm of vaccines as the traditional path for preventing cancer as well as Covid-19 needs review for realism. Cancer requires patient specific treatment similar to the Covid-19 NP Treatment [1] as opposed to vaccines for the diverse patients of the world population. With this in mind, the purpose of this paper to assess simple QED induced UVC as a NP Treatment for the individual cancer patient similar to the NP Treatment for Covid-19.

Another purpose is to assess cancer metastasis as simple QED induced UVC radiation from the filopodial protrusions of the leading edge of cancer cell to distal normal cells powered only by the thermal energy of the ambient surroundings.

3. Analysis

3.1 Mechanism

In 2009, researchers [4] found UV radiation caused human cancer cells to trigger cell death, suggesting UV induced cell death would be better than spreading further growth. Usually, p53 triggers the cascade of events that lead to cancer cell death, but cell death occurs in the absence of p53. More likely, cell death in cancer is caused by accumulative UV induced DNA damage over time reaching a critical level. Unlike chemical chemically induced DNA damage, UV is generally accepted [5] as the cause of immunosuppressed cancer growth with DNA damage accumulating over time. Hence,

Accumulated UV induced DNA damage controls cancer growth

In this regard, the DNA damage in cancer and normal cells requires the high UV absorption by purine and pyrimidine bases. However, the UV absorption of DNA suggested in cell death includes [6] thermal denaturation of DNA known as the hyperchromic shift. Double-stranded DNA absorbs less strongly than denatured DNA due to the stacking interactions between the bases. UV absorption in both native and denatured DNA in the UV from 200 to 300 nm is shown in Fig. 1.

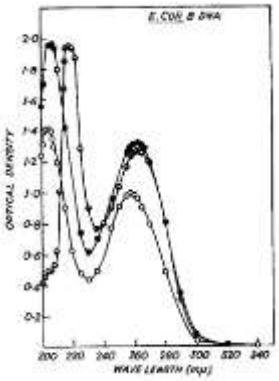

Figure 1. DNA absorption spectrum
Native DNA at pH 7.2 (Open circles) Denatured DNA at 100°C (Black circles)

3.2 Source of UV

Generally, solar radiation in the UV from 290–320 nm is recognized as the cause of skin cancer. However, only UV irradiation was shown [7] to somehow reduce the progression of tumours. Indeed, UV irradiation of the skin is hypothesized [8] to produce immune cells having tumor-specific antigens, the clonal expansion of which protects the host against tumors in internal organs. In effect, solar radiation acts as a helio-vaccination to immunize the host.

However, solar UV is not likely to reach internal organs and immunize the host and unlikely to even penetrate the epidermal layer of the skin. Langerhans cells comprise [9] diverse nanoscopic entities: Birbeck granules (BG), worm-like bodies (WLB), and narrow endoplasmic reticulum (Nrer) including the lupus erythematosus (LE) virus as shown in Fig. 2. The WLB and Nrer have diameters from 20 to 80 nm.

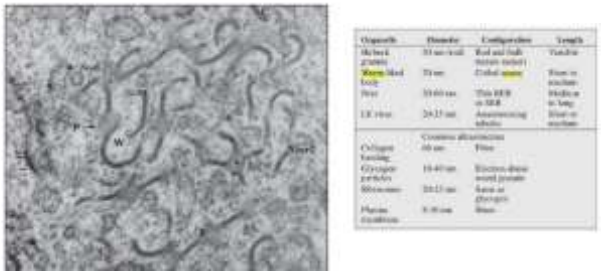

Figure 2. Nanoscopic Langerhans Organelles

Solar UV including VIS and IR light absorbed is absorbed in Langerhans cells to produce simple QED induced EM radiation [10] produces EUV levels that is promptly absorbed and cannot reach internal organs. Therefore,

Solar radiation cannot cause cancer in normal cells of distal body organs

3.3 Warburg's Theory of Cancer

In 1956, Warburg proposed [11] the origin of cancer as the rapid metabolic cell growth by glucose fermentation upon the lack of oxygen for respiration only to fall by the wayside to Watson and Crick's genetic explanations of cancer. Nevertheless, Warburg did not associate metabolic growth to UV induced ATP synthesis.

In the 1960's, Mitchell [12] proposed ATP synthesis in mitochondria followed hydrolysis given by chemiosmosis driven by the flow of H+ protons across the inner membrane. In contrast, Sagan [13] 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. Sadly, ATP by hydrolysis and not UV dehydration was chosen the hallmark of modern molecular biology. Otherwise, the importance of UV in ATP synthesis would have long-since been recognized in the origin of cancer. It follows,

Mitochondria produce endogenous UV radiation

3.4 Endogenous UV

In 2019, Prevenslik proposed [14,15] simple QED produces endogenous UV in the mitochondria to allow ATP synthesis consistent with by Sagan's theory [13] of UV induced dehydration. Later, Prevenslik [15] extended endogenous UV to Warburg's theory of cancer that lacked a source of UV to explain observed DNA mutations.

The ATP synthesized by respiration in mitochondria involves more structure than required for synthesis by fermentation. In the cell, ATP by fermentation [16] in peroxisomes having a far simpler structure, but like mitochondria produce endogenous UV. Although solar UVC radiation provides an understanding of the mechanism of ATP production in the evolution of life on the primitive Earth, only endogenous UV produced within the mitochondria and peroxisomes by simple QED is relevant to molecular evolution after the ozone layer blocked solar UVC - a process that continues to this day.

Simple QED produces endogenous UV radiation

3.5 Simple QED

Simple QED is a method [9] of nanoscale heat transfer that conserves heat with EM radiation instead of temperature. QED stands for quantum electrodynamics, a complex theory based on virtual photons advanced by Feynman [17] and others. In contrast, simple QED is far simpler based on the Planck law that requires the heat capacity of the atoms in nanostructures to vanish allowing conservation to proceed by the creation of real photons comprising EM waves standing across the nanostructure. Like electron orbitals, simple QED quantum states are size dependent based on the dimension of the nanostructure over which the EM waves stand.

By classical physics, the kT heat capacity of the atom is independent of the EM confinement wavelength λ, where k is the Boltzmann constant and T absolute temperature. QM differs as the heat capacity of the atom decreases under EM confinement λ < 100 microns, and at the nanoscale for λ < 100 nm, the heat capacity may be said to vanish. The Planck law [18] at 300 K is illustrated in Fig. 3.

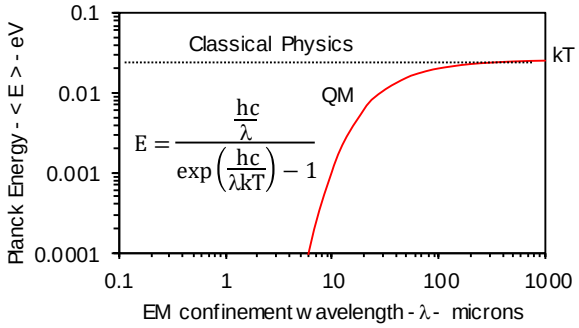

Figure. 3: Planck law of the Atom at 300 °K
In the inset, E is Planck energy, h Planck's constant, c light speed, and λ EM wavelength

EM confinement occurs by the high surface-to-volume (S/V) ratio of nanostructures that requires the heat Q to almost totally be confined in the surface, the surface heat itself as EM energy providing the brief EM confinement necessary to create EM waves standing across the internal dimension d of the nanostructure. For heat (or light) having

wavelength $\lambda < d$, the absorption occurs over the incident face of the particle. However, for small particles $d << \lambda$, the light fully immerses the particle to be absorbed uniformly over the full surface. Fig. 4 illustrates $\lambda >> d$ with light - yellow- immersing the NP and absorbed in penetration depth δ over the full NP surface.

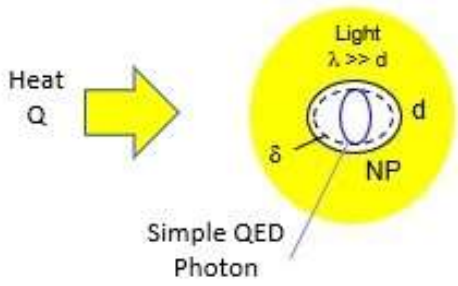

Figure 4. Heat Q (or light) absorbed in full NP surface

Confinement of the light Q while creating the UVC standing wave requires EM confinement at least equal to the Planck energy E of the light. The pressure P acting on the surface is given for bulk modulus B and volume strain $\Delta V/V$ by, $P = B \cdot \Delta V/V = 6 \cdot \delta \cdot B/d$. But $P = E / V = 6E/\pi d^3$ giving $\delta = Q/\pi B d^2$. For an 80 nm NP with bulk modulus $B \sim 2x10^9$ N/m^2, the absorption depth δ of a single UVC photon is $\delta \sim 20$ fm - a small but necessary depth to confine the absorbed heat Q = E to the geometry of the standing wave.

Simple QED absorbs heat Q in the NP surface given by the penetration δ depth. Unable to conserve the surface heat by a change in temperature, conservation requires the creation of simple QED radiation, the time τ to create the standing wave, $\tau = 2d/(c/n)$. The Planck energy $E \sim h/\tau = hc/2nd$ depends on the refractive index n of the NP to correct for the velocity c of light within the NP. Fig. 5 illustrates the standing EM radiation in a spherical NP of diameter d, but NP atoms still follow their quantized electron energy levels.

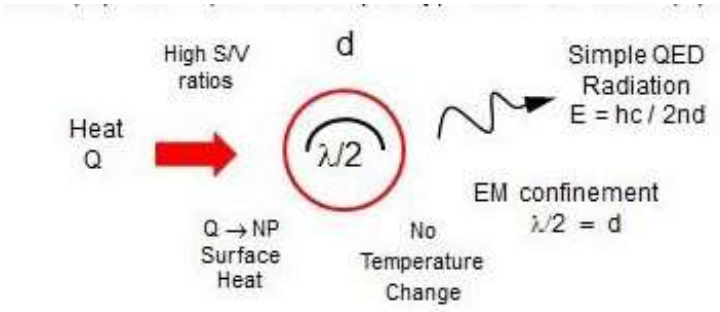

Figure. 5: Planck Energy of EM Radiation

4. Application

The simple QED analysis of the thermal response of a single lipid NP in a thermal bath of tissue and blood is illustrated in Fig. 5.

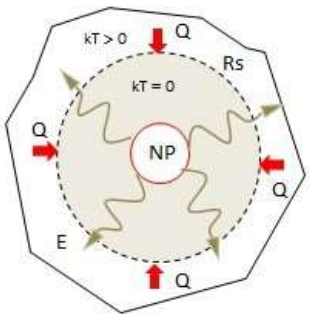

Figure. 5: NP in a Thermal Bath

The NP absorbs heat Q from the thermal bath at absolute temperature T by conduction. Fig. 2 shows Fourier's heat conduction equation at 300 K is only valid in the bath for kT = 0.0254 eV. The radius Rs at which bath atoms at have thermal kT energy is $\lambda > 200$ microns. 1. For body tissue and water having refractive index n = 1.4, the radius $Rs = \lambda/4n \sim 36\ \mu m$. What this means is the heat flow Q from the bath at temperature T is converted at Rs to EM radiation in the far IR ($\lambda = 200$ microns) and upon being absorbed at by the NP is conserved by emitting simple QED radiation.

Classically, all atoms in the NP at equilibrium have temperature T equal to the bath temperature. In terms of the Boltzmann constant k and the number N of atoms, the total LNP thermal energy U is,

$$U = \frac{3}{2} NkT$$

However, by the Planck law the N atoms do not have temperature T. Instead, simple QED conserves thermal energy kT that otherwise would occupy the 80 nm NP by creating standing EM radiation across the NP.

Taking the molecular weight 616 of the lipid meibomian C44H56O2, the number Nm of molecules is, $Nm = (\rho V/616)\cdot Av$, where volume $V = \pi d^3/6 = 2.68 \times 10^{-22}\ m^3$, density $\rho = 1000\ kg/m^3$ and Avagadro's number $Av = 6.023 \times 10^{26}$ mols/kg-mol. Hence, $N = 2.62 \times 10^5$ and N = 0.27 million atoms $\rightarrow$ U ~ 10.8 keV. For $E = hc/\lambda$ at $\lambda = 254$ nm, E ~ 4.88 eV and the lipid NP creates about 2200 UVC photons to equilibrate the 300 °K thermal bath temperature. Once created, the emitted UVC photons are absorbed by the Covid-19 virus or water bath, the bath temperature T once again produces the number of ~ 2200 UVC photons repetitively.

But how rapidly does the NP surface temperature recover?

The simple QED creation of UVC having Planck energy E = 4.88 eV absorbing a pulse [19] of heat from the water changing the temperature ΔT at the radius Rs is shown in Fig. 6. The Planck energy E is spread over the spherical surface area πRs^2. The pulse duration is $\Delta t = 2d / (c /n) \sim 0.85$ fs. The UVC heat $Q = E/\Delta t \sim 900\ \mu W$. For water, thermal diffusivity $\alpha = K/\rho C$, where $\alpha = 1.24 \times 10^{-7}\ m^2/s$ and K = 0.52 W/m-K. The white circle in Fig. 6 shows the initial drop in temperature ΔT for a single UVC photon ~ 2 μ°C that recovers < 1 ps. For 2200 UVC, the $\Delta T \sim 0.004$ °C.

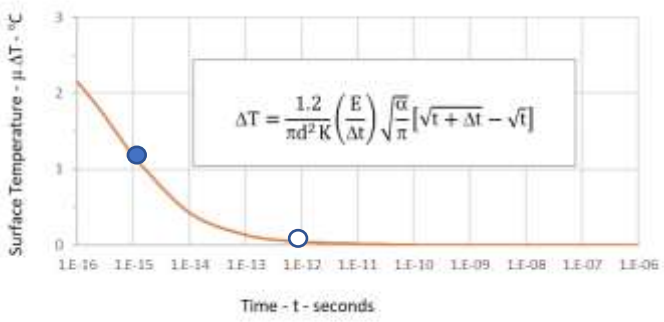

Figure. 6: Single Photon Creation Time

The Planck energy E is spread over the spherical surface area πRs^2. The pulse duration is $\Delta t = 2d / (c /n) \sim 0.85$ fs. The UVC heat $Q = E/\Delta t \sim 900$ μW. For water, thermal diffusivity $\alpha = K/\rho C$, where $\alpha = 1.24$ x10-7 m^2/s and K = 0.52 W/m-K. Fig. 6 shows the initial drop in temperature ΔT to be ~ 2 μ°C that recovers < 1 ps.

However, the UVC photon must be created promptly, say < 5 fs as noted by the blue circle. Classically, the UVC photon cannot be created from body temperature surroundings. Much higher bath temperatures are required, the required temperature $T = E/1.5k \sim 37{,}000$ °K.

QM differs. High temperatures are not necessary for NPs under high EM confinement. Indeed, once the heat Q is absorbed in the penetration depth $\delta = 20$ fm of the NP, the creation time τ of the UVC photon $\tau = 2d/(c/n) \sim 0.85$ fs < 5 fs < 5 fs and acceptable. Indeed, UVC photons are created at 300 K body temperature.

6. DNA Repair in UVC induced Cancer

The Cancer NP treatment follows that for Covid-19 in that the UVC induces apoptosis of the cancer like the virus, but differs as far more NPs are required to inactivate the cancer placing a greater burden on the DNA repair system for normal cells. Nevertheless, the DNA damage to the cancer patient is justified as the cancer patient is in a far more critical condition than his Covid-19 counterpart. Inactivation of Covid-19 virions with NP induced UVC is relatively trivial with minimal risk at low NP dosage compared to cancer, but otherwise the UVC inactivation of the cancer is the same.

Simple QED applied to 80 nm NPs producing UVC radiation allows past UVC experiments on cancer without NPs to be extended to the NP treatment. In contrast, most NP experiments lack any theoretical basis for destroying cancer and simply provide a set of results for a set of NP sizes and materials, thereby lacking an overall approach to cancer. Over more than a decade, Photodynamic Therapy (PDT) was reported [19] using an IR laser to irradiate gold NPs < 5 nm that having migrated inside the cancer cell are heated to a high temperature which killed the cancer. At that time, the notion of the heated NPs emitting EM radiation at UV or EUV levels with DNA damage were never considered.

Warburg [10] foretold the future of EM irradiation of tissue containing both normal and cancer cells. Normal cells survive PDT because of a higher residual respiration after irradiation. But descendants of the surviving normal cells may compensate the respiration decrease by fermentation increase and, thereby become cancer cells. Warburg concluded that radiation which kills cancer cells can also at the same time produce cancer - a lesson only learned recently with DNA damage [20] and apoptosis from silver NPs in PDT.

Like PDT, the NP treatment uses UVC to inactivate cancer, but at low levels should allow the DNA repair systems to correct for UVC damage to normal cells. Unlike Covid-19, cancer may not be killed by low level NP induced UVC, a conclusion which CDC should verify experimentally. But high levels of NP induced UVC may still be acceptable as the power of DNA repair systems should not be underestimated.

Indeed, DNA repair systems that evolved on the Earth over billions of years under intense UVC allowed species survival by DNA repair systems before the ozone layer blocked the UVC 600 million years ago. Indeed, Sagan's discovery [12] of UVC enhanced ATP synthesis shows UVC sustained life with collateral DNA damage obviously corrected based on our survival. Other theories of the origin of life avoid the reality of UVC by arguing life began in benign hydrothermal vents [21] by chemiosmosis [11] which is superseded [13] by endogenous UV in mitochondria.

In effect, the NP treatment induces cancer cell death by accumulative UVC induced DNA damage while suppressing cancer DNA repair. Unlike cancer cells, DNA damage to normal cells is corrected by DNA repair systems. The NP treatment is illustrated in Fig. 7.

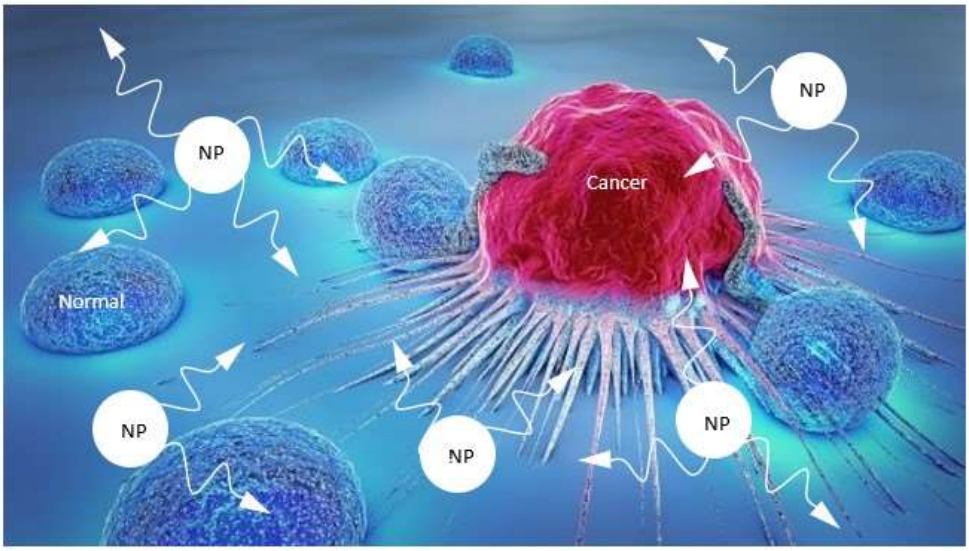

Figure 7. Cancer NP Treatment - UVC from 80 nm lipid NPs

7. Discussion

7.1 Treatment

The Cancer NP Treatment is based on the premise UVC radiation induces human cancer cells to trigger apoptosis or suicidal cell death which would be better than spreading further cancer growth. Necrosis aside, apoptosis in cancer is caused by accumulative UV induced DNA damage over time upon reaching a critical level. However, if collateral DNA damage leads to the death of the patient from cancer spreading to normal cells, the NP treatment fails, but this outcome assumes the DNA damage in normal cells is not corrected by DNA repair systems. To the contrary, the NP Treatment is expected to be successful because UVC induced DNA damage to normal cells is corrected by the patient's DNA repair system.

The expectation of DNA repair correcting for the collateral UVC induced DNA damage to normal cells while cancer cells undergo apoptosis is not yet proven. Indeed, the Cancer NP treatment requires considerable testing of patients in critical condition. Nevertheless, success is expected because of the significance of UVC in evolution of the human and other species. In the origin of life on the primitive Earth, normal cells underwent significant DNA damage because survival under intense UVC required the evolution of comparable DNA repair systems. The important point is *survival* required the evolution of a very powerful DNA repair system to correct UVC induced damage, specifically nucleotide excision repair (NER) of pyrimidine dimerization. It is not surprising NER is a highly evolutionarily [22] conserved repair mechanism and is used in nearly all eukaryotic and prokaryotic cells.

It is generally thought Mitchell's chemiosmosis theory [12] upon the emergence of Earth's oxygen-rich atmosphere presenting potentially damaging free radicals in the cell due for oxidative phosphorylation necessitated the evolution [22] of DNA repair mechanisms that act specifically to counter the types of damage induced by oxidative stress. However, the far simpler UV enhanced ATP synthesis [14] only requiring the presence of UVC to produce ATP avoids the complex chain reactions of chemiosmosis.

But UVC also damages DNA, yet organisms are found [23] to be more sensitive to UVC than mammalian cells. With appropriate doses, organisms may be selectively inactivated by UVC with minimum damage to mammalian cells. Indeed, UVC at the effective antimicrobial doses can cause DNA damage to mammalian cells. Nevertheless, UVC-induced DNA damages can be rapidly corrected by the DNA repair systems of the host. Applicability to microorganisms like Covid-19 is obvious, but extensions to larger cancer cells is less certain.

Regardless, UV and specifically UVC was not only important in sustaining the ATP energy supporting organism life on the primitive Earth, but also threatened life by inducing DNA damage. Where it not for DNA repair systems, we would not be here today. On this basis, the Cancer NP treatment of intravenous NP injections is expected to induce cancer apoptosis with attendant DNA damage to normal cells corrected by DNA repair systems. Critically ill cancer patients may therefore extend their life by DNA repair as organisms did on the early Earth.

7.2 Metastasis

Cancer cell spreading across a vessel wall depends on the interaction between the tumour cell and the cell wall. It is thought [24] the interaction involves the secretion of substances to degrade the basement membrane and extracellular matrix. By the process of intravasation, blood vessels near the tumour provide a route for the cancer cells to enter the bloodstream and metastasize to distant sites. Once the tumour cell arrives at a point of intravasation, once again interacts with the endothelial cells by secreting substances to rapidly penetrate the normal cell wall by extravasation.

But how tumour interaction occurs is not well understood. Tumour cells contain microvilli comprising finger-like structures, especially on the surfaces of circulating T and B lymphocytes. About 30 years ago, the speculation [25] was microvilli play an important role in tumor growth and metastasis, and the density of microvilli on the surface of tumor cells was closely associated with the ability of the tumor cells to metastasize. Microvilli density on the surface of tumour cells was correlated with growth. A comparison of low and high microvilli density is shown in panels 1 and 2 of Fig. 8.

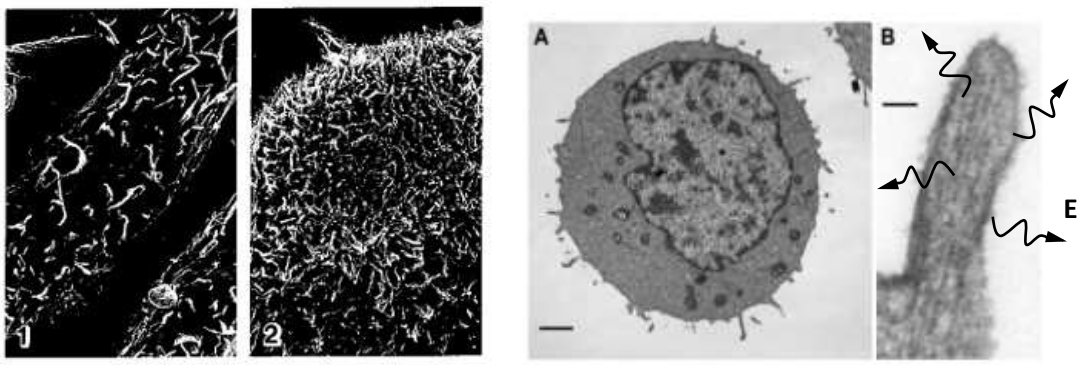

Figure 8. Microvilli density [25] in Cancer: 1 Low growth 2 - High growth.
Microvilli [26]: A Cancer cell - Bar 1 micron, B Microvillus - Bar 50 nm

Microvilli cover the surfaces of lymphocytes [26] as shown in Fig. 8A, of which a single microvillus is shown in Fig. 8B. The microvillus has a length of 300-400 nm and diameter of about 100 nm. Of interest is the role of the microvilli in penetrating the cell wall of normal cells in metastasis. In this regard, microvilli burrowing through the wall of normal cells by EM radiation is noted simple QED induced EM radiation E emitted from the cylindrical surface of the microvillus in Fig. 8B.

Simple QED states nanoscale structures emit EM radiation instead of acquiring the temperature of the surroundings. Microvilli on cancer cells having diameters d ~ 100 nm emit EM radiation having wavelength $\lambda = 2nd$. For actin treated as skin [27] having refractive index n ~ 1.4, the microvilli emit EM radiation $\lambda \sim 280$ nm which is in the UV.

A similar EM effect of burrowing of Covid-19 was proposed [28] to explain why the virus is found in the brain and not in the lungs. To reach the brain, the Covid-19 cannot pass through the nasal olfactory nerve cells because of the lack of ACE2 receptors suggesting the spikes of the Covid-19 burrow through the cell wall. In this regard, point sources of EM radiation are known to burrow through cell walls by ionization, but cannot be translated to the nose unless the Covid-19 spikes are a source of EM radiation. But Covid-19 spikes having diameter ~ 15 nm emit EUV radiation which is less favorable to burrow through cell walls than ~100 nm cancer microvilli emitting UV radiation.

In cancer, microvilli described by actin-based plasma membrane protrusions [29] called filopodia at the leading edge of migrating tumour cells. Like microvillus, filopodia are a few microns long with a diameter of about 100 nm as shown in Fig. 9.

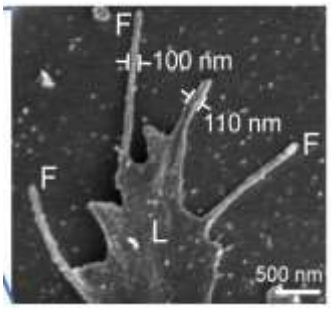

Figure 9. Filopodia (F) at leading edge of Cancer cells

Cancer cell filopodial protrusions play key roles in cell motility and signalling in tumour invasion. and metastasis. HER2 is thought [29] a marker of cancer growth of breast cancer at protrusions, but how HERS produces signalling is not well understood. But HER2 is thought to activate new protrusion growth requiring no active energy sources and diffuses freely within filopodia. HER2 activation, propagation, and functional protrusion growth is explained [29] by evolution of filopodia from Brownian thermal fluctuations within a barrier-free nanostructure.

Simple QED differs. HER2 is not a chemical marker of metastatic signalling evolved from Brownian thermal fluctuations at cancer cell protrusions, but rather metastasis is proposed caused by DNA damage at distal normal cells from UVC radiation emitted from the filopodial protrusions at body temperature.

6. Conclusions

Cancer NP Treatment comprises ~ 80 nm NPs injected intravenously in cancer patients that convert body heat to UVC radiation to allow DNA damage to accumulate and initiate cancer apoptosis.

UVC also induces DNA damage to normal cells, but is promptly corrected by DNA repair systems. But DNA repair of accumulated DNA damage in cancer cells is not favored compared to apoptosis.

Metastasis of cancer by secreting HER2 or other substances is proposed superseded by simple QED induced UVC emission from filopodial protrusions that spread the cancer by causing DNA damage to distal normal cells.

The NP Treatment is expected to be successful because UVC induced DNA damage to normal cells is corrected by the patient's DNA repair system. Nevertheless, the CDC is requested to run tests to determine the safe dose of NPs for cancer patients. NPs entering the brain may damage neurons, but for cancer patients in a life-threatening condition, the side-effects may be justified.

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