Ultra-weak Photon (Biophoton) Emissions (UPE)-Background Information

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http://www.anatomyfacts.com/research/photonc.htm

Introduction

Basic Physics and Chemistry

I wish I had paid more attention in my high school physics and chemistry classes but instead I counted ceiling tiles, wrote bad poetry and picked at my zits. With that in mind I will try to explain what I remember about photons, physics and chemistry in general Chemical Organization . What follows could have factual errors so beware. About 4.5 billion years (that is approximately 4500 million years-hard to imagine) ago our Sun formed as a result of hydrogen atoms (there are 118 elements of which 92 are naturally occurring. Periodic Table These are unique atoms which are detailed in the elemental table) compressing so much that the relatively weak electrical force exerted by the electrons (Like negative charges repel) of the hydrogen atoms could no longer oppose one another. Remember an atom is composed of electrons (-charge), which move in fixed orbits around the central nucleus, which contains protons (+ charge) and neutrons (neutral charge). The protons are held together by the strong nuclear force of the neutrons otherwise because like charges repel they would fly apart disintegrating all matter. Electrons (- charge) are held in their orbits around the protons (+ charge) because opposite charges attract. Likewise electrons normally repel adjacent atoms so that atoms don't normally dissolve into one another. This is considered a relatively weak electrical force, which is a good thing because then under the right circumstances atoms can combine to form new elements. Chemistry studies the various atomic combinations. It's almost like legos the childhood play construction game. 99% of the universe is comprised of hydrogen (H) and helium (HE). This is good because they are the simplest atoms with one and two electrons orbiting their 1 and two protons and neutrons respectively. Simple atoms can then be used by the compressive forces in the sun and extreme heat to form a host of new elements. Most of the other 90 naturally occurring elements are made in stars. We are mostly made of star stuff.

Because there is so much hydrogen floating around in space over time (millions of years) it becomes compressed due to the gravitational attraction of matter. Eventually the hydrogen atoms collapse into one another (Fusion) to form helium. When that happens photons are produced to form visible and invisible light. Photons are thus produced as a result of chemical reaction when electrons orbits degrade or when electrons are lost. It is the reason you see sunlight and it is still going on today. Photons take about 8 minutes to get from the sun to earth traveling at the speed of light at about 186,000 miles per second. Photons generally bounce off things and so your retina is sensitive to them and you can see objects in your environment. When the sun runs out of hydrogen then our sun will literally burn out (probably in about 12 billion years). A photon is a sub atomic particle (or string). According to Edward Witten Edward Witten (M Theory) (Many physicists think he is the smartest man alive-even smarter than Einstein) a string is a vibrating string (think violin) and or membrane of energy. The frequency (how many times it vibrates in a given period of time) and amplitude (How forceful the vibration is) will determine what type of sub-atomic particle it is (quark, gluon, photon, ect). There are 21+ sub-atomic strings (particles) (things that are smaller than an atom). Particle Physics They can be compressed into a very small space. When massive suns die all of their particles collapse to form a "BLACK HOLE." It is thought that the entire universe that exists today is a result of these particles being compressed into a space smaller than the size of the nucleus of one atom. This concentrated matter then exploded into what

is popularly described of as the "BIG BANG" to form the visible universe about 14 billion years ago. It used to be thought (Democritus (450BCE-?)) that the atom was the smallest unit of matter. Then we began smashing atoms into one another at high speeds at which point we could see some of these smaller particles or strings. For example, when you smash up protons and neutrons you get quarks. Other particles such as photons can be produced thru chemical reactions, which produce new chemical elements.

Photons

A photon could be visualized as a tortilla or pizza pie without the topping. Throw it in your imaginary air space and slow mo its free fall so that you can carefully observe its properties. Notice that it is not perfectly flat because when you threw it in the air it slid off of your hand and began undulating. That is visualize your tortilla with waves coursing across its surface in its free fall. These are just like waves in the ocean, which you could watch splashing onto shore with an almost rhythmic chant. The regularity of the waves over a given period of time could be counted. This is known as the frequency of the waveform. How big the wave is known as the amplitude of the wave. All photons have the same frequency and amplitude of their waveform. Instead of a tortilla you could substitute a rubber band like string that surrounds a membrane. You could also imagine (for our metaphorical purposes only) that the string and membrane are made of energy. Other subatomic strings (particles) as aforementioned vibrate at different frequencies and amplitudes but all subatomic strings are made of the same energy. Think about that. Although string theory, is interesting it is far from certain because we just don't have the equipment to actually see a vibrating string or membrane. These are elegantly elaborated mathematical models which suggest but do not prove an almost Alice in wonderland world.

Photons themselves also travel along electromagnetic waves. [i][1] This means that visible light for example is both a particle (string) and a wave. This was a huge debate in physics for the longest time. Sir Isaac Newton (1643-1727) [ii][2] believed that light consisted of a stream of particles, while Newton's colleagues, most notably the Dutch physicist Christiaan Huygens (1629-1695)[iii][3], disagreed with him and argued that light is a wave. In an experiment by Thomas Young (1773-1829) [iv][4] performed around 1805 known as the Double-slit experiment or two-slit experiment [v][5] the debate was settled. It's a simple experiment that does not require an understanding of quantum mechanics but once its implications are carefully considered disproves Newton's notion that light is composed of particles. Take a single light source, cut two slits in a board, place a screen in back of the board so that the board is between the light and the screen. The single light source now projects through the two slits and creates two light sources, which project onto the screen behind. If light were a particle the light projected onto the screen would diffuse evenly onto the background screen. If light were a wave its properties would be similar to waves in an ocean. Imagine you are next to a beautiful lake, which is perfectly calm, with not a ripple on its placid surface. In fact it is so smooth you can see the high snow capped mountains, towering above the lake, reflected onto its surface. Now with both hands hold two stones at arm length apart and drop them into the lake simultaneously. You will note an interference pattern where the waves of one stone cancel out the waves of the other stone. Double-Slit Experiment Diffraction. The areas of darkness on the screen behind the light source are the result of the light waves interfering (Diffraction) with one another. The dark areas are caused when peaks and troughs occur together (destructive interference) and the light areas are caused when two peaks coincide (constructive interference). According to this experiment, nearly 100 years after his death Newton was proved wrong and his colleague Huygens was right. During their lives Newton and Huygens did not know the outcome of this debate but later on both would be proved right.

In the 20th century Albert Einstein (1879–1955) [vi][6], Louis de Broglie (1892–1987) [vii][7] and many others postulated and confirmed that light (photons) and matter consist of both particles and waves. This was known as the Wave–particle duality [viii][8]. It has been shown experimentally that all-electromagnetic waves and also other subatomic particles (strings) as well as atoms demonstrate the same interference patterns. Photons travel at the speed of light along the electromagnetic wave. The speed of light is

186,171.116418 miles per second (299,792,458 metres per second (approximately 3 × 108 metres per second. 1 Kilometre is 1,000 metres. 1 Kilometre is 0.621 of a mile). That means a photon of light travels 7.48 times around the earth in one second. (Earth circumference 40,076 km in circumference or 24,887.196 miles) The distance from the earth to moon is 384,400 km or 238,712.4 miles so it takes light approximately 1.28 seconds to reach the moon. Click on this link and then on the dark image at the top of the page to see how fast light goes from the earth to the moon in real time. Speed of Light. It takes about 8 minutes for a photon of light to reach the earth from the sun.

String theory was developed (Yoichiro Nambu (and later Lenny Susskind and Holger Nielsen) in the late 1960's and early 1970's to explain the behavior of subatomic particles (proton and neutron which experience the strong nuclear force). Later M-Theory was developed in 1995 by Edward Witten to tie together the various string theories. According to these theories photons are not really particles (zero-dimensional point in space) but rather vibrating strings (one-dimensional extended objects) (String Theory) [ix][9] and or membranes (M-Theory) [x][10]. As discussed above photons move at the speed of light along a wave with a particular frequency, wavelength and amplitude. This wave of photons is electromagnetic radiation [xi][11] (light wave example) of the electromagnetic spectrum in order of increasing frequency (radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays). The frequency [xii][12] (Frequency Example) is determined by counting the frequency of the wave in a given time period. The wavelength [xiii][13] (Wave Length) is measured as the distance between repeating units of wave pattern. Electromagnetic radiation is actually composed of two self-propagating waves, (one electrical-one magnetic), at right angles to each other (light wave example). Therefore a time-varying electric field generates a magnetic field and vice versa. Thus, as an oscillating electric field generates an oscillating magnetic field, the magnetic field in turn generates an oscillating electric field, and so on. These oscillating fields together form an electromagnetic wave composed of photons traveling at the speed of light generating the electromagnetic spectrum from radio waves to gamma rays.

History of Biophoton Research

Alexander Gavrilovich Gurwitsch, also Gurvich (Russian: Александр Гаврилович Гурвич 1874-1954) [xiv][14] famous Russian embryologist, developmental biologist, medical scientist, and Professor of Histology in Taurida University (1918-1924) discovered ultraweak UV (260 nm) photon emissions from living tissue in the 1920's. Prof. Gurwitsch named these photon emissions "mitogenetic rays" (refers to UV electromagnetic waves of photons which stimulate increased cell division (mitosis)) because his experiments showed that they stimulated cell division rates [xv][15] of nearby cells. Prof. Gurwitsch was thinking about how living tissues transfer the information about the size and shape of organs given that chemical reactions "do not contain spatial or temporal patterns a priori (formed or conceived beforehand). Prof. Gurwitsch began looking for a morphogenetic (relating to or concerned with the development of normal organic form) field, which might regulate cell growth and differentiation. (Don't geneticists explain this better through DNA expression) [xvi][16] He devised what he called the basic experiment ("Grundversuch") [xvii][17]. It should be noted that normal window glass blocks UV rays and quartz glass plate is transparent for UV light of about 260 nm. Two onion roots were arranged at right angles to one another with the horizontal root (Inductor) pointed towards the vertical stem (Detector) with a space for either normal window glass or quartz glass plate (Experiment). The subject of observation was the cell division (number of mitoses) rate on the stem where the root tip was pointed. When window glass was placed in the space between the root and the stem no cell division changes were noted whereas when the quartz glass plate was placed in the space cell division (number of mitoses) increased significantly. Prof. Gurwitsch concluded that ultraweak UV (260 nm) photon emissions in the in the horizontal root (Inductor) were stimulating increased cell division in the vertical stem (Detector). The lack of cell growth when a normal window glass blocked UV stimulation and increased cell growth when quartz glass plate facilitated UV stimulation suggested to the professor that photons might regulate cell growth and

differentiation. Prof. Gurwitsch's work, however, was criticized because of inaccurate photon counting methods and the fact that cell growth can be stimulated by other forms of Electromagnetic Radiation (radio waves, microwaves, infrared radiation, visible light, ultraviolet radiation, X-rays and gamma rays) [xviii][18]. In addition biochemists were explaining cell growth in terms of hormones and other biochemicals. The work of Alexander G. Gurwitsch was largely forgotten. It is unclear whether other scientists repeated his experiments. Current "debate surrounds such evidence and conclusions, and the difficulty of teasing out the effects of any supposed Biophotons amid the other numerous chemical interactions between cells makes it difficult to devise a testable hypothesis" [xix][19]

After World War II in the 1940s Colli (Italy), Quickenden (Australia), Inaba (Japan) and Boveris (USA) began experimenting with a newly devised Photomultiplier which accurately counted single photon emissions. They all dropped Professor Gurwitsch's term "mitogenetic radiation" preferring the terms "dark luminescence", "low level luminescence", "ultraweak bioluminescence", or "ultraweak chemiluminescence". The aforementioned researchers also proposed that these biological photon emissions were the result of "rare oxidation (removal of electrons and hydrogen ions or addition of oxygen) processes and radical (radicals (often referred to as free radicals) are atomic or molecular species (a particular kind of atomic nucleus, atom, molecule, or ion) with unpaired electrons on an otherwise open shell configuration) reactions".[xx][20] According to Popp [xxi][21] with the exception of Quickenden (Australia), Inaba (Japan) and Boveris (USA) the phenomenon of "low-level luminescence" "did not ever become a serious subject of fashionable science" and was largely disregarded and disrespected. Essentially the research by the aforementioned and other post World War researchers regarded these photon emissions as random missteps of cellular metabolism or as "imperfections in metabolic activity" (Russian Biophysicist Zhuravlev & American Chemist Seliger) while acknowledging their existence disregarded their importance.

In the 1970s then assistant professor Fritz-Albert (Alexander-Alex) Popp (1938-Present) [xxii][22], German Biophysicist (Earned PhD in Theoretical Physics-Mainz university) who could be considered the modern founder of a whole new branch of biophysics exploring Biophoton emissions, discovered a much wider spectrum of photon emissions than had previously been recorded (200 to 800 nm). Prof. Popp coined the term "Biophoton" and holds patents, which include the use of Biophotonics to examine the quality of food, of the environment and in medicine, among many others. Prof. Popp has proposed that this electromagnetic radiation (Biophotons) is both semi-periodic and coherent but has yet to win general approval from his colleagues.

Also in the 1970's biochemists considered the measurement of Biophotons as a way to study reactive oxygen species (superoxide for example) within a single cell more specifically within the mitochondria but because biophoton production is relatively rare within a single cell structure, overall Biophoton production ultra-weak, and the mechanisms of production complex most biochemists were put off. Britton Chance (1913 –Present) Eldridge Reeves Johnson University Professor Emeritus of Biophysics at the University of Pennsylvania did measure photon production in isolated mitochondria. But detailed subsequent studies failed to detect a signal in dog's brain.

Hamamatsu Photonics K.K. (founded in 1953) is a Japanese manufacturer of optical sensors, electric light sources, and other optical devices and their applied instruments. In the 1980's its Electron Tube Division first developed the Photomultiplier tube which was able to more easily and accurately measure Biophotons. The Japanese Government began a five-year, multibillion-yen research programme into Biophotons in 1986. Humio Inaba, an engineer at the Research Institute of Electrical Communication at Tohoku University headed the project.

Weak Biophoton emissions have been discovered in everything from plant seeds to fruit flies. Humio Inaba has noticed in study after study that distressed and diseased cells emit significantly more photons

than adjacent non-injured "healthy "cells. These experiments have been replicated demonstrating that cell injury increases Biophoton production. If you tear a tree leaf, for example, while measuring Biophoton emission, a spiked rise in emission in the tens of thousands (as opposed to a normal range of 1-1000) with what amounts to a light burst occurs. These experiments and others have been conducted by Ken Muldrew, a biophysicist at the University of Calgary in Alberta, Canada. In animal tissue the same phenomena of injured cells increased photon production has also been observed. At the Institute of Physics at the University of Catania in Italy, tumor cells were studied. It was discovered that "mammalian tumor cells ejected photons at rates as high as 1400 per square centimeter per minute-healthy tissues average rates of less than 40." [xxiii][23] Other teams of researchers have found biophoton emission from tumor cells is 4 times higher than surrounding healthy tissue.

Imaging devices to detect disease, although still in development, are within the realm of scientific imagination as useful non-invasive imaging tools. Reiner Vogel, a biophysicist at the University of Freiburg in Germany, says "The emission may give a very sensitive indication of the conditions within a cell and on the functioning of the cellular defense mechanism," Philip Coleridge Smith, a surgeon at University College Medical School in London, agrees. "You could perhaps use biophotons to assess inflammation in tissues, he suggests, which might warn of leg ulcers, for example."

That injured cells emit more biophotons is well established but some researchers have suggested that biophotons may actually represent some form of communication between cells. In the 1990's, Guenter Albrecht-Buehler, a biophysicist at Northwestern University Medical School in Chicago conducted experiments with near infrared (850 nm=.850 µm-Near infrared=(0.75–1.4 µm=micrometer)) directing light onto cell-sized latex beads, which were situated near mouse fibroblast cells (connective tissue cells). The latex beads would project this infrared light towards the mouse fibroblast cells. The mouse cells reached toward the light emitted from the cell sized beads with their Pseudopodia ((false feet) are temporary projections of eukaryotic cells). The mouse cells even began moving towards the light source (latex beads) with some rotating 180º swiveling and moving toward the infrared light. The power and wavelength of the light source produced virtually no heat to direct the cellular movement or behavior. The light alone seems the cause of the cellular behavior. If two light sources were presented at equal intensities the cell would respond to both as if to see two distinct light emissions. In yet another experiment Albrecht-Buehler studied elongated hamster cells [xxiv][24]. First he spread the cells onto one side of a glass pane and they grew parallel to one another. Then he spread the cells in two thin layers on opposite sides of a glass pane with a section in between which could accommodate a filter. Without a filter the hamster cells grew at 45º to one another. When an infrared filter (blocks infrared light emission from one side to the other) was added the cells on either side of the glass pane demonstrated random orientations.

The aforementioned and other cumulative research prompts Albrecht-Buehler to speculate on the meaning. Perhaps this infrared light is emitted represents cell-to-cell communication to help determine orientation, either parallel if next to each other or criss-cross if on opposing sides. The criss cross pattern is adaptive because it provides extra strength. Is there some kind of eye within the cell that detects light? Albrecht-Buehler speculates that the centrioles within the cell are potentially light sensitive because he says their microtubule cylindrical structure creates slanted blades, which act like blinds, allowing light in but only from certain angles. This arrangement could act as a photoreceptor to determine which direction the photons emanate. The microtubules-hollow filaments could act as fiber optics to direct light from the periphery of the centrioles to the core. Are cells talking to each other? Albrecht-Buehler guesses that embryos might signal their position with photons and receives information for other cells to know how and where they fit into the developing body. If this signally system like a language could be learned could be redirect cancer cells to stop growing or enhance would healing, or send signals to perform unforeseen tasks.

In the 1980's, Popp, then lecturer at the University of Marburg Germany, concluded that cell-to-cell communication was evident in synchronous biophoton emissions between cells without a light barrier vs. asynchronous biophoton emissions between cells separated by an opaque barrier.

Cyril Frank surgery professor at the University of Calgary's medical school agrees with Popp speculating that biophotons could trigger events in the receiver cell such as: mitosis rate, protein expression but further research is needed before certainty can be claimed.

Ken Muldrew, a biophysicist at the University of Calgary in Alberta, Canada, is not convinced that complex messages can be conveyed by biophotons arguing that increased oxidation reactions may be conveyed but that's all.

The practical uses of the detection of biophoton emissions would include as aforementioned early detection of diseases like cancer. Problem is how to ferret out random photon emissions coming from the occasional but possibly significantly frequent given the 1 million per second per cell reactions (15 trillion cells) and the increased biophoton emissions produced by disease. This might affect the ability to replicate the results of the aforementioned researchers. Barbara Chwirot, head of the Laboratory of Molecular Biology of Cancer at Nicolas Copernicus University in Torun, Poland states that this is a of "reproducibility of results, even for relatively simple systems like cell cultures," Biophotons may also be affected by enzyme activity as well as a host of other factors as yet determined. Bottom line direct diagnosis of disease is not a done deal and may require further technical or medical innovation.

Popp now heads both the International Institute of Biophysics in Neuss, Germany (Scientists interested in biophoton research) and runs Biophotonen. Biophotonen evaluates food products to assure for example that beer does not contain harmful microbes (Bitburger=German brewer). Chinese groups are perfecting food related biophoton evaluation for the presence of unwanted bacteria.

Look for future innovation in the form of cutting edge detectors,; avalanche photodiodes ect.

Classical physics can't explain how brains think says Scott Hagan, a theoretical physicist at the British Columbia Institute of Technology in Burnaby. Pierre St. Hilaire Interval Research Corp., Palo Alto, USA Dick J. Bierman University of Amsterdam, The Netherlands StarLab, and Brussels, Belgium would all agree, "Consciousness implicates quantum coherent states in the brain" [xxv[25]]. The question of how brain cells can function with massive communal simultaneous coordinated synchronicity may be answered according to Scott Hagan by thinking of biophotons as speed of light optic communicators. Quantum coherent states are states where the wave functions of individual atoms combine to form a coherent pattern [xxvi[26]]. According to Sir Roger Penrose, OM, FRS (1931-Present) is an English mathematical physicist and Emeritus Rouse Ball Professor of Mathematics at the University of Oxford and Emeritus Fellow of Wadham College, Orch OR ("Orchestrated Objective Reduction") [xxvii[27]], may provide a conceptual framework to better understand brain function. Prof. Ball thinks that these quantum coherent states are propagated by protein structures within the cells as part of its cytoskeleton but more to the point of this discussion they are found with the neural cell structure including the axons the essential wiring of the brain. These thin tubes may be likened to fiber optics and are thought to move energy about the cell, building junctions between neurons and perhaps aide in memory retention. Hagan and Stuart Hameroff, associate director of the Center for Consciousness Studies at the University of Arizona, are proponents of this highly speculative theory that quantum coherence is mediated by these intercellular structures and may in fact give rise to consciousness [xxviii[28]]. Experimental evidence of this according to Hagan is the effect that anesthetics have in binding to the microtubules "Because anesthetics make consciousness evaporate, their site of action is important in determining the mechanisms responsible for consciousness." Biophotons may use these microtubules as conduits for consciousness. This is just a theory with scant evidentiary proof.

Kenneth J. Dillon, B.A. in history from Georgetown University and a PhD in history from Cornell University makes the fantastic claim that red blood cells have some kind of biophotonic signaling [xxix[29]]. Dillon claims that the circulatory system is involved in the reception, transmission, and processing of electromagnetic data and acts as a "Animal Magnetoreceptor" which can sense magnetic fields. It is hard to say how carefully these claims can be supported by the data.

Biophotons

Biophotons (Greek Bio=Life, Photon=Light) [xxx[30]] are photons emitted from living organisms including plants and animals. Biophotons are not the same as Bioluminescence that are produced by many marine (80% of marine creatures emit light) [xxxi[31]](Anglerfish & Flashlight fish) and non-marine creatures (Glow Worms & Fire flies) and is a result of a chemical reaction within the organism, which produces photons, which are visible to the naked eye. The process of bioluminescence is well understood by the biological sciences. Bioluminescence is due to a "chemical reaction between ATP-the cell's energy store-oxygen and a molecule called luciferin. Luciferin converts the chemical energy locked up in ATP into photons of light." [xxxii[32]] Biophoton emissions are very low intensity photon emissions from living organisms, which are poorly understood, ill defined by the experts in the field, and its "study is controversial and is not generally accepted as a legitimate area of study by mainstream scientists" [xxxiii[33]]. Does this mean that research on Biophotons is accepted in mainstream journals? This is a specialized area of biophysics known as Biophotonics (Popp), which involves the study of the relationship between biological materials and the emission of photons. It "refers to emission, detection, absorption, reflection, modification, and creation of radiation from living organisms and organic material." [xxxiv[34]]

Ultra Weak Photon Emissions

The wavelength of the ultra weak photon emission (several million times weaker than Bioluminescence) is measured in nanometres, which are very small, a thousand millionth of a metre. A nanometre is notated as follows; 10^{-9} nanometre nm=0.000 000 001. Typical human eye will respond to wavelengths from 400 to 700 nm, although some people may be able to perceive wavelengths from 380 to 780 nm. Some of the research [xxxv[35]] on ultra weak photon emissions is reporting UPE from 420 to 570 nm (Popp reports 260 to 800 nm) [xxxvi[36]] with a range from 1 to 1,000 photons (x s-1 x cm-2)(I think this means photons per second per square centimeter of surface area) [xxxvii[37]]. This range would correspond to the visible light color ranges of indigo (Violet), blue, cyan, green and yellow (colors) (colors2)(colors3) The wavelength is longer than greatest particle size that can fit through a surgical mask but smaller than width of strand of spider web. Due to the low concentration of photons it is not believed that these photons emissions can be seen by the naked eye ("much weaker than in the openly visible" [xxxviii[38]]) as in bioluminescence

Photomultiplier

The detection of Biophotons is facilitated by Photomultipliers (Photomultiplier tubes-PMTs) (Biophoton Tube Schematics)(Biophoton Tube) which greatly amplify photons emitted in the ultraviolet, visible and near infrared ranges. Photomultipliers are widely used in many fields (nuclear and particle physics, astronomy, medical imaging and motion picture film scanning (telecine) [xxxix[39]]. I could find no references of the use of photomultipliers however in the area of medical imaging [xl[40]]. This is probably because this particular field of study is suspect. The photomultiplier makes use of the photoelectric effect [xli[41]] where photons hit a metallic surface and electrons are emitted. The photomultiplier contains various electron capture devices (glass vacuum tube which houses a photocathode, several dynodes, and an anode), which result in the accumulation of charge and in a sharp current pulse indicating the arrival of a photon at the photocathode. This device then can count the number of individual photons produced from a variety of sources but for our purposes from biological organisms.

Popp describes the photomultiplier that he uses as an EMI 9558 QA. Popp summarizes the specifications [xlii][42] from a more detailed dissertation paper [xliii][43] as follows; This photomultiplier uses a uses a "single photon counting system" with a sensitivity of 10^{17} W. 10 is the signal-to-noise ratio and the cathode has a range sensitivity of between 200 to 800 nm. To reduce the noise to a minimum a copper wool-cooling jacket "provides thermal contact". "A grounding metal cylinder" accomplishes electric and magnetic field protection. The multiplier tube and cooling jacket are housed in a vacuum and therefore the quartz glass anterior to the tube in not in thermal contact with the cooled cathode thus preventing moisture accumulation on its surface (resulting in freezing). With this arrangement the optimal cooling temperature -30º C (Centigrade)(-22º F Fahrenheit). A chopper (photomultiplier) enhances current density to 2 photons/(s cm2) with a significance level of 99.9% within 6 hours.

Theoretical Model-Biophoton Production-Mainstream Biophysicists

Although no experimental proof for any definitive theory has been accepted even among the field of experts, Biophotons are thought, by many biophysicists, to be random photon emissions as a result of cellular metabolism. Given the 15 trillion cells in the average human body (100 million in the brain alone), with the average cell diameter of 10 micrometers, and the average photon emission of 1-1000 photons per second per square centimeter of surface area, this amounts to a single photon per cell per month. Since cellular metabolism [xliv][44] is a stepwise chain of small energy exchanges, occasionally mistakes are made (random irregular steps ('outlying states")), which result in a physiochemical energy imbalances and the rare emission of a photon. In other words it is the occasional sour note in the symphony and not some orchestrated background chorus.

According to this hypothesis there is no need to attribute order where none exists, as does the mitogenetic radiation hypothesis (see above). These physiochemical energy imbalances occur as part of the electron transport chain within the mitochondria (Organelle) [xlv][45], which is in every cell of the body. The electron transport chain creates stepwise chemical reactions with the ultimate aim of creating useable energy for cell metabolism. The mitochondria are known as the "cellular power plants" because they convert organic materials into energy in the form of ATP via the process of oxidative phosphorylation [xlvi][46]. There are hundreds of thousands of mitochondria in every cell (can occupy 25% of the cells cytoplasm)(mitochondria have their own DNA and may have once been independent bacteria many millions of years ago). There are 10^5=100,000 or one hundred thousand chemical reactions per cell/per sec and as aforementioned 15 trillion cells in the average human body (100 million in the human brain). We are buzzing with activity. One purpose of the mitochondria is to create energy for the cell to produce protein ect. Free Radicals (Reactive oxygen species or ROS (superoxide, hydrogen peroxide, and hydroxyl radical)) are produced inside the mitochondria and are associated with cell damage. Free radicals may be created as a part of the production of ATP from ADP and may also be responsible for the emission of Biophotons. The mitochondria produce energy by converting ADP (Adenosine diphosphate) [xlvii][47] to ATP (Adenosine triphosphate) [xlviii][48] in a stepwise process along a protein matrix and the inner mitochondrial membranes. The third step (electron transport chain) in this process involves reattaching the phosphate group to ADP (Adenosine diphosphate) to form ATP (Adenosine triphosphate). Once this is accomplished the cell can convert ATP back into ADP and an inorganic phosphate producing the following amount of energy; (12 kcal / mole in vivo (inside of a living cell) and -7.3 kcal / mole in vitro (in laboratory conditions)). This third step as aforementioned is called the electron transport chain in which electrons are stepped down in energy by passing through a series of proteins. This way the lowered energy of the electron can be safely utilized by the mitochondria. The third protein in the electron transport chain is actually a lipid [xlix][49] called Coenzyme Q [l][50]. Unfortunately 1-4% of the electrons that pass through Coenzyme Q leaks onto an oxygen molecule in its outer shell (Open Shell configuration). This oxygen molecule is called superoxide (O2) but it is unstable because it needs an additional electron on its outer shell. Remember Coenzyme Q leaked an electron onto its outer shell. Superoxide is prone to steal an electron from the nearest source as follows; 1.) Mitochondrial DNA 2.) Mitochondrial Membrane

(called lipid peroxidation) 3.) Protein 4.) Reductants (Vitamin C, E, Non-Enzymatic antioxidants (glutathione or thioredoxin). Borrowing electrons from Reductants and Non-Enzymatic antioxidants does no harm to the cell. This is why you would want to eat your vegetables and fruits because they contain antioxidants, which lend electrons to the superoxide molecule which won't then borrow from structures such as mitochondrial DNA ect. Otherwise cell damage can result in apoptosis, or programmed cell death. Not good for you.

According to radical chemistry programmed cell death occurs as follows; "Bcl-2 proteins are layered on the surface of the mitochondria, detect damage, and activate a class of proteins called Bax, which punch holes in the mitochondrial membrane, causing cytochrome C to leak out. This cytochrome C binds to Apaf-1, or apoptotic protease activating factor-1, which is free-floating in the cell's cytoplasm. Using energy from the ATPs in the mitochondrion, the Apaf-1 and cytochrome C bind together to form apoptosomes. The apoptosomes binds to and activates caspase-9, another free-floating protein. The caspase-9 then cleaves the proteins of the mitochondrial membrane, causing it to break down and start a chain reaction of protein denaturation and eventually phagocytosis of the cell." [li][51]

The Free Radical Theory of Aging [lii][52] advocates the use of antioxidants because they donate an electron to superoxide without becoming unstable themselves. Aging occurs as mitochondria (cellular power plant) become less functional or die out. As the cell can no longer function and fail, aging accelerates. Free radicals like superoxide are an inevitable by product of cellular metabolism but their damaging effects are mitigated through the intake of antioxidants.

When Superoxide borrows an electron from another source the theory is that a photon is produced. This may be the explanation for ultraweak photon emissions. Since this electron leakage only occurs in a small percentage of electron transfers through Coenzyme Q the relatively low rate of photon emissions may be consistent with this finding.

Theoretical Model-Popp & Others-The Proponents

Biophotons are involved in various cell functions, which include as aforementioned by Gurwitsch cell mitosis and according to Russian, German, and other Biophotonics experts may be produced and detected by the DNA in the cell's nucleus. Gurwitsch's basic experiment ("Grundversuch") was the first example of a proof that cell mitosis could be increased by UV (260 nm) alone after carefully separating the inductor and detector plants with both a space of air and alternately UV transparent and opaque glass. As whacky a proposition as this is, the mostly vague dismissals by the mainstream biophysics community will not dilute the implications. If replicated under strict controls inevitable conclusions will demand explanation over extended time. The usual Cell signaling mechanisms such as Notch signaling require physical contact between the cells and or in the case of other cell to cell communication a fluid medium such as blood (endocrine cells (Hormones)). Other cell-to-cell communication is conducted thru interstitial fluid. Gurwitsch's simple experiment appears to thwart the usual mechanisms of cell signaling. The conclusion is that Biophotons in the form of UV (260nm) emanating possibly from the DNA of the inductor plant is signaling the DNA in the cell nucleus of the detector plant to increase cell mitosis. Biophotons may then represent a more primitive and yet subtly more complex cell-to-cell communication, which by passes the usual fluid medium of information transmission and instead relies upon speed of light transmission thru the air. (Does electromagnetic radiation within the visible range transmit well through tissue? How and in what direction cell to cell photon communication occurs between DNA strands may be unknown.

Gurwitsch was himself an embryologist who was puzzling about how organs develop, and modern Biophotonics experts suggest that Biophotons may offer some signaling mechanism in the development

of organs or other structures. Would electromagnetic carrier waves such as radio, or light (fiber optics) inform us about the transmission of information from cellular or mitochondrial DNA? Certainly before the neurological or cardiovascular hardware was evolved electromagnetic communication may have sufficed. Definitive proof is to date lacking. (?)

Given the 10^5=100,000 or one hundred thousand chemical reactions per cell/per sec, as aforementioned, Popp states "Without electronic excitation of at least one of the reaction partners, it would be impossible, and the number of thermal photons in the tiny reaction volume of a cell could never suffice to explain this high reaction rate. At least a 10^{14} (100,000,000,000,000=100 trillion) higher photon density in the optical range is necessary to provide this huge amount of chemical reactivity." [liii][53] Given that not enough photons are produced in the cell there must be some other explanation for the high chemical reaction rate within each and every cell. Erwin Rudolf Josef Alexander Schrödinger (1887–1961) may have led the way with a simple observation and question. During cell division biomolecules must migrate to either side of the cell as the two new cells form from one cell and yet there are relatively few mistakes ("aberrations") in this very complicated process. Schrödinger simply asked his famous question why? A quick look at a cell in mitosis on the left and an example of a cavity resonator wave on the right is suggestive of an answer. Cell Mitosis vs. Cavity Resonator Waves A cavity resonator wave in this case is electromagnetic wave of a particular frequency (300-700nm) bouncing back and forth between the walls of the cell, which somehow reflect these waves with little loss of coherence. If more wave energy enters the cavity its intensity is increased. This could explain the effects of Gurwitsch's basic experiment that by increasing to electromagnetic flow from the inductor plant cell mitosis was increased in the detector plant. Popp believes that cavity resonator waves are "the only plausible answer to this question" of how there are relatively few mistakes during cell mitosis and with the biochemical migration, which Popp thinks "also provide the necessary stability of the molecular arrangements as the guiding forces for their movement." [liv][54] If the cell is viewed as a dielectric and or conducting resonant cavity, Popp, demonstrates in Table 1 transverse magnetic and electric modes and their wavelengths given the dimensions and boundary of a cell. By superimposing the cavity resonator wave patterns onto the "dynamical structures of the mitotic figures during cell division, Popp reasons is "the most likely answer to Schrödinger 's question of why the error rate vanishes". Popp acknowledges that there is no workable way to measure these quasi-standing light waves directly within the intracellular space although a photomultiplier placed near living tissue can measure single photons within the visible range, which are correlated (spatial and temporal) to cell mitosis. The more cell growth the greater the photon emissions. Around 1970 Popp organized an interdisciplinary group (University of Marburg physicists, physicians, and biologists) to study the optical properties of such biomolecules as polycyclic hydrocarbons (derived chiefly from petroleum and coal tar?). Carcinogenic activity and other biological efficacy were studied drawing out some questions of causality. Do the biomolecules themselves produce photon ("light") emission or does some type of "photon field" "the regulator for the excitation of biological matter." Which causes which, chicken and egg conundrum. Popp puzzled over this question proposing to characterize nonclassical light as a form of information transfer in biological systems. What are the experimental results that support this bold claim that biophotons can actually have a regulating function in biochemical reactions? What is the physical basis for this and what are the theoretical implications?

What are the properties of biophotons, which are well described by multiple independent groups and replicated numerous times [lv][55] [lvi][56] [lvii][57]?

1. The phenomenon of photon emission from biological systems is quantum physical (coming from the subatomic field within the organism?). Since fewer 100 photons are present (on the surface) within the investigation field the total intensity i from a few up to some hundred photons/(s cm^2) confirms the quantum physical nature of photon emission.
2. What about the nature of the biophoton emissions? The spectral intensity i(v) does not peak around definite frequencies v. The characteristic of the spectral distribution is flat and thus is a non-equilibrium system whose excitation temperature ϑ (v) linearly increases, as does frequency

v. The responsible excited states of the occupation probability f(v) does not follow the Boltzmann distribution f(v)=exp(-hv/kT) but the rule f(v)=constant (Fig. 4)

3. "The probability p(n, Δ t) of registering n biophotons (n=0,1,2...) in a preset time interval Δ t follows under ergodic conditions surprisingly accurately a Poissonian distribution (exp(-<n>) $<n>^n/n!$ <n>=mean value of n over Δ t time intervals Δ t down to 10^{-5} s. For lower time intervals t there are no results known up to now" [lviii][58] (Fig 5)
4. "Delayed luminescence" (DL) (Long term and ultra weak reemission of photons after exposure to monochromatic or white light illumination) diminishes with a hyperbolic-like (l/t) function. Time after excitation=t There is no exponential function evident in the diminution of photon emission. (Fig 6)
5. The optical extinction coefficient (fraction of light lost to scattering and absorption per unit distance in a participating medium) of Biophotons that penetrate thin layers of sea sand and Soya cells (various thickness) was one order of magnitude lower than artificial light tested in the same manner. The light sources (biophotons/artificial) were matched for intensity and spectral distribution and thus cannot be cited to explain the difference. Biophotons loose less light when penetrating these mediums.
6. Physiological functions such as membrane permeability and (Glycolysis) are known to be affected by temperature and biophoton emission displays similar temperature dependence. When temperature fluctuations occur both overshoot and undershoot reactions occur. That is temperature increases cause overshoot and temperature decreases cause undershoot biophoton emission reactions. These biophoton emission fluctuation can be characterized as "temperature hysteresis loops" (Fig 7) as described by a Curie-Weiss law.
7. As stress levels increase so do biophoton emissions.
8. Ethidium bromide (EB) increases the unwinding (Conformation) of DNA. Biophoton emissions are strongly correlated to the unwinding of DNA so that when EB is intercalated into the DNA an increase in biophoton emission is noted. (Figure 8) This and other results suggests to Popp "that Chromatin (chromatino?) is one of the most essential sources of biophoton emission. [lix][59] [lx][60]
9. Popp maintains, "Biophotons originate from a coherent field". Evidence for this is demonstrated in photocount statistics, which produce a Poissonian distribution. These "photocount statistics p(n, Δ t) under ergodic conditions together with hyperbolic relaxation function of delayed luminescence is a sufficient condition of a fully coherent photon field." [lxi][61]

There are biological phenomena, which can't be understood by molecular biology or conventional biological thinking, which are better explained if we assume biophotons originate from a coherent field. These biological phenomena are better understood and predicted by biophoton theory. The end result is a deepening of our collective biological understanding.

1. Since the sum of the energy has to remain constant in a closed system (Energy conservation law) constructive interference (super-radiance) destructive interference (sub-radiance) (Interference Constructive and destructive interference) serves the function of equity manager. (interference example) (Fig. 9) (interference example 2) Patterns of radiation according to Dicke [lxii][62] are affected by time periods of interaction "between radiation and non-randomly oriented matter of suitable size." Constructive interference dominates in the initial interaction time period and destructive interference dominates after longer time periods. Popp concludes that the probability of destructive interference in intercellular space between living cells is high for biophoton emissions.
2. Since biophoton fields between cells or living cellular organism cause interference patterns, biophoton intensity (biophoton emissions counts?) is reduced. The emission from single cells cannot be added up to find the total emission intensity because biophotons are being canceled out by these interference patterns. Popp states "biophoton intensity of living matter cannot increase

linearly with the number of units, but has to follow the effective amplitudes of the interference patterns of the biophoton field between living systems." [lxiii][63]

3. The measurements of biophoton emission of the planktonic, crustacean Daphnia magna [lxiv][64] [lxv][65] illustrate the concepts explained in # 2 above. (Daphnia Magna Illus) The biophoton emissions of these animals was measured under controlled conditions; Darkness, housed within the quartz curvette of the biophoton measuring equipment, Constant temperature 18º C (64.4º F). The numbers n (Independent Variable) of daphnia was altered (1-250) maintaining equal size for these inbred animals. The biophoton emissions (Dependent Variable) were then measured after each increase in the count. Each of these creatures emits about the same intensity of biophoton emission, which means an increase in the number of animals should result in a linear increase in biophoton emissions. Correcting for the self-absorption of biophoton emission of the individual animal the biophoton emissions should look like the linear graph in fig. 10 A (Fig. 10). Instead what was observed was the graph plot in Fig. 10 B. Popp concludes "there is a tendency for destructive interference resulting in a lower intensity than expected from the linear increase." [lxvi][66] In nature daphnia is found in concentrations of about 110 (Popp doesn't say per square what?) animals. In this experiment at the same concentration (110) is also creates the most efficient destruction zones around the organism (?) which conserve stored light most effectively within the animals. The destruction zone traps light within the animal according to the energy conservation law but as aforementioned most efficiently at the natural concentration of 110 creatures.
4. Popp states "to some extent one is justified in saying that living systems "suck" the light away in order to establish the most sensitive platform of communication." [lxvii][67] [lxviii][68] Individual animals can be distinguished by similar wave patterns (?1), which are distinct among species. Mutual interference patterns among groups of animals are also distinct among species, which provides "necessary information about the equality or difference of species." This mutual interference is a form of biological communication. Each of the individual animals becomes aware of the other thru biophoton communication (?2). The Signal-to-noise ratio (Signal Noise) or mutual interference patterns (?3) are optimized at a certain number of animals, which is also unique between species (?4). This optimization results as aforementioned allows maximum light storage. (?5) This optimization is achieved as noted by wave patterns, which interfere under maximum destruction between the communication systems. Popp notes "every perturbation leads then to an increase (signal) that the connected systems have to become aware of." "This rather ingenious means of biocommunication provides the basis for orientation, swarming, formation, growth, differentiation, and "gestaltbildung" (?6) in every biological system." [lxix][69] [lxx][70]
5. Damaged and or destroyed tissue (first stage) (?1) [lxxi][71] affects the intensity of biophoton emission. The "capacity for coherent superposition of modes of the biophoton field (where longer wavelengths may also be included) breaks down." As a result there is an increase in biophoton emission and or delayed luminescence reflecting the breakdown of interference patterns between the individual cells, which prevented the outward radiation of photon emission. (?2) [lxxii][72] Schamhart and Van Wijk [lxxiii][73] (Fig. 11) [lxxiv][74] (?3) and Scholz et al. [lxxv][75] (Fig. 12) [lxxvi][76] (?4) were among the first to confirm this. Individual tumor cells, for example, loss of coherence results in concomitant loss of destructive interference capacity and delayed luminescence (converts from hyperbolic-like relaxation of normal cells to exponential one of tumor cells).
6. Dinoflagellates exhibit asynchronous bioluminescence flickering when optically separated but the opposite synchronous flickering when in optical contact. (Fig.13) [lxxvii][77] When seen by other Dinoflagellates their bioluminescent flickering also decreases. [lxxviii][78] Bioluminescent is "chemically amplified biophoton emission" according to Popp. The phenomena of destructive interference are, according to Popp, responsible for flickering decreases and synchronous light pulses. "As the animals see each other and displaying synchronous pulses as a consequence of the disruption of the destructive interference patterns."
7. Bacteria also exhibit the same kind of communication within their nutrition media. [lxxix][79]

8. Fig. 14 illustrates the phenomena of bacteria (Enterococcus Faecalis) grown in a nutrition media. The nutrition media emits biophotons as a result of the oxygenation processes. Therefore the nutrition medium produces a higher intensity of photon emissions than the growing bacteria, which emit low biophoton intensity. Thus the biophoton emissions of the bacteria are not registered. As the bacteria grow in numbers their photon emission creates destructive interference within the coherence volume of the light-emitting nutrient molecules. This results in a drop in emitted biophotons at a specific bacteria number. As the number of bacteria increase (Fig. 14) biophotons may again increase, as photons are no longer absorbed thru destructive interference.
9. Growth regulation of biophoton emission follows the reciprocal laws where in addition to linear stimulation $n \propto n$ (Proportionality (mathematics)) nonlinear inhibition $n \propto n^2$ occurs in concert. That is to say there is a correlation between growth rate and biophoton emission and that relationship is proportional as aforementioned confirmed in Fig. 15.
10. The presumptions of Bajpai [lxxx[80]], Gu and Li [lxxxi[81]] that organisms emit squeezed light [lxxxii[82]] as opposed to classical coherent light. These presumptions underlie a theoretical basis for biophoton emission.

What theoretical perspectives can be derived from the experimental observations outlined above and subsequently summarized? Certainly classical electrodynamics and thermodynamics as well as quantum theory provide a basis for biophoton theory. Biophoton theory as aforementioned will need to explain the following summarized experimental results namely: spectral intensity [lxxxiii[83]] [lxxxiv[84]], Photocount statistics [lxxxv[85]], hyperbolic oscillations [lxxxvi[86]] [lxxxvii[87]], coupling of the different modes [lxxxviii[88]], squeezing into both branches of minimum uncertainty wave packets [lxxxix[89]], strong correlation to DNA dynamical states [xc[90]]. Biological phenomena will also need explanation; mitotic figures (?) [xci[91]], interference structure from daphnia [xcii[92]], tumor tissue photon emission vs. normal tissue [xciii[93]], and the correlation to growth and differentiation of cells [xciv[94]].

1. (?1) Popp proposes an equation to estimate the mean value of photons within a homogeneous electromagnetic field. The Mean value is of the N=number of photons of hv=Energy of a homogeneous electromagnetic field (?) with E_0=Amplitude. This mean value can be estimated by equating the energies nhv of the photons and $\varepsilon_0(8\pi)\,|E_0|^2$ V of the field where ε_0=Dielectric constant and V=Volume of field. A photon in the optical range of 3 eV equals a field amplitude of 10^6 V/cm over a cell volume of $10^9 cm^3$. The aforementioned draws the following conclusion; "Electric Field Amplitudes (of the cavity modes) which stabilize the mitotic figures are in the range of 10^6 V/cm (corresponding to about the membrane field components). It would take only one photon in the optical range would suffice for this effect." [xcv[95]] The ultraweak photon emissions can then be explained to reflect the requirement of only one photon to provide for the biological functions within the cells which include; "stabilization of the migration of the biomolecules, transportation of the angular momentum for rotating the DNA during replication or transcription, and provision of the chemical reactivity of about 10^5 reactions per cell and per second, always at the right time and at the right place." [xcvi[96]]
2. Popp states, "living systems may be looked upon as the most stable forms of matter through use of the storage of sunrays" with the resonators model as a powerful tool in understanding biophoton emission. [xcvii[97]] Since the sun is very hot and the earth is comparatively very cold the light from the sun either reflects from the earth or through a process of entropy transforms heat to cold. To sustain life organisms must prolong this process by optimizing their "storage capacity for sunlight." [xcviii[98]] In plants for example photosynthesis provides for its elementary food supply by synthesizing glucose from sunlight, carbon dioxide, and water. Animals get their glucose from plants, protein from other animals and as Popp proposes uses sunlight to guide the molecular biology of the cell and literally spark biomolecular processes to convert ADP $\rightarrow$ ATP to provide the energy for cellular metabolism.
3. A resonator value within any cavity (including the cell) can be determined and Popp states that there is a "clear connection between the resonator value of a cavity and its information content."

This establishes some key understandings of biological systems namely; These biological systems are informational rather than energetic "engines", and the resonators may develop nonlinear capacities "just because of their low photon emission." [xcix][99] The equation, (Q*=Q/1-C), represents the deviation from the classical Q-value (Q factor (Q-Value)) of the typical resonator. The variables are defined as follows; Q*=resonator value of the quantum coherent resonator Q=value of the classical "chaotic" resonator C=ratio of a quantum coherent energy distribution of the resonator to the totally available (chaotic + coherent) energy.

4. The high storage time and ability to emit or to remove photons actively for C>1 is reflected in this equation; Eq. # 1=(Q*/Q$\rightarrow \infty$ for C$\rightarrow$ 1). Bose-Einstein condensate (Bose-condensation) (Bose-condensation-like phenomena) as postulated by Herbert Fröhlich can also be explained by taking the Bose–Einstein statistics (Bose-Einstein Distribution) "of the spectral photon density (number of photons per units of volume and wavelength λ) at temperature Eq. # 2=TN(λ)=8 π / λ^4 1/(exp((ε - μ)/(kT))-1) where ε=hc/λ is the photon energy and μ the chemical potential, and k is the Boltzmann constant." [c][100]
5. The chemical potential is defined as μ=T(ϑ(?)S/ϑ n)e,v where dS is the entropy change through absorption of a photon. Entropy in the system is increased along with the value of μ>0 when a biophoton is absorbed by the multiplier outside the system (dn<0) as depicted in Fig. 2. When there is no entropy loss due to thermal noise then $\mu = \varepsilon$. Also possible is Eq. # 3= $\mu = \varepsilon$ - kTlnW where W corresponds to the thermo dynamical probability of the photons under investigation. Insertion into Eq. (2) results in Eq. # 4=N(λ)=8 π / λ^4 1/(W-1). This demonstrates the Bose-Einstein condensate (Bose-condensation) (Bose condensation effect) of the Fröhlich mode (?) according to W$\rightarrow$ 1 as well as the connection to the corresponding value C in Eq. (1). C=1 determines that all of the energy of this system conforms to a coherent field except the classic currents. In the case of classical currents resonance-like absorption of photons in the mode W$\rightarrow$ 1 occurs. "Squeezed" light would describe removal of photons by W>1 or the extension of W, where the thermo dynamical potency of the photon field corresponds to the vanishing chemical potential according to Eq. # 3. Eq. # 5=Ln W=ε /(kT); This results in a spectral intensity of thermal radiation. Can we determine the nature of biophoton emission by analyzing its average spectral intensity? W turns out to be rather constant and indepencent of the wavelength (see Fig. 16=There was no figure 16 in the research article I had)

A significant increase in photon emission is evident around sites of tissue injury, as do injured organisms prompting some Biophotonics experts to suggest this could be a "distress signal" possibly to promote wound healing. The mainstream critics are quick to remind that cellular damage increases oxidative stress, electron leakage, and increased concentration of superoxide with the greater potential for electron swapping and thus increased photon production. However proponents argue a correlation between greater wound healing and increased photon production, which reverses with lower levels of photon emission. Could Biophoton emissions for example signal malignancy in tissue before more conventional imaging? Do photons transmit thought just as the nervous system? Even the experts answer these questions differently but the answers cover the spectrum.

Perhaps, say proponents, Biophoton emissions are primitive neural systems used by single celled organisms as they developed into more complex creatures. Biophotonic signaling may also be used in modern complex organisms, such as us, in the reception, transmission, and processing of electromagnetic data perhaps with some of the same transmission features of fiber optics or radio waves.

The Skeptics

The skeptics argue that mainstream biological sciences and biophysics regard Biophotonics as pseudoscience [ci][101], which has been, relegated to the fringe; References in respectable journals are virtually unknown. (Is this true?) According to doubters Signal noise or artifacts from the measuring equipment (photomultipliers) as aforementioned are responsible for photon production and represent random noise and no coherent cell-to-cell communication. This phenomena of Biophotons although as all agree is a natural phenomena has no meaning beyond that. Just as the bumps in a persons cranium does not reveal traits of personally (Phrenology) or the conjunction of the planets predict wars (Astrology). We as humans are pattern-seeking creatures, which may relate to the evolutionary need to avoid being eaten (establish and predict the movements of friend or foe both with movements and coloration for example). This natural pattern seeking affects even scientists who observe patterns in nature which in fact does not exist, or marketers for example who create colorful logos and marketing campaigns to get us to buy product.

Cell to cell communication is further compromised by the relatively more intense sunlight or even starlight, which would interfere with any photon signaling. Conversely proponents argue that this "kind of signaling involving entangled quanta of light (e.g. Biophotons) can't be swamped out by classical light, the same way a laser beam can still send information in bright daylight, coherence affords "special privileges." AW

New age, complementary and alternative medicine, and quantum mysticism profit mongers are selling Biophotons in health cures for serious illness such as cancer causing people to postpone more effective but conventional treatments. In short this is metaphysics and not science. The field of Biophotons is rife with new age devises and Web sites which promote the Biophotonics proof that healing energy exists and can restore health.

Web Sites

http://www.google.com/search?hl=en&q=biophoton+healing

Quantum Mysticism Fugue-Implications of we are light (substitute light for energy where appropriate)

Taoist cosmology (secrete teachings)(I am using broad strokes-its been many years and some factual errors may exist) believes that over many lifetimes we give birth to our energy body, which is housed, in our abdomen in what is known as the crystal palace. It is between the navel and 3rd lumbar vertebrae. This energy body can be used by our spiritual consciousness (housed between the pineal and third eye point between the eyebrows) to break free from the cycles of birth and death. When we die for example our consciousness, whose signature is embedded in light, continues without a physical body but without an energy body is unstable and longs to return to physicality. Our task in the physical realm is to give birth and mature an energy body, which can sustain spiritual consciousness, the energy body can only grow and mature in the physical realm (Taoist masters may disagree on this point) , that is when we have a physical body. In order to do this the energy body must be nurtured in a neutral energy environment. Strong emotions for example must be transmuted into this neutral energy. This includes too much anger or kindness, fear or gentleness, joy and spitefulness ect. This is why Taoism is about a balanced path. Each organ houses the excesses of these emotions. All of this is carried by our consciousness after physical death imprinted and stored in a light signature. This is likened to the slow process of creating a pearl only at the center of the pearl is the energy body and the outer layers are made of light energy. Both the energy body and consciousness are poised between two large energy balls above and below our heads (The Indian system I believe calls these atman and Brahman.) Disease can be as an imbalance of energy streaming between these balls and stored overly positive or negative emotions in the organs and channel system. The energy channels are composed of light waves, which transmit this energy. Once an energy body is stabilized we become enlightened beings similar to Abraham Maslow’s (1908–1970) actualized

being. This is also reminiscent of Mesmer's theory of Animal Magnetism. Perhaps our spirit is a light wave signature embedded in Eugenio Calabi's (1923-present) and Shing-Tung Yau's (1949-present) Calabi-Yau manifold.

9219/300= 30.73

Notes

10^{-9} nanometre nm
420-470 nm 470-570 nm
range from 1 to 1,000 photons x s-1 x cm-2
420-440 nm — wavelength of indigo light
440-500 nm — wavelength of blue light
500-520 nm — wavelength of cyan light
520-565 nm — wavelength of green light
565-590 nm — wavelength of yellow light

γ = Gamma rays
HX = Hard X-rays
SX = Soft X-Rays
EUV or XUV= Extreme ultraviolet (1–31 nm)
FUV or VUV=far or vacuum UV (200–10 nm)
NUV = (380–200 nm) Near ultraviolet
Visible light
NIR = Near infrared (0.75–1.4 μm)
MIR = Moderate infrared
FIR = Far infrared

Radio waves:
EHF = Extremely high frequency (Microwaves)
SHF = Super high frequency (Microwaves)
UHF = Ultrahigh frequency
VHF = Very high frequency
HF = High frequency
MF = Medium frequency
LF = Low frequency
VLF = Very low frequency
VF = Voice frequency
ELF = Extremely low frequency

Need Definitions

Photon counting techniques, refractive index matching, bioluminescence, biophotons, high quantum efficiencies, C2550 photon counter (Hamamatsu Photonics K.K.), R647 (1/2 inch), R331 (2 inch), and R329 (2 inch) photomultiplier tubes (PMT, Hamamatsu Photonics K.K.), bialkali photocathode, spectral response, mode coupling, Steady State Biophoton Emission, Poisssonian Photo Count Distribution, fully Coherent, Squeezed States, Thermodynamic and Quantum Optical Interpretation, Gestalthbildung=Swarming, Non-Thermal Photon Vs. Thermal Photons Emission, Cavity Resonator Waves, long lasting photon storage, resonance wavelengths, transverse magnetic and electric modes, dielectric resonant cavity, (eigenvalues of the Bessel functions m, n correspond to the radial axis and p to

the length of a right circular cylindrical cavity.), TE mode mnp TM mode mnp, Number of stored photons, superposition of cavity resonator waves, Schrödinger 's question of small number of aberrations in the migration of biomolecules during cell division, polycyclic hydrocarbons, (photon counting system functions at a sensitivity of about 1017 W and a signal-to-noise ratio of at least 10), EMI 9558 QA photomultiplier cathode sensitive within the range of 200-800 nm, (decay parameter, hyperbolic approximation, relaxation dynamics, cell suspension afterglow, weak white light illumination, normal amnion cells, cell density, malignant Wish cells, nutritive medium. (Fig. 12))

Questions

1. What is a thermal photon and how are the number of these counted within a single cell anyway? I thought counting photons within a single cell was impossible? Is a thermal photon different from other ultraweak photons under discussion? Reference; Popp Fa. (2003). Properties of biophotons and their theoretical implications. Indian J Exp Biol, 41-5, pp. 391 - 402. Full Text Article; http://www.anatomyfacts.com/research/PropertiesBioph.pdf

2. Given that the high chemical reaction rate 10^5=100,000 per cell per sec the number of thermal photons says Popp are insufficient to explain this high reaction rate? In other words you would need vastly more photons in the cell to explain the high reaction rate on the order of 10^{14} (100,000,000,000,000=100 trillion) since at least one of the chemical reactants needs a little electrical buzz to allow the chemical reaction. Popp implies that these are the other biological phenomena (high number of chemical reactions), which explain the existence of photons within cells. Is there a disconnect here? It doesn't seem to be explained well. Reference; Popp Fa. (2003). Properties of biophotons and their theoretical implications. Indian J Exp Biol, 41-5, pp. 391 - 402. Full Text Article; http://www.anatomyfacts.com/research/PropertiesBioph.pdf

3. Is cell-to-cell signaling an accepted scientific fact which explains "bloom of bioluminescent algae creating an entrainment of light pulsing" AW. What is the mechanism ect? Could the same mechanism be at work between the cells of organisms only in this case ultra weak photon emissions and has this been considered?

4. What evidence do we have on "cell-to-cell signaling within the human CNS through biophotons" AW? The reference in this paper is CNS.

5. Please expand on the "implications (biophotons) this could have for developmental biology, as well as injury healing." AW

6. What is "structured water"? AW

7. What is "NAD, and CoQ10"? AW

8. What is the "ubiquitous and critical process of gel/sol transition states in all biological systems" AW?

9. What is Coherent non-classical light and optical coherence? Contrast and compare classical light terms vs. non-classical light terms with regards to biophotons.

10. Talk about non-classical or squeezed light behaviors referencing quantum entanglement aka Einstein's " "spooky action at a distance."

11. How can we measure single photon behaviors?

12. What is the experimental evidence supporting quantum entanglement?

13. What is "sub-threshold" photon counting"?

14. What is spontaneous emission of photons via vacuum fluctuations?

15. Perhaps then these quantum entanglement "spooky action at a distance" are like some cosmic tug of war in the fabric of space, where simultaneity does not violate special relativities speed limit (SOL). Its like pulling on a rope at some summer back yard barbeque. Perhaps at the cellular level we might observe similar effects. Are there cancers for example that simultaneously appear in different parts of the body with no currently known route of transmission? Do these weak photon emissions transmit data like some fiber optics. How do radio waves or any electromagnetic waves transmit data? Can data be stored and preserved?

16. What are the applied Biophysics books edited by Popp? More information about summer school/conferences at Neuss?

17. Are these articles listed the best ones to do a literature review on? http://www.anatomyfacts.com/Muscle/photonr.html

18. What is “Van Wijk's paper on Human Biophoton counting” AW?

19. Has Gurwitsch’s basic experiment ("Grundversuch") been replicated?

20. How did Gurwitsch determine that particular range of UV light (260nm) was being emitted?

21. By what process does the DNA of one plant produce DNA signaling to another plant cell? Is this one way or two ways? Is this the same cell-to-cell communication we see in animals? Have we been able to image any of this and if so by what technology is imaging possible?

DNA plays a role in things, but not in the sense that is normally thought. AW

22. Would injury to a cell for example increase photon production from other healthy cells to stimulate the DNA of the injured cell to facilitate healing?

23. Wouldn't the by many times multiplied relative intensity of sunlight for example interfere with the ultra weak photon emission cell to cell signaling?

The kind of signaling involving entangled quanta of light (e.g. biophotons) can't be swamped out by classical light, the same way a laser beam can still send information in bright daylight, coherence affords "special privileges." AW We nee references for this. TN

24. Do we have an English translation of the full text version of the paper that took us down this rabbit hole in the first place? A.G. Gurwitsch: "Über Ursachen der Zellteilung". Arch. Entw. Mech. Org. 51 (1922), 383-415

25. Popp, provides us with a good historical review and then seems to suggest that cell mitosis is guided by electromagnetic resonant waves (?)(300-700nm), which would explain Erwin Schrödinger’s question regarding how there could be so few errors in the biomolecular migration during cell mitosis. It is in Table 1 that I become lost. What is the meaning of Table 1? Reference; Popp Fa. (2003). Properties of biophotons and their theoretical implications. Indian J Exp Biol, 41-5, pp. 391 - 402. Full Text Article; http://www.anatomyfacts.com/research/PropertiesBioph.pdf

26. Who is Dr. Sutherland and what is his experience with regards to scientific skepticism?

William Garner Sutherland DO (1873-1954) was a student of Andrew Stills (circa 1900) who believed the bony cranium was capable of respiratory motion. "While looking at a disarticulated skull, Sutherland was struck by the idea that the cranial sutures of the temporal bones where they meet the sphenoid bones were "beveled, like the gills of a fish, indicating articular mobility for a respiratory mechanism."" Dr. Sutherland "the cranial-osteopath who laid the foundation for cranio-sacral therapy especially the biodynamic branch. "Liquid Light" he would say is the property of inherent health expressing within the body." AW

27. What does BG stand for as used in the phrase "BG Chem and physics"?

28. Can we determine whether or not the Taoist Cosmology, traditional Eastern medicine and Channel theory has any merit? For example do photon emissions seem to concentrate along the traditional channel lines such as Stomach or liver channels in the leg or lung and large intestine channels in the arms? Can we see photons produce an aura and is there any photon research to show how energy work effects. Do we find increased photon emissions above and below the head and below the feet for example? Is there a greater concentration of photon emission around the crystal palace area or near the third eye? Does more energy come out of the hands when energy work is being done? Do energy workers produce a significant increase in cell mitosis in plants when compared to Gurwitsch's basic experiment? What statistical tools should be employed?

29. If in Biophotonics human energy fields can be photographed, what is the technology used?

30. Is our spirit is a light wave signature embedded in Eugenio Calabi's (1923-present) and Shing-Tung Yau's (1949-present) Calabi-Yau manifold?

31. How do the interior walls of a cell reflect electromagnetic waves (Cavity resonator waves)? Do cavity resonator waves help guide biochemicals and reduce error rate during cell mitosis?

32. Do cavity resonator waves explain the effects of Gurwitsch's basic experiment that by increasing the electromagnetic flow from the inductor plant cell mitosis was increased in the detector plant?

33. Does the sweet reason Popp uses to justify cavity resonator waves answering Schrödinger 's question a plausible explanation to other biophysicists? Is there experimental proof of this. The reference is as follows; Popp, demonstrates in Table 1 transverse magnetic and electric modes and their wavelengths given the dimensions and boundary of a cell. By superimposing the cavity resonator wave patterns onto the "dynamical structures of the mitotic figures during cell division, Popp reasons is "the most likely answer to Schrödinger 's question of why the error rate vanishes".

34. What is the "electric field of TM_{11} cavity modes in the Right side explanation of Fig. 2 in this illustration Cell Mitosis vs. Cavity Resonator Waves?

35. What are the eigenvalues of the Bessel functions m, n in Table 1 and how do they correspond to the radial axis and p to the length of a right circular cylindrical cavity? In the same table what is TE mode mnp TM mode mnp and what's the concept and actual number of stored photons mean?

36. What are the experimental results that support this bold claim that biophotons can actually have a regulating function in biochemical reactions? What is the physical basis for this and what are the theoretical implications?

37. What are the single photon counting system functions? W=Wattage? Signal-to-noise ratio. What's a cathode? What kind of photomultiplier is the EMI 9558 QA. What do range sensitivities mean (200 to 800nm)? Why does inserting the multiplier into a cooling jacket, where copper wool provides thermal contact, reduce the noise? How does a grounding metal cylinder protect the multiplier from electric and magnetic fields? Why does freezing occur if the multiplier is not kept in a vacuum? Why does the quartz glass in front of the multiplier tube have no thermal contact with the cooled cathode? Why doesn't it become covered with moisture? Why is the optimal cooling temperature -30° C (Centigrade)(-22° F Fahrenheit)? What is a chopper? What is current density (2 photons/(s cm^2)? What is significance level (99% within 6 hr.)?

38. What is quantum physical (coming from the subatomic field within the organism?)?

39. There are only three references in this section and none of them appear independent. What are the multiple independent groups and replicated studies? (Studies?)

40. Please interpret the following # 2 (Boltzmann)

41. What is spectral intensity, non-equilibrium system, excitation temperature ϑ (v), occupation probability f(v), Boltzmann distribution f(v)=exp(-hv/kT) but the rule f(v)=constant.

42. Please explain the following terms; probability p(n, Δ t) n biophotons (n=0,1,2...) preset time interval Δ t ergodic conditions Poissonian distribution (exp(-<n>) $<n>^n/n!$ <n>=mean value of n over Δ t time intervals Δ t down to 10^{-5} s

43. Please interpret this statement "The probability p(n, Δ t) of registering n biophotons (n=0,1,2...) in a preset time interval Δ t follows under ergodic conditions surprisingly accurately a Poissonian distribution (exp(-<n>) $<n>^n/n!$ <n>=mean value of n over Δ t time intervals Δ t down to 10^{-5} s. For lower time intervals t there are no results known up to now" [cii][102] (Fig 5)

44. What is a hyperbolic-like (l/t) function? (Fig 6)

45. What is the optical extinction coefficient?

46. Please explain how temperature increases and decreases cause "temperature hysteresis loops" (Fig 7) as described by a Curie-Weiss law.

47. Popp uses the word chromatino is this the same as chromatin? http://www.anatomyfacts.com/research/PropertiesBioph.pdf

48. Are the DNA strands separated from other cellular material so that the DNA can be the only source of biophoton emission?

49. Does the phenomena of destructive interference explain the phenomena of ultra-weak photon emissions? (Interference reference) Given the large role these electromagnetic waves have in all biological functions wouldn't you expect greater intensity photon emissions?

50. What does Popp mean by the statement "biophoton intensity of living matter cannot increase linearly with the number of units, but has to follow the effective amplitudes of the interference patterns of the biophoton field between living systems."? [ciii][103] (Reference)

51. Could the elimination of destructive interference explain phenomena such as spontaneous combustion of living organisms? (Reference)

52. How do these destruction zones trap light within the organism and does the same mechanism work intercellular? (Reference)

53. What is the daphnia concentration in nature that Popp references? (Reference) He found in concentrations of about 110 (Popp doesn't say per square what?) animals. Can we get an English translated copy of the referenced dissertation article? civ[104]

54. Is this energy that is trapped within the creatures from sunlight? (Reference)

55. What does Popp mean by the statement "to some extent one is justified in saying that living systems "suck" the light away in order to establish the most sensitive platform of communication."? cv[105] Where does this light come from? (Reference)

56. Can individual animals be distinguished by similar wave patterns and if so could this be used to identify certain bacteria within cultures or types of cancer tumors within people? (Biological phenomena 4 Q1)

57. Is this mutual interference is a form of biological communication and how does it work? How does each of the individual animals become aware of the other thru biophoton communication? (Biological phenomena 4 Q2)

58. Is the Signal-to-noise ratio the same as mutual interference patterns? (Biological phenomena 4 Q3)

59. Is the number of animals necessary for the optimization of the mutual interference pattern unique to individual species? If it is, could bacteria for example be further identified by the number of animals required for the optimization of the mutual interference pattern? (Biological phenomena 4 Q4)

60. How does this optimization allow for maximum light storage? What experimental proof do we have? (Biological phenomena 4 Q5)

61. How do biophoton emissions provide the biocommunication necessary for orientation, swarming, formation, growth, differentiation and "gestaltbildung"? What is swarming? What is "gestaltbildung"? (Biological phenomena 4 Q6)
    Gestaltbildung is the formation and differentiation of tissues and organs.
62. What does Popp mean by the "first stage" of tissue destruction? (Biological phenomena 5 Q1)

63. Are these interference patterns also responsible for maintaining coherence within individual cells (Maintain "Cavity resonator waves" within cell)? Once tissue destruction occurs and interference patterns are eliminated where do biophoton emissions come from? Why does delayed luminescence increase exponentially subsequent to tissue destruction and interference pattern elimination? How does the breakdown of interference patterns between the individual cells occur from tissue destruction? (Biological phenomena 5 Q2)

64. What is non-linear (cubic) dependence of intensity from cell-number n in (Fig. 11)? (Biological phenomena 5 Q3)

65. Please rephrase the description under (Fig. 12) with "layperson friendly" definitions of the following terms; (decay parameter, hyperbolic approximation, relaxation dynamics, cell suspension afterglow, weak white light illumination, normal amnion cells, cell density, malignant Wish cells, nutritive medium.) (Biological phenomena 5 Q5)

66. Please make this equation layperson friendly. (Theoretical Perspective 1 Q1)

Project Wish list

1. Skeptical dissertation of Biophotonics AW TN
2. Synopsis of BG physics and chem. AW
3. Profile on the typical reader of JBMT. TN
4. Literature Review Misc Articles AW TN
5. Literature Review Photon Counting for injured tissue AW TN
6. Literature Review of articles examine the implications of "We are made of light" Taoist Cosmology, Eastern Medicine and Western energy work AW TN
7. Send lit review to both skeptic and proponent biophysicists and others for review.
8. E-Mail online Chat list with identified interest area.
9. Start local Journal Club So. Ca. TN
   Massage Journal Club Online was initiated on 11/6/2006
   http://health.groups.yahoo.com/group/journalclubonline/ Unit Presentations are scheduled during November to recruit interested members.

10.

Glossary

Basic aromatic ring
Basic aromatic rings are aromatic rings in which the lone pair of electrons of a ring-nitrogen atom is not part of the aromatic system and extends in the plane of the ring. This lone pair is responsible for the basicity of these nitrogenous bases, similar to the nitrogen atom in amines. In these compounds the nitrogen atom is not connected to a hydrogen atom. Basic aromatic compounds get protonated and form aromatic cations (e.g. pyridinium) under acidic conditions. Typical examples of basic aromatic rings are pyridine or quinoline. Several rings contain basic as well as non-basic nitrogen atoms, e.g. imidazole and purine.

Biophotonics
Popp's definition "Corresponding field of applications, provide a new powerful tool for assessing the quality of food (like freshness and shelf lif), microbial infections, environmental influences and for substantiating medical diagnosis and therapy."

Boltzmann Constant
The Boltzmann's Constant (k or kB) is the physical constant relating temperature to energy. It is named after the Austrian physicist Ludwig Boltzmann, who made important contributions to the theory of statistical mechanics, in which this constant plays a crucial role. Its experimentally determined value (in SI units, 2002 CODATA value) is: 1.380 6505(24)×10−23 joule/kelvin 8.617 343(15)×10−5 electron-volt/kelvin. The digits in parentheses are the uncertainty (standard deviation) in the last two digits of the measured value. The conversion factor between the values of the constant in the two different units of measure is the magnitude of the electron's charge: q = 1.602 176 53(14)×10−19 coulomb per electron.

Bose-Einstein condensate (Bose-condensation)
Bose–Einstein condensate (Einstein-Bose Condensation) is a phase of matter formed by bosons cooled to temperatures very near to absolute zero (0 kelvin or -273.15 degrees Celsius). Under such supercooled conditions, a large fraction of the atoms collapse into the lowest quantum state, at which point quantum effects become apparent on a macroscopic scale. This state of matter was first predicted as a consequence of quantum mechanics by Albert Einstein, building upon the work of Satyendra Nath Bose in 1925. Seventy years later, the first such condensate was produced by Eric Cornell and Carl Wieman in 1995 at the University of Colorado at Boulder NIST- JILA lab, using a gas of rubidium atoms cooled to 170 nanokelvin (nK). Cornell and Wieman and Wolfgang Ketterle were awarded the 2001 Nobel Prize in Physics.

Bose–Einstein statistics (Bose-Einstein Distribution)
In statistical mechanics, Bose–Einstein statistics (Bose-Einstein Distribution) (or more colloquially B-E statistics) determines the statistical distribution of identical indistinguishable bosons over the energy states in thermal equilibrium. Fermi–Dirac and Bose–Einstein statistics apply when quantum effects have to be taken into account and the particles are considered "indistinguishable". The quantum effects appear if the concentration of particles $(N/V) \geq nq$ (where nq is the quantum concentration). The quantum concentration is when the interparticle distance is equal to the thermal de Broglie wavelength i.e. when the wavefunctions of the particles are touching but not overlapping. As the quantum concentration depends on temperature; high temperatures will put most systems in the classical limit unless they have a very high density e.g. a White dwarf. Fermi–Dirac statistics apply to fermions (particles that obey the Pauli exclusion principle), Bose–Einstein statistics apply to bosons. Both Fermi–Dirac and Bose–Einstein become Maxwell–Boltzmann statistics at high temperatures or low concentrations.

Chromatin
A complex of nucleic acid and basic proteins (as histone) in eukaryotic cells that is usually dispersed in the interphase nucleus and condensed into chromosomes in mitosis and meiosis.
Chromatin is a complex of DNA and protein found inside the nuclei of eukaryotic cells. The nucleic acids are generally in the form of double-stranded DNA (a double helix). The major proteins involved in chromatin are histone proteins, but other chromosomal proteins are prominent too. DNA is packaged into chromatin thereby constraining the size of the molecule and allowing the cell to control expression of the chromatin-packaged genes. Changes in chromatin structure are affected mainly by methylation (DNA and proteins) and acetylation (proteins). Chromatin structure is also relevant to DNA replication and DNA repair. Chromatin can be made visible by staining, hence its name, which literally means coloured material.

Coherent state
In quantum mechanics a coherent state is a specific kind of quantum state of the quantum harmonic oscillator whose dynamics most closely resemble the oscillating behaviour of a classical harmonic oscillator system. It was the first example of quantum dynamics when Erwin Schrödinger derived it in 1926 while searching for solutions of the Schrödinger equation that satisfy the correspondence principle. The quantum harmonic oscillator and hence, the coherent state, arise in the quantum theory of a wide range of physical systems. For instance, a coherent state describes the oscillating motion of the particle in a quadratic potential well. In the quantum theory of light (quantum electrodynamics) and other bosonic quantum field theories they were introduced by the work of Roy J. Glauber in 1963. Here the coherent state of a field describes an oscillating field, the closest quantum state to a classical sinusoidal wave such as a continuous laser wave. Figure Description : The electric field, measured by optical homodyne detection, as a function of phase for three coherent states emitted by a Nd:YAG laser. The amount of quantum noise in the electric field is completely independent of the phase. As the field strength, i.e. the oscillation amplitude α of the coherent state is increased, the quantum noise or uncertainty is constant at

1/2, and so becomes less and less significant. In the limit of large field the state becomes a good approximation of a noiseless stable classical wave. The average photon numbers of the three states from top to bottom are <n>=4.2, 25.2, 924.5 (source: link 1 and ref. 2)

Conformation
Formation of something by appropriate arrangement of parts or elements : an assembling into a whole <the gradual conformation of the embryo>

Constructive and destructive interference
When two sinusoidal waves superimpose, the resulting waveform depends on the frequency (or wavelength) amplitude and relative phase of the two waves. If the two waves have the same amplitude A and wavelength the resultant waveform will have an amplitude between 0 and 2A depending on whether the two waves are in phase or out of phase.

Consider two waves that are in phase,with amplitudes A1 and A2. Their troughs and peaks line up and the resultant wave will have amplitude A = A1 + A2. This is known as constructive interference.

If the two waves are pi radians, or 180°, out of phase, then one wave's crests will coincide with another wave's troughs and so will tend to cancel out. The resultant amplitude is $A = | A1 - A2 |$. If A1 = A2, the resultant amplitude will be zero. This is known as destructive interference.

Curie-Weiss law
The Curie-Weiss law describes the magnetic susceptibility of a ferromagnet in the paramagnetic region above the Curie point

Daphnia (Daphnia magna)
Daphnia are small, mostly planktonic, crustaceans, between 0.2 and 5 mm in length. Daphnia are members of the order Cladocera, and are one of the several small aquatic crustaceans commonly called water fleas because of their Saltatory swimming style (although fleas are insects and thus only very distantly related). They live in various aquatic environments ranging from acidic swamps to freshwater lakes, ponds, streams and rivers. The most popular live food for aquarium fishes is Daphnia. Daphnia includes several species, the largest of which is D. magna. D. Magna can reach a size of 1/5 of an inch in diameter. Each pregnant Daphnia female delivers up to fifteen babies (all are females under good conditions) every three days (depends on food, temperature, and water condition). Daphnia are heavy filter feeders and eat a wide variety of tiny organisms of appropriate size. Daphnia can be used to clear the green water of aquariums and large outdoor ponds without using dangerous chemicals. All Daphnia species produce large black (resting) eggs under certain conditions. The resting eggs survive frost and dryness.

Delayed Luminescence
Long term and ultra weak reemission of photons after exposure to light illumination

Dependent variable
In experimental design, a dependent variable (also known as response variable or regressand) is a factor whose values in different treatment conditions are compared. That is, the experimenter is interested in determining if the value of the dependent variable varies when the values of another variable – the independent variable – are varied, and by how much. In simple terms, the independent variable is said to cause an apparent change in, or simply affect, the dependent variable. In analysis, researchers usually want to explain why the dependent variable has a given value. In research, the values of a dependent variable in different settings are usually compared. For example, in a study of how different dosages of a drug are related to the severity of symptoms of a disease, a measure of the severity of the symptoms of the

disease is a dependent variable and the administration of the drug in specified doses is the independent variable. Researcher will compare the different values of the dependent variable (severity of the symptoms) and attempt to draw a conclusion. In the graphing of data, the dependent variable goes on the y-axis (see Cartesian coordinates). Other terms for the dependent variable are y-variable, outcome variable, and response variable.

Dielectric
Dielectric, or electrical insulator, is a substance that is highly resistant to electric current

Dinoflagellate
The dinoflagellates are a large group of flagellate protists. Most are marine plankton, but they are common in fresh water habitats as well; their populations are distributed depending on temperature, salinity, or depth. About half of all dinoflagellates are photosynthetic, and these make up the largest group of eukaryotic algae aside from the diatoms. Being primary producers make them an important part of the aquatic food chain. Some species, called zooxanthellae, are endosymbionts of marine animals and protozoa, and play an important part in the biology of coral reefs. Other dinoflagellates are colorless predators on other protozoa, and a few forms are parasitic (see for example Oodinium, Pfiesteria).

DNA
Deoxyribonucleic acid (DNA) is a nucleic acid that contains the genetic instructions for the biological development of a cellular form of life or a virus. All known cellular life and some viruses have DNAs. DNA is a long polymer of nucleotides (a polynucleotide) that encodes the sequence of amino acid residues in proteins, using the genetic code.

Electric field
Effect produced by an electric charge that exerts a force on charged objects in its vicinity.

Electrodynamics
Electrodynamics is the theory of the electromagnetic interaction. See Electromagnetism (Classical electromagnetism, Quantum electrodynamics)

Electromagnetic field
A field composed of two related vector fields, the electric field and the magnetic field.

Electromagnetism
The physics of the electromagnetic field: a field, encompassing all of space, composed of the electric field and the magnetic field. Electromagnetism is the physics of the electromagnetic field; a field encompassing all of space, which exerts a force on particles that possess the property of electric charge, and is in turn affected by the presence and motion of those particles.

Electromagnetism (Classical)
Classical electromagnetism (or classical electrodynamics) is a theory of electromagnetism that was developed over the course of the 19th century, most prominently by James Clerk Maxwell. It provides an excellent description of electromagnetic phenomena whenever the relevant length scales and field strengths are large enough that quantum mechanical effects are negligible (see quantum electrodynamics).

Energy conservation law
Conservation of energy states that the total amount of energy (often expressed as the sum of kinetic energy and potential energy) in an isolated system remains constant. In other words, energy can be converted from one form to another, but it cannot be created or destroyed. In modern physics, all forms of energy exhibit mass and all mass is a form of energy. In thermodynamics, the first law of

thermodynamics is a statement of the conservation of energy for thermodynamic systems. The energy conservation law is a mathematical consequence of the shift symmetry of time; energy conservation is implied by the empirical fact that physical laws remain the same over time.

Enterococcus Faecalis
Enterococcus faecalis is a Gram-positive commensal bacteria inhabiting the alimentary canals of humans and animals, are now acknowledged to be organisms capable of causing life-threatening infections in humans, especially in the nosocomial (hospital) environment. The existence of enterococci in such a dual role is facilitated, at least in part, by its intrinsic and acquired resistance to virtually all antibiotics currently in use.

Entropy
In thermodynamics, entropy is an extensive state function that accounts for the effects of irreversibility in thermodynamic systems, particularly in heat engines during an engine cycle. While the concept of energy is central to the first law of thermodynamics, which deals with the conservation of energy, the concept of entropy is central to the second law of thermodynamics, which deals with physical processes and whether they occur spontaneously. Spontaneous changes occur with an increase in entropy. In simple terms, entropy change is related to either a change to a more ordered or disordered state at a microscopic level, which is an early visualisation of the motional energy of molecules, and to the idea dissipation of energy via intermolecular molecular frictions and collisions. In recent years, entropy, from a non-mathematical perspective, has been interpreted in terms of the "dispersal" of energy.

Ergodic theory
In mathematics, a measure-preserving transformation T on a probability space is said to be ergodic if the only measurable sets invariant under T have measure 0 or 1. An older term for this property was metrically transitive. Ergodic theory, the study of ergodic transformations, grew out of an attempt to prove the ergodic hypothesis of statistical physics. Much of the early work in what is now called chaos theory was pursued almost entirely by mathematicians, and published under the title of "ergodic theory", as the term "chaos theory" was not introduced until the middle of the 20th century.

Ethidium bromide
Ethidium bromide is an intercalating agent commonly used as a nucleic acid stain in molecular biology laboratories for techniques such as agarose gel electrophoresis.

Extinction Coefficient
Extinction Coefficient is the fraction of light lost to scattering and absorption per unit distance in a participating medium. The optical properties of the solid are governed by the interaction between the solid and the electric field of the electromagnetic wave. In electromagnetic terms extinction coefficient can be explained as the decay, or damping of the oscillation amplitude of the incident electric field. The velocity of propagation of a electromagnetic wave through a solid is given by the frequency-dependent complex refractive index $N = n - ik$ where the real part, n is related to the velocity, and k is the extinction coefficient.

Fröhlich, Herbert
Herbert Fröhlich (9 December 1905 - 23 January 1991) was a German-born British physicist and a Fellow of the Royal Society. H. Fröhlich was born in Rexingen, Germany, the son of Fanny Frida (née Schwarz) and Jakob Julius Fröhlich, members of an old-established Jewish family. He grew up in Munich, where he received his Ph.D. (1930) as a pupil of Arnold Sommerfeld.

Gestaltbildung (morphogenesis)

The formation and differentiation of tissues and organs

Glycolysis
Glycolysis is a biochemical pathway by which a molecule of glucose (Glc) is oxidized to two molecules of pyruvic acid (Pyr).

Hysteresis
Hysteresis is a property of systems (usually physical systems) that do not instantly follow the forces applied to them, but react slowly, or do not return completely to their original state: that is, systems whose states depend on their immediate history. For instance, if you push on a piece of putty it will assume a new shape, and when you remove your hand it will not return to its original shape, or at least not immediately and not entirely. The term derives from an ancient Greek word υστέρησις, meaning 'deficiency'. The term was coined by Sir James Alfred Ewing.

Independent variable
In an experimental design, the independent variable (also known as predictor or regressor) is the variable which is manipulated or selected by the experimenter to determine its relationship to an observed phenomenon (the dependent variable). In other words, the experiment will attempt to find evidence that the values of the independent variable determine the values of the dependent variable (which is what is being measured). The independent variable can be changed as required, and its values do not represent a problem requiring explanation in an analysis, but are taken simply as given.
More generally, the independent variable is the thing that someone actively controls/changes; while the dependent variable is the thing that changes as a result. In other words, the independent variable is the "presumed cause", while dependent variable is the "presumed effect" of the independent variable. The independent variable is also called the manipulated variable, predictor variable, exposure variable, explanatory variable, or x-variable. Independent variable is the most common name given for this item.

Intercalation
To insert between or among existing elements or layers

Interference
Interference is the superposition of two or more waves resulting in a new wave pattern. As most commonly used, the term usually refers to the interference of waves which are correlated or coherent with each other, either because they come from the same source or because they have the same or nearly the same frequency. Two non-monochromatic waves are only fully coherent with each other if they both have exactly the same range of wavelengths and the same phase differences at each of the constituent wavelengths.

Ion (Ī-on)
Any charged particle or group of particles usually formed when a substance, such as a salt, dissolves and dissociates. Particle Physics

Magnetism
Phenomenon by which materials exert an attractive or repulsive force on other materials.

Magnetohydrodynamics
The academic discipline which studies the dynamics of electrically conducting fluids.

Messenger particles

Sub-atomic particles that are exchanged between matter and are responsible for force, (i.e., electromagnetic). An example of a messenger particle is a photon, which is responsible for the electromagnetic force.

Molecule (MOL-e-kyool)
When two or more atoms combine in a chemical reaction, the resulting combination is called a molecule. A molecule may contain two atoms of the same kind, as in the hydrogen molecule: H_2. The subscript 2 indicates that there are two hydrogen atoms in the molecule.

Modes
Any of various stationary vibration patterns of which an elastic body or oscillatory system is capable <the vibration mode of an airplane propeller blade> <the vibrational modes of a molecule>

Nucleic acid
A nucleic acid is a complex, high-molecular-weight biochemical macromolecule composed of nucleotide chains that convey genetic information. The most common nucleic acids are deoxyribonucleic acid (DNA) and ribonucleic acid (RNA). Nucleic acids are found in all living cells and viruses.

Nucleotide
A nucleotide is a chemical compound that consists of a heterocyclic base, a sugar, and one or more phosphate groups. In the most common nucleotides the base is a derivative of purine or pyrimidine, and the sugar is the pentose (five-carbon sugar) deoxyribose or ribose. Nucleotides are the monomers of nucleic acids, with three or more bonding together in order to form a nucleic acid. Nucleotides are the structural units of RNA, DNA, and several cofactors - CoA, FAD, FMN, NAD, and NADP. In the cell they play important roles in energy production, metabolism, and signaling.

Oxidation (ok-si-DĀ-shun) **and Reduction (REDOX)**
Oxidation does not necessarily involve oxygen, after which it was named, but is most easily described as the loss of electrons from atoms and molecules. The inverse reaction, reduction, occurs when a molecule gains electrons. The removal of electrons and hydrogen ions (hydrogen atoms) from a molecule or, less commonly, the addition of oxygen to a molecule that results in a decrease in the energy content of the molecule. The oxidation of glucose in the body is also called cellular respiration. According to this study that lost energy may produce a photon. The oxidation of glucose, for example, is also known as cellular respiration. It occurs in every cell in the body (except red blood cells which lack mitochondria) and provides the cell's chief source of energy. The complete oxidation of glucose to carbon dioxide and water produces large amounts of energy. It occurs in three successive stages; glycolysis, the Krebs cycle, and the electron transport chain. Another definition= http://www.ilpi.com/msds/ref/oxidation.html
Antioxidants like vitamin C can minimize oxidation and are often electron donors.

Oxygenation
Oxygenation refers to the amount of oxygen in a medium. In blood it may be taken to be synonymous with saturation, which describes the degree to which the oxygen-carrying capacity of haemoglobin is utilized, normally 98-100%. Oxygenation also refers to the process of adding oxygen to a medium such as water or body tissue. Claims have been made that oxygenation of human tissue prevent diseases, including cancer, however some regard these claims as unverifiable. Oxygenation of various fluorocarbon liquids has been used successfully in liquid breathing systems, allowing air-breathing animals, including humans, to breathe via liquids for short periods of time.

Photosynthesis
Photosynthesis (photo=light, synthesis=putting together), generally, is the synthesis of sugar from light, carbon dioxide and water, with oxygen as a waste product. It is arguably the most important biochemical

pathway known; nearly all life depends on it. It is an extremely complex process, comprised of many coordinated biochemical reactions. It occurs in higher plants, algae, some bacteria, and some protists, organisms collectively referred to as photoautotrophs.

Polycyclic hydrocarbons (Polycyclic Hydrocarbons, Aromatic)
A major group of unsaturated cyclic hydrocarbons containing two or more rings. The vast number of compounds of this important group, derived chiefly from petroleum and coal tar, are rather highly reactive and chemically versatile. The name is due to the strong and not unpleasant odor characteristic of most substances of this nature. (From Hawley's Condensed Chemical Dictionary, 12th ed, p96)

Proportionality (mathematics)
In mathematics, two quantities are called proportional if they vary in such a way that one of the quantities is a constant multiple of the other, or equivalently if they have a constant ratio.

Quantum electrodynamics
Quantum electrodynamics (QED) is a relativistic quantum field theory of electromagnetism. QED mathematically describes all phenomena involving electrically charged particles interacting by means of exchange by photons, whether the interaction is between light and matter or between two charged particles. It has been called "the jewel of physics" for its extremely accurate predictions of quantities like the anomalous magnetic moment of the electron, and the Lamb shift of the energy levels of hydrogen.

Quantum Physical

Quantum theory
In physics, quantum theory, is a term that may be used to refer to several related types of theories, which make use of quanta.

Q factor (Q-Value) (Q factor or Q, in resonant systems, is a measurement of the effect of resistance to oscillation.)
The Q factor or quality factor compares the time constant for decay of an oscillating physical system's amplitude to its oscillation period. Equivalently, it compares the frequency at which a system oscillates to the rate at which it dissipates its energy. A higher Q indicates a lower rate of energy dissipation relative to the oscillation frequency. For example, a pendulum suspended from a high-quality bearing, oscillating in air, would have a high Q, while a pendulum immersed in oil would have a low one.

Resonant Cavity
A resonant cavity is a cavity in which standing waves can be built up. In a parallelepiped resonant cavity for electromagnetic waves, the TE_{lmn} modes have

Signal noise
In science, and especially in physics and telecommunication, noise is fluctuations in and the addition of external factors to the stream of target information (signal) being received at a detector. In communications, it may be deliberate as for instance jamming of a radio or TV signal, but in most cases it is assumed to be merely undesired interference with intended operations. Natural and deliberate noise sources can provide both or either of random interference or patterned interference. Only the latter can be cancelled effectively in analog systems; however, digital systems are usually constructed in such a way that their quantized signals can be reconstructed perfectly, as long as the noise level remains below a defined maximum, which varies from application to application.

Signal-to-noise ratio

Signal-to-noise ratio (often abbreviated SNR or S/N) is an electrical engineering concept defined as the ratio of a given transmitted signal to the background noise of the transmission medium. It is also known as D/U ratio, which stands for desired to undesired signal ratio.

Spectral Intensity

Squeezed light
Non classical states of light with noise below the standard quantum limit in one quadrature component. In physics, a squeezed coherent state is any state of the quantum mechanical Hilbert space such that the uncertainty principle is saturated. Depending on at which phase the state's quantum noise is reduced one can distinguish amplitude-squeezed and phase-squeezed states or general quadrature squeezed states. If no coherent excitation exists the state is called a squeezed vacuum. The figures below give a nice visual demonstration of the close connection between squeezed states and Heisenberg's uncertainty relation: Diminishing the quantum noise at a specific quadrature (phase) of the wave has as a direct consequence an enhancement of the noise of the complementary quadrature, that is the field at the phase shifted by π / 2. From the top: the following figures are illustrated; Vacuum state, Squeezed vacuum state, Phase-squeezed state, arbitrary squeezed state, and Amplitude-squeezed state. In the first figure : Measured quantum noise of the electric field of different squeezed states in dependence of the phase of the light field. For the first two states a 3π-interval is shown, for the last three states, belonging to a different set of measurements it is a 4π-interval. (source: link 1 and ref. 3) Measured quantum noise. The next figure is Oscillating wave packets of the five states. Oscillating wave packets The final figure are Wigner functions of the five states. The ripples are due to experimental inaccuracies. Wigner functions As can be seen at once in contrast to the coherent state the quantum noise is not independent of the phase of the light wave anymore. A characteristic broadening and narrowing of the noise during one oscillation period can be observed. The wave packet of a squeezed state is defined by the square of the wave function introduced in the last paragraph. They correspond to the probability distribution of the electric field strength of the light wave. The moving wave packets display an oscillatory motion combined with the widening and narrowing of their distribution: The "breathing" of the wave packet. For an amplitude-squeezed state, the most narrow distribution of the wave packet is reached at the field maximum, resulting in an amplitude that is defined more precisely than the one of a coherent state. For a phase-squeezed state the narrowest distribution is reached at field zero, resulting in an average phase value that is better defined than the one of a coherent state. In phase space quantum mechanical uncertainties can be depicted by Wigner distributions. The intensity of the light wave, its coherent excitation is given by the displacement of the Wigner distribution from the origin. A change in the phase of the squeezed quadrature results in a rotation of the distribution. The squeezing angle, that is the phase with minimum quantum noise, has a large influence on the photon number distribution of the light wave and its phase distribution as well. This figure illustrates measured photon number distributions for an amplitude-squeezed state, a coherent state, and a phase squeezed state. Bars refer to theory, dots to experimental values. (source: link 1 and ref. 2) Measured Photon Number Distributions This figure illustrates Pegg-Barnett phase distribution of the three states. Pegg-Barnett

Superposition
To place or lay over or above whether in or not in contact. to lay (as a geometric figure) upon another so as to make all like parts coincide

Thermodynamics
Thermodynamics (from the Greek thermos meaning heat and dynamics meaning power) is a branch of physics that studies the effects of changes in temperature, pressure, and volume on physical systems at the macroscopic scale by analyzing the collective motion of their particles using statistics.[1][2] Roughly, heat means "energy in transit" and dynamics relates to "movement"; thus, in essence thermodynamics

studies the movement of energy and how energy instills movement. Historically, thermodynamics developed out of the need to increase the efficiency of early steam engines.

Web Resources

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Bose-Einstein condensate (Bose-condensation)
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Squeezed coherent state (Squeezed Light)
http://en.wikipedia.org/wiki/Squeezed_coherent_state
http://www.lifescientists.de/publication/pub2001-08.htm
Table of mathematical symbols
http://en.wikipedia.org/wiki/Table_of_mathematical_symbols
http://www.scenta.co.uk/tcaep/maths/symbol/Mathematical%20Symbols/index.htm
The German Research Groups, Neuss, Germany
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Thermodynamics *
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Wavelength λ *
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William Garner Sutherland DO (1873-1954)
http://www.craniosacraltherapy.org/History.htm
http://www.sctf.com/about/index.html
http://www.osteodoc.com/sutherland.htm
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