PHOTONIC ACUPUNCTURE :

A Model To Explain Acupuncture,
From Phylogenesis To The Multiplicity
Of Methodologies And Results

by

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ABSTRACT

Photonic acupuncture is the application of monochromatic light to classical acupuncture points, and is the correct name for what has been described as laser acupuncture, or low-level laser therapy.

One may describe electro-magnetic radiation (EMR) in space in terms of wavelengths, and in tissue in terms of photons or packets of energy. A more accurate scientific concept describes EMR as variations in the electrical field strength, where the frequency and amplitude are the features of importance.

Understanding the biological effects of light's action in tissue clearly demonstrates there are disadvantages, but no clinical or biological advantages, in using a low level laser light compared to using a non-coherent light.

A unifying electro-physiology theory is advanced, postulating how the various forms of stimulation of acupuncture points result in similar changes in physiological parameters.

An understanding of the phylogenetic evolution of the body's electro-magnetic field sensory systems, allows a rational explanation for the origin of acupuncture points and channels.

INTRODUCTION

Much confusion has been caused by the inability of some workers in acupuncture, to demonstrate the exact nature of an acupuncture loci, or to identify them in neuro-anatomical terms (Gunn et al. 1976). As it was known that the skin over a muscle motor point had the least resistance to electrical stimulation, one of the earlier attempts to explain acupuncture points, was in terms of the relatively fixed patterns of motor lines. (Walthard and Tchicaloff 1971). Gunn et al.(1980) demonstrated that dry needling muscles at motor points relieved pain. To date, acupuncture has not been fully explained in western neuro-physiological

terms (Smith 1994). Due to the number of methods of stimulating acupuncture points (Altman 1994, O'Connor and Bensky 1992), there are difficulties in accurate interpretation, as it is unknown to what extent extraneous influences occur, and to what extent these may cause errors (Bensoussan 1991).

There are four major theories that attempt to explain the reduction in pain and the wide range of physiological effects of acupuncture:- (1) The neural non-opiate theory, now largely discounted by Stux and Pomeranz (1989); (2) The neural opiate theory; (3) The hormonal opiate theory; and
(4) The bioelectric theory (Becker 1985). This theory has neither been fully endorsed nor dismissed (Bensoussan 1991).

Traditional acupuncture is basically an invasive technology, and each of the above theories start with the initial microtrauma, which creates a chemical cascade of inflammatory and immunological responses (Smith 1994). These theories do not explain how non-invasive or non-traumatising stimulation produces an equivalent physiological effect.

That low level laser light could stimulate acupuncture points has been known since 1968 (Mester 1985). Simple light emitting diodes (LEDs) became available in the early 1970s, with the first Gallium-Arsenide diode laser developed in 1979, but only in the last five years have superbright or super-luminous diodes (SLDs) been commercially available. A recent survey amongst physiotherapists showed 94% of respondents were dissatisfied with the amount and quality of information available on laser therapy (Baxter 1994). Due to a lack of basic understanding, controversies surround the stimulation of tissue with light, and whether or not coherent, collimated, and narrowly mono-chromatic, laser generated light, produces different effects from non-coherent broad band light (Pontinen 1992, Baxter 1994).

Both laser diodes and modern SLDs are now made from a Gallium-Aluminium-Arsenide (Ga-Al-As) alloy formed into a double hetero-junction chip. This means that there are two junctions of dissimilar crystalline alloys, not just one junction as in the older style LEDs. The SLD has the same chip structure as a solid state laser, but it lacks the thin films of reflective aluminium to form a resonant cavity, which would technically make it a laser.

In the biological literature, it is common to find comments relating the wavelength of light to specific effects, such as absorption, penetration depth, and even mode of function, however, as the velocity of light changes with each change in the density of the tissue, so does the wavelength (Kane and Sternheim 1988). The past ten years have seen an explosion in knowledge regarding the molecular basis for membrane transport, which permits an understanding of the physiological basis for clinical acupuncture at a level not previously possible.

THE BIOLOGICAL EFFECTS OF LIGHT

The efficacy of phototherapy has long been known, even though its' mechanism of action was not understood. From 1500 BC Indian Sanskrit documents, through the histories of the ancient Egyptians, Greeks and Romans, one finds references to the healing powers of light. Henri de Mondeville (1260-1320 AD) used red light to treat smallpox. John of Goddesden, physician to Edward II of England, in 1510 treated a prince with smallpox, using red dyes, red bedclothes and red curtains (diffuse red light), and cured him without a vestige of pock marks. In 1903 a Danish doctor, was awarded a Nobel prize for treating tuberculosis and smallpox with red light to abolish suppuration and lessen scarring (Kleinkort and Foley 1984).

With the advent of modern antibiotics and improved hygiene much of this old information was forgotten or ignored (Karu 1989). Not surprisingly, suggesting that light could be used to treat disease risked accusations of pseudo-science, as quackery flourishes in the twilight zone of knowledge.

When lasers were discovered in the late 1950s, the observed biological effects were attributed to the uniquely high coherence of the radiation (Mester et al 1985), however, Karu (1987), conclusively demonstrated that there was no scientific or physical basis for such a belief.

While low powered laser light was used to stimulate acupuncture points from 1963, it was not until 1989 that sufficient, detailed, scientific information was available to understand the interaction of light with tissue. In 1990 with the advent of SLD technology, and then in 1991 with the publication of Bioenergetics texts, it was possible to introduce a rational, scientific, advanced method of non-invasive acupuncture treatment, which Pontinen (1992) described as pain-free, sterile, safe, and effective.

It must be clearly stated that biological specimens only absorb non-coherent light, and the coherence of laser light is lost after the first millimetre of epidermis.

In discussing the biostimulatory effects of low intensity light on tissue, a number of erroneous points are commonly encountered:

(a) Basford (1989) states that red light penetrates 0.8-15mm into tissue whereas infrared light reaches 10-50mm, (penetration increases with wavelength). This statement is incorrect.

There is little penetration up to 600nm, due to absorption by the various peptide bonds, chromophores, porphyrins, haemoglobin, oxyhaemoglobin, and photo-inducible components such as urocanic acid and melanin (Wilson and Jaques 1990). From 600nm to 700nm there is a steep rise in penetration (about 2.5 times the distance), due to decreasing haemoglobin absorption, and then penetration is roughly constant above this region to about 1300nm, with a small dip at 960nm due the high absorption at this level by water (Smith 1991).

(b) Light beams of lasers and non-lasers show a variety of different intensity

profiles, divergent beam widths, and wavelengths. In an attempt to rationalise different forms of treatment, a common suggestion is to quote all treatments in Joules per square centimetre, regardless of the spot size (Pontinen 1992, Baxter 1994). As time is involved in the measurement of Joules/square cm, this has led to various high intensity treatments over short times being quoted as equivalent to low intensity long time treatments (Bliddal et al 1987), whereas the irradiation in the first case can introduce bio-inhibition (Harris 1988). This is equivalent to a driver speeding at 200 km/hr, with three passengers, telling a traffic policeman he was only travelling at 50km/hr/person.

(c) A common fallacy is that pulsing makes for deeper penetration. When lasers were first utilised, to get sufficient electrical strength, one had to pulse the current to get a solid material to lase. In modern lasers, pulsing is merely switching on and off and reduces the effectiveness, by a factor equal to the on/off period relationship, thus increasing the time per treatment required (Baxter 1994). This is analogous to suggesting that if the room light was to be switched on and off it would make the room brighter. Manufacturers may provide pulsing because their competition do so, but to purport any benefits from pulsing is wrong.

All electro-magnetic radiation (EMR) has its own frequency with visible light falling between 4x10*14 to 7x10*14 cycles per second (Hz). Gas lasers tend to produce continuous energy, while laser or otherwise semiconductor light is in bursts of 5000Hz. The claim of clinical benefit is based on confusion with the known fact, that slowly pulsing a strong electric field will affect the cyclic adenosine-mono-phosphate (cAMP) and de-oxyribose-nucleic-acid (DNA) synthesis in tissue, while different pulse frequencies of strong electrical fields effect the production of encephalin, dynorphins, endorphins and monoamines (Stux and Pomeranz 1989).

(d) Another fallacy is that pressing the light into the tissue makes the light penetrate further. Proponents of such suggestions (Pontinen 1992, Baxter 1994), do not consider that compression changes the tissue's density, the refractive index, the light's subsequent scatter and therefore may reduce penetration but not increase it.

(e) Many articles describe laser coherence, and the various types of lasers available from gas to diodes, without explaining that most diodes are technically not true lasers, a fact made clear by Baxter (1994). A common error is to describe He-Ne lasers as producing 632.8nm wavelength and Ga-As as producing 904nm (Flemming 1994) as if this were the only wave length produced.

Using a ruby rod, Maiman (1960) produced the first visible laser light at 694.3nm. Within a year, numerous lasers were available, among them being invisible infra-red He-Ne lasers of 1118, 1153, 1160, 1199 and 1207nm, while the first visible He-Ne laser of 633nm did not appear until 1962. In diode systems (laser or otherwise), the radiated wavelength depends on the percentage of aluminium in the diode, which can be manufactured to produce virtually any wavelength required (Baxter 1994).

It is necessary to counter much misinformation and erroneous conceptions if progress is to be made in the use of light to stimulate acupuncture points.

All living cells require energy for growth and metabolism, usually supplied by ATP phosphate bond hydrolysis, which is the common energy transfer in all living organisms (Herbert et al. 1989). The chemiosmotic theory, is based on the principle that concentration gradients across a cell membrane and the phosphodiester bonds in ATP are inter-convertible forms of storing energy.

There is a great similarity between photosynthesis in plant chlorophyll and mitochondrial oxidation utilising cytochromes. Both chlorophyll and mitochondrial cytochromes have a metalated, conjugated porphyrin ring, which is an efficient light absorber. Singlet oxygen is highly reactive, rapidly oxidises a large variety of biological molecules, damages DNA and is responsible for cell destruction. Singlet oxygen is photo-produced by porphyrins, the efficiency of which depends on the side chains, and the radiation energy frequency. Incorporation of metal ions into the porphyrin molecule depresses or even inhibits formation of singlet oxygen (Lubart et al. 1990, 1991).

The absorption of specific wavelengths of light by specific receptors such as rhodopsin, phytochrome, or chlorophyll is easily demonstrated, but can not be as easily demonstrated for porphyrins. All photoreceptor pigments (porphyrins and their derivatives) when irradiated, change colour, and their absorption peak shifts due to cis-trans isomerization.

An even more complex matter is to demonstrate the absorption by non-specialised chromophores such as flavins. Reactions with various components of light produces a photobiological response in the terminal oxidases of the mitochondrial respiratory chain, which has a complex structure as well as a complicated absorption spectrum near 400, 450, 605, 680, 760, and 830nm. Flavoproteins and their semiquinone forms have absorption bands in the red region, which in the case of the respiratory chains are represented by dehydrogenases (Brunori and Wilson 1982).

This is affected by whether the receptor is in the reduced or oxidised form. As the cellular redox potential is lowered or moved more in the reduced direction, the effect of light on tissue is greater. The cellular response is not an all or nothing response, but a graded reaction.

If DNA synthesis is taken as an indicator of cellular stimulation by light, then with as many factors controlled for as possible, DNA synthesis can be observed in wave-length range of about 320nm to 450nm and 600nm to 840nm with maxima peaks at 400, 630, 680, 760, and 820nm (Karu 1989). Light in the wavelengths mentioned is not absorbed directly by the DNA, therefore there has to be intervening photo-acceptors producing photo-products which influence the metabolic processes in the cells. This is why spectral bands of 50-150nm are advantageous (Karu 1989), and why laser's single wave length, used as a stimulatory mechanism is disadvantaged by comparison.

Quoting numerous studies, Karu (1987) states that at the level of a whole organism, the skin possesses light sensitivity, and the presence of the eyes

only modifies the skin's photo-sensitivity effect. When light is applied to acupuncture points it stimulates mitochondrial membrane cytochromes, which are normally engaged in electron transfer. This may be seen as the local activation of a universal, primitive, photo-synthetic mechanism, to low intensity near mono-chromatic light, suggesting a similar molecular mechanism with the same primary photoreceptor.

THE PHYLOGENETIC EVOLUTION OF ACUPUNCTURE POINTS

The cells normal function is to pump hydrogen ion (H+) out of the cell against high electrical and chemical gradients. The electro-chemiosmotic pressure so generated, when released by the influx of hydrogen ions into the cell drives the ADP + P -> ATP (Nicholls and Ferguson 1992). Ions have a relatively high surface charge, a high attraction to water, which accounts for the relative lack of ion permeability through membranes.

In the context of cell to cell signalling, if one accepts the term first messenger as a generic term to cover all types of extracellular signal molecules, the term second messenger represents the intracellular signal molecules that are produced in response (Hardie 1993). Almost all mammalian cells, except red blood cells, produce prostaglandin and eicosanoids, which like hormones, have profound physiological effects at extremely low concentrations. Mechanical deformation of cells produces prostaglandin (first messenger) which provokes the metabolic activity as revealed by increased cAMP (second messenger), leading to DNA synthesis and the activation of protein kinases which is involved in the stimulation of phosphorylation (Bereiter-Hahn 1986).

Stimulation with electrical fields serves the same role as the prostaglandin effect. In the neuromuscular systems, electrical potentials which are the product of intercellular chemical reactions, serve as messengers, provoke specific responses, and cyclic series of potentials can be used to automatically control a target organ (Martin and Burr 1988).

In the evolution of single cell organisms, the two major branches formed are the eukaryotes (plants, animals and fungi), which have a membrane-enclosed nucleus, and the prokaryotes (bacteria), which lack this organelle. According to the endosymbiotic hypothesis, a purple photosynthetic bacteria formed an evolutionary successful, symbiotic relationship with a primitive form of nucleated cells giving rise to chloroplasts in plants and mitochondria in animal cells. The only known eukaryotes which do not have chloroplasts, mitochondria etc., have symbiotic cyanobacteria within them (Voet and Voet 1995).

Every unicellular organism has to be capable of the full panoply of biochemical processes required, with growth and metabolism controlled only by nutrient availability, with each cell competing for these nutrients with the same and other species. In multicellular organisms, cells are differentiated for a particular purpose, and close cooperation is required between them for efficient function, particularly in the co-ordination of movement, metabolism, and growth (Hardie 1991).

Anatomical and cytological studies have shown that all living things have an underlying regularity that derives from their being constructed in a hierarchal manner. One striking feature that all living organisms have in common is the presence of an ADP-ATP system. Understanding photo-receptor evolution and function, shows that different organisms use different photoreceptors for essentially the same function, while in other cases, essentially the same photoreceptor has been used to achieve different objectives Holmes (1991).

Bacteria and other single cell organisms do not have a nervous system, but they have both a form of memory and a sense of direction, due to electrical potential differences across their cell membranes. Sharks and fish use the electric fields around their body for prey detection, and communication (Kane and Sternheim 1988, Kramer 1990, Moller 1995) as do echidnas and platypus (Manger 1994). Snakes have infrared sensors on their lips (Bereiter-Hahn et al 1986). Having originated from a common phylogenetic base, all creatures develop characteristics best suited to the environment they inhabit, and as all species share common features to a greater or lesser degree, this may be exemplified by cellular response to electro-magnetic radiation.

Each electrical charge produces an electric field in its vicinity, with the total electric field of multiple charges being the sum of their individual electric fields.

In the case of fish and sharks using the electric fields around their body for prey detection, and communication, this may be exemplified by a school of fish being attacked by a shark. The shark is sensitive to, and attracted by the minute electric fields produced by each fish, which in a school may be considered as an aggregated field. As soon as the shark breaches the outer limits of the school's associated field, a force is transmitted to the entire school and all fish turn as one. In the case of fish living in a conductive medium, these sensors in their skins are particularly well developed.

All living tissue produces electromagnetic fields, and have EMF sensors developed to a greater or lesser extent. Monotremes, which are of a higher phylogenetic development than fish, also utilise electromagnetic radiation sensing, especially under water. Birds, higher mammals, and humans have well developed eyes to receive electromagnetic radiation in the form of visible light. These terrestrial beings also have areas on the skin of increased electrical conductivity, the stimulation of which can alter physiological function. This strongly suggests that acupuncture points are phylogenetically, simply the skin's electric field sensory system, which is common in all things.

THE ELECTRO-PHYSIOLOGY OF ACUPUNCTURE

It is known that the transmembrane potential of a neurone or other cell is in the order of 90mV, and that it only takes an action potential of 20mV to trigger a reaction. Acupuncture points are bilaterally symmetrical, skin loci of increased electrical conductivity, approximately 5mV more positive than the

surrounding skin with a range of from 2-42mV (Ulett 1989).

Therefore, one can now offer an electro-physiological theory for the function of acupuncture, both as a triggering mechanism and to explain the long term function (McLaren M.App.Sc. Thesis 1996).

Under the skin is connective tissue, which is largely comprised of collagen. Of the 32 crystalline shapes known to science, 20 of these are so arranged that pressure causes an electrical charge within the crystal. This is known as the Piezo-electric crystal effect. Of these 20 crystals, 10 are also Pyro-electric, that is heat causes an electric charge separation. Collagen is comprised of crystals which are both Piezo and Pyro electric. Thus when the skin is touched the body recognises both pressure and warmth. This information is conveyed to the brain electrically via the nerves.

When an acupuncture point is stimulated with a needle it produces pressure, and via the Piezo-electric effect stimulates the brain, via the nerves. The inflammatory reaction and immune response occasioned by needle insertion is highly localised, incidental and not of importance, where as the induced electrical current known as the discharge of injury, is important.

The electrical stimulation of the brain is not just a momentary effect, as the change in electrical potential of the cells at the acupuncture point, changes the energy level of the surrounding tissue for some 32 to 48 hours.

If cells are grown on an agar plate in an incubator in the dark, on exposure to light (and return to the incubator), it will be noticed they grow at a greater rate for anything up to 3 or 4 generations. If the cells are examined immediately after exposure to light, little change would be noticed. However after 32 to 48 hours improvements in growth rate etc, can be demonstrated.

When a light is shone on an acupuncture point it changes the electrical potential of the cell's walls and the energy level of the cells, in exactly the same way as an acupuncture needle would do, without the problems associated with skin penetration.

Altering skin potentials via irradiation alters the electrical activity in the brain and causal relationships have been shown to exist between the variations in concentrations of the neurohormones, (noradrenaline, dopamine, 5HT, cAMP, and Ca++), the concentration of DNA and RNA synthesis (Martelly and Franquinet 1984). Laakso (1995) showed transcutaneous stimulation of human skin increased blood endorphin levels.

Acupuncture may be shown to be a therapeutic modality which is as effective as, or in some cases more effective than Western medicine (Bensoussan 1991), yet the number of people seeking acupuncture as a method of first choice tend to suggest that it has remained relatively unpopular as a treatment. This may be due to a number of factors including the fact that acupuncture, like chiropractic or physiotherapy, requires a series of treatments for best results. The unpopularity may also be partly due to the strong dislike a large number of

people have of needle insertion (Mann 1977, Le Bars et al. 1987), or the risks associated with skin penetration (Waylonis 1988). Also it may be due in no small measure, to the difficulty of TCM theory, not being easily equated by qualified medical personnel, with their own scientific, knowledge base.

The problems related to understanding photonic acupuncture are significant to a more complete scientific understanding of acupuncture. A unifying theory to explain a common mode of action for all of acupuncture's various methodologies, invasive and otherwise, will help explain acupuncture to the medical scientists, open for debate some of the firmly held dogmas now perceived as truths, and reduce the requirement for teaching needle techniques to that associated with other ancient, invasive and potentially dangerous methodologies.

Acupuncture is not a static method, but has changed as it has been developed over thousands of years. A theory to explain acupuncture in a scientific manner may allow it to develop further, and with photonic techniques eliminating the need for skin penetration acupuncture's popularity may be enhanced.

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